Key Components for Potential Sustainable Vehicle-to-Grid Business Models within the Netherlands

Qualitative research to explore the components for sustainable Vehicle-to-Grid business models by conducting semi-structured expert-interviews

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Key Components for Potential Sustainable Vehicle-to-Grid Business Models Within the Netherlands

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I. Acknowledgments

After 6 months of research, I can present my master thesis for my study of ‘’Complex Systems Engineering and Management’’. With this master thesis, my student career at the Delft University of Technology comes to an end. The last phases of my study doing my research were rare times because of the corona situation. I never thought that my last day at Delft was my last day as a student. I have spent five years in this university and now my student days are coming to an end, I can conclude that I have made the right choice. I have enjoyed and learned a lot in this time period, for which I am very grateful to the education staff and my fellow students.

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II. Executive summary

Vehicle-to-Grid (V2G) is a concept that operates with a bidirectional charger. In this way, electric vehicles (EVs) can also be discharged to inject the energy from the batteries back to the grid. The shifts towards more use of EVs within the vehicle fleet and more use of renewable energy sources (RES) in the utility industry make this technology prevalent in scientific literature. Although the attention to V2G is high, the focus on business models, which refers to the analysis of market segments and business mechanisms that capture the value of V2G services, is low.

Notably, the literature has neglected the attention towards sustainable business models for V2G. Sustainable business models focus to transform a share of the value generated for a stakeholder towards a value that is useful for a company. It searches for sustainable value which can meet social, environmental, and economic benefits at the same time. Therefore this research aimed to develop potential sustainable V2G business models within the scope of Dutch market conditions. The reason for choosing the Netherlands was because V2G gets a lot of attention in the Netherlands due to the increasing trend of EVs and RES, which creates congestion on the Dutch grid.

The corresponding research question was as follows:
"What are the key components for potential sustainable Vehicle-to-Grid business models within the Dutch market conditions?"

Answering this research question helped to shed light on the components for sustainable V2G business models to support and understand the development of business models within the Netherlands for a V2G service provider.

Methodology
The research followed a qualitative approach. The primary research method for analysing this research question was to conduct semi-structured interviews with experts in the field of V2G. These interviews were transcribed and coded to analyse the results and determine the critical components for a potential sustainable V2G business model within the Dutch market conditions. The perspective of a V2G service provider was chosen because this actor would be the provider of V2G services and therefore needs a sustainable V2G business model. Before the expert-interviews, three methodologies were applied as a stepping stone to the expert-interviews. First, a literature review was conducted to construct a theoretical framework. This framework was the lens of the expert-interviews. After that, an actor analysis was applied. This made it more clear which actors are relevant for a working V2G business model. This served as input for contacting experts who are employed in those actor groups, who have knowledge or experience with V2G, and who would like to participate in the expert-interviews. Furthermore, this actor analysis helped to enrich the theoretical lens. Thereafter, a case study was applied, focusing on business models that were developed during pilot projects. The cases that have been used were companies that have participated in V2G pilot projects and which could share their insights regarding their business models. The literature was also explored regarding technological developments and their impacts on a V2G business model. All of these methods provided insights in the business environment and shaped the lens of the expert-interviews. In total, eleven experts were interviewed.

Results
The results showed that there are three themes: business environment, sustainability, and business model with twenty-six categories, which include the key components for a sustainable V2G business model. Based on the insights of each category, the key components for a sustainable V2G business model was developed (Figure 1). An expert validated a draft version of this model in an online meeting. In this meeting, a draft version of Figure 1 was shown to the expert and a second opinion was asked. Based on the recommendations of the expert, Figure 1 was further detailed in several use cases. These use cases were Public V2G charging, V2G for homeowners (Vehicle-to-Home), and V2G for office building/building owners (Vehicle-to-Building). For V2G, both the Vehicle-to-Home and Vehicle-to-Building use cases are assumed local (on microgrid), which results in that the V2G business model would focus on peak shaving (storing energy when energy generation is high and using it when energy

consumption is high) and load balancing building (balancing energy need of charge points and building). The sustainable V2G business model for each case has been shown in Figures 2, 3, and 4.

The relationship of themes, business environment, sustainability, and business models are represented by arrows. The first arrow represents the impact of the business environment on the business model. The second arrow represents the sustainable archetypes that are underlying to the V2G business model or that are results of a working sustainable V2G business model.

The third arrow represents the evaluative criteria of the sustainability categories which a business model must satisfy, at least, to penetrate the market. Hereby, the economical category could be of key importance for a sustainable V2G business model. The component that V2G is commercial and also contributes to a sustainable society is a leading criteria to have been satisfied.

Conclusion
The institutional, technical, and standardization issues make the Dutch market not mature enough to be feasible for a V2G business model.

The institutional barriers make it challenging to earn money from congestion markets by serving distribution system operators (DSOs) in congestion management. This is because DSOs are under heavy regulation. They may not use batteries and they cannot apply dynamic price structuring because of legislations. This makes the application of V2G at the DSO market for now too complicated. Multiple taxes that must be paid for each charging session after the car is discharged poses a barrier for a V2G business model too. Whereas public V2G charging has also to deal with municipal regulation regarding restrictions on the occupation of charge points, Vehicle-to-Home and Vehicle-to-Building cases do not have to face such rules. What particularly disturbs the Vehicle-to-Home case is the netting arrangement in which energy generation from solar panels can be virtually stored in the energy grid. The Vehicle-to-Building case could be feasible because building owners or businesses could also save money from lower grid connection tariffs, for which the regulatory issues are less a bottleneck.

Regarding standardization, the main issues are that there are no open data communication protocols for V2G. This is expected to be enabled by ISO-15118 but this is not ready at the moment. Currently, only the CHAdeMO protocol is compatible with V2G, while Tesla and CCS protocol are commonly applied in the Netherlands. There is also no V2G charging infrastructure environment, which negatively contributes to the standardization of V2G.

Regarding the technical barriers, the battery capacity of vehicles are not very high, there is no commercially available vehicle fleet which is capable of V2G, and the V2G infrastructure costs are too high at the moment.

Although the V2G market is not mature at the moment, there is potential for a sustainable V2G business model due to the increasing trend of EVs, increasing grid congestion, and decreasing costs for V2G charging infrastructure. Also, the netting arrangement is expected to be expired from 2023 on and the prevention of multiple taxes is expected to happen soon. This will have a positive impact on the development of sustainable V2G business models.

Contribution
A sustainable V2G business model is developed, which was as far as known not developed yet by applying a qualitative approach and conducting expert-interviews. The use of such an approach was new in this field. This business model also showed the key themes, categories, and components for a sustainable V2G business model. Although, the components could differ per use case, customer segment to which these services would be offered, and which country market the V2G business model is operating in. The themes and categories that are constructed could be the basis for each sustainable V2G business model. So, this research contributes to the scientific literature by providing a comprehensive view of the key actors and key factors for a sustainable V2G business model as well.

Limitations
This research also had several limitations. One limitation was the lack of an expert from a transmission system operator (TSO), which is a key player for delivering ancillary services and the lack of an expert from a municipality. Moreover, a limitation of this research is the perspective that has been used. The interview was conducted by semi-structured questions which followed the same perspective for each expert-interview. This is done because of the V2G service provider's perspective which was chosen. Consequently, actors specific questions were not asked, which in particular could be important for the automobile industry, governmental agencies, and the DSOs. Because the attitudes of these actors towards V2G appeared to be unobvious, while those actors are vital for a sustainable V2G business model.

Another limitation was that the research was limited to the Netherlands. This was necessary because the market conditions in which a V2G business model will operate is vital. So, the market conditions must be determined. The available timeframe for this research did not allow to widen the scope to multiple countries and therefore the choice was made to focus on one specific country. The Netherlands was chosen because of accessibility to actors as well as the fact that relative to many other countries, many V2G projects have taken place or are ongoing.

Recommendations
With this research managerial implication and recommendations for policy and future research could be given. The recommendations for policy were based on three dimensions: solve institutional issues, contribute to use of open data, and incentivize the market until V2G is commercially feasible.

Managerial implications that are addressed are in the first place to be aware that V2G associates with a lot of R&D, investment costs, risks, and cooperation. However when it is operationally feasible, its realization costs decrease, and it becomes widely applied, then it could be profitable because the costs are mainly those investment costs. This makes the V2G market complicated but also promising due to the ability to generate revenue through V2G services.

The business environment is hereby the main contributor to the success of V2G. How this business environment develops is something to be alert on. It is important to make V2G easily accessible and easy to use for the end-user. Therefore, offering the V2G option during the sale of an EV is an important channel to reach the end-users. V2G technology is developing beyond their initial intention. It is possible that V2G technology will be applied in other cases than the ones for which business models are intended to be developed for. To keep this in mind and search for such opportunities could make a company which is involved in the V2G market more competitive.

A recommendation for future research is to use qualitative research to shed light on the perceptions and attitudes from different automotive companies, governmental agencies, and DSOs towards V2G. Another recommendation is to conduct similar researches for other countries which could give the opportunity to see how key components for sustainable V2G business models differ for other countries. A recommendation for future research is also to look into what the impacts of the expiration of the netting arrangement will be for V2G. Thereby, research to whether V2G can contribute to the adoption of EVs and/or solar panels is recommended. Research towards the calculation of business cases for a sustainable V2G business model per use case is also recommended. Research towards other use cases of the ones determined in Figure 1,2,3 could be recommendable either. Lastly, it is recommended to conduct research towards battery degradation, impact of shared vehicles on V2G, and impact of the corona situation on V2G.

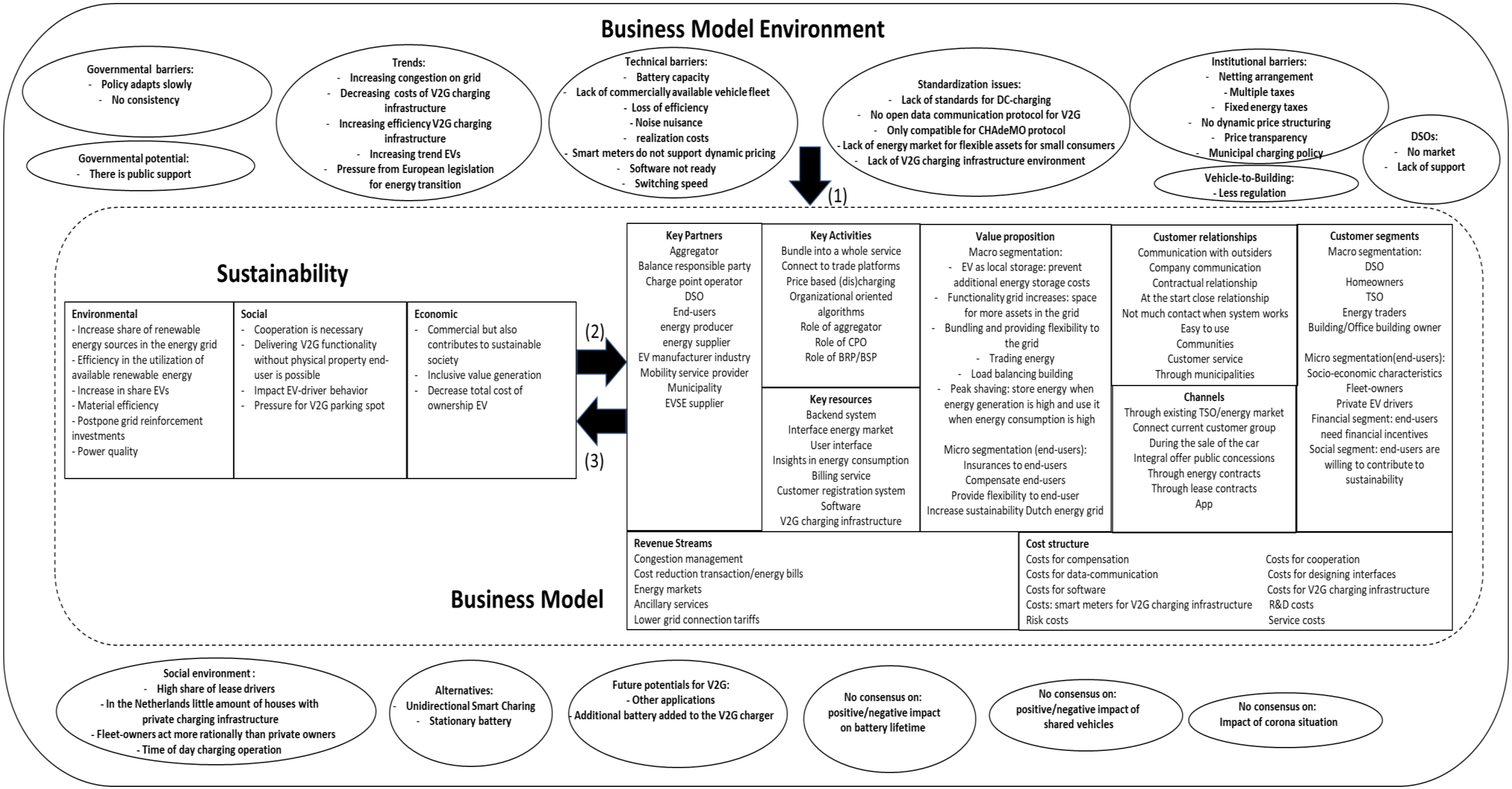

Figure 1: key components sustainable V2G business model

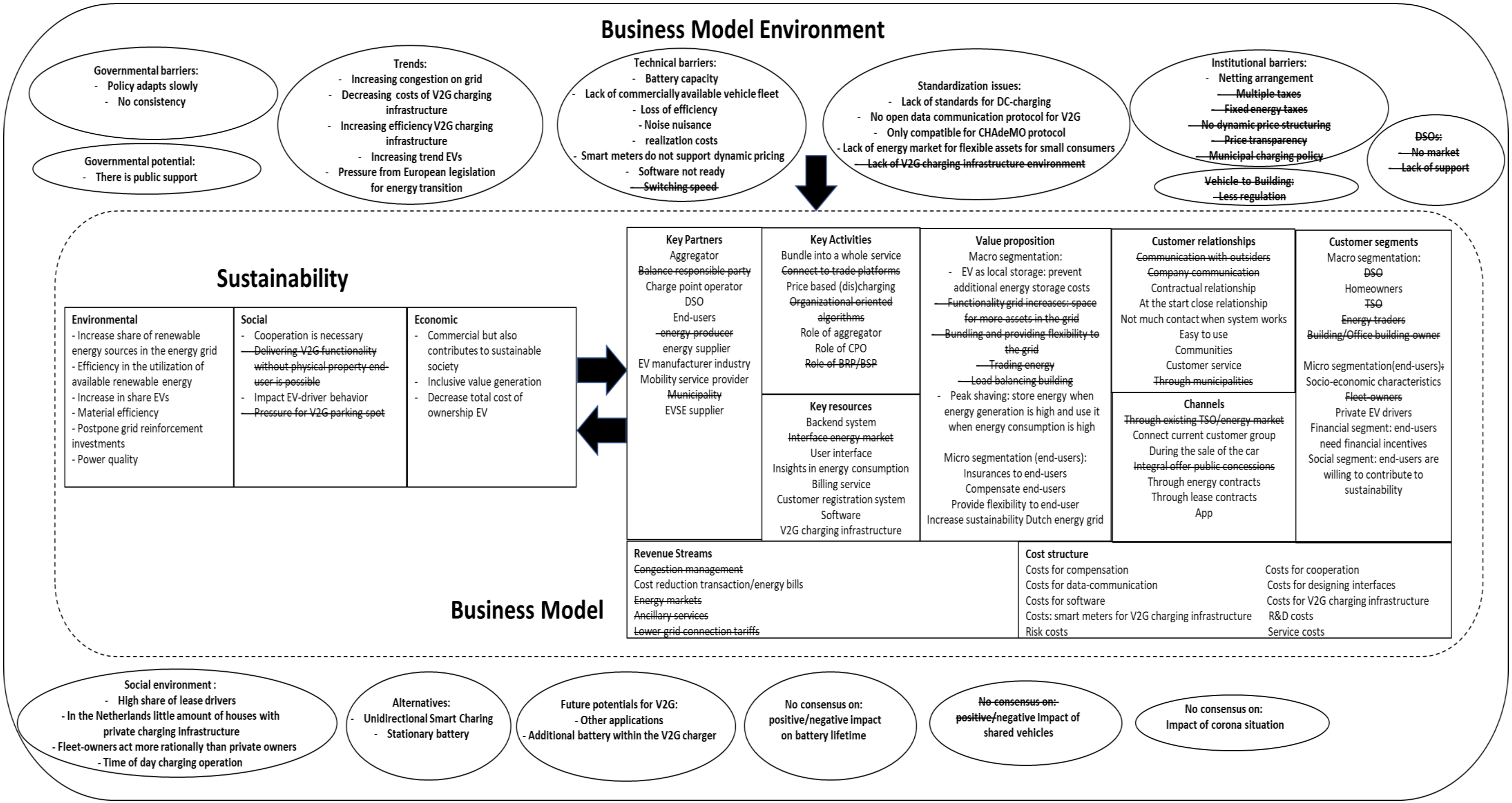

Figure 2: sustainable business model Vehicle-to-Home use case (local)

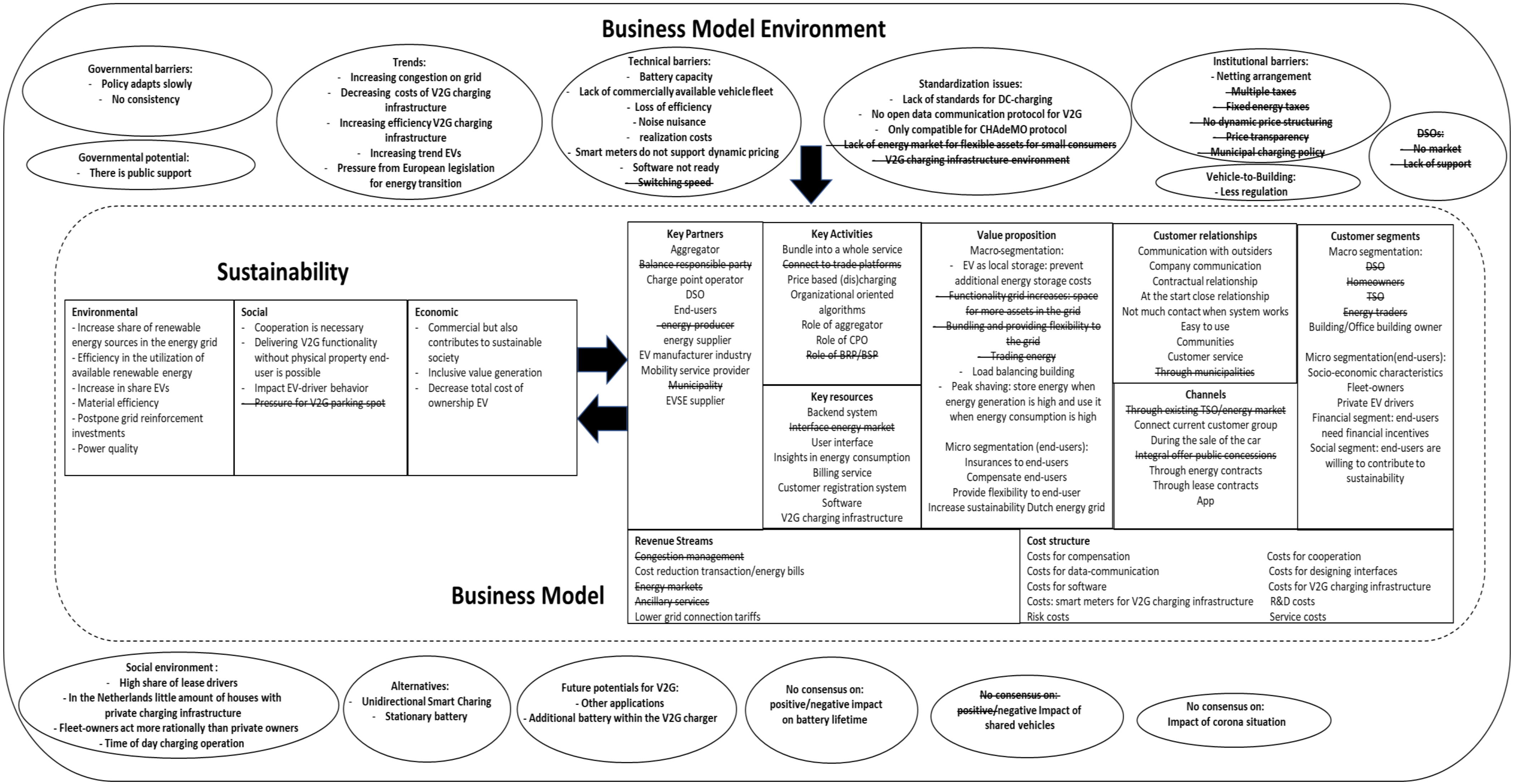

Figure 3: sustainable business model Vehicle-to-Building use case

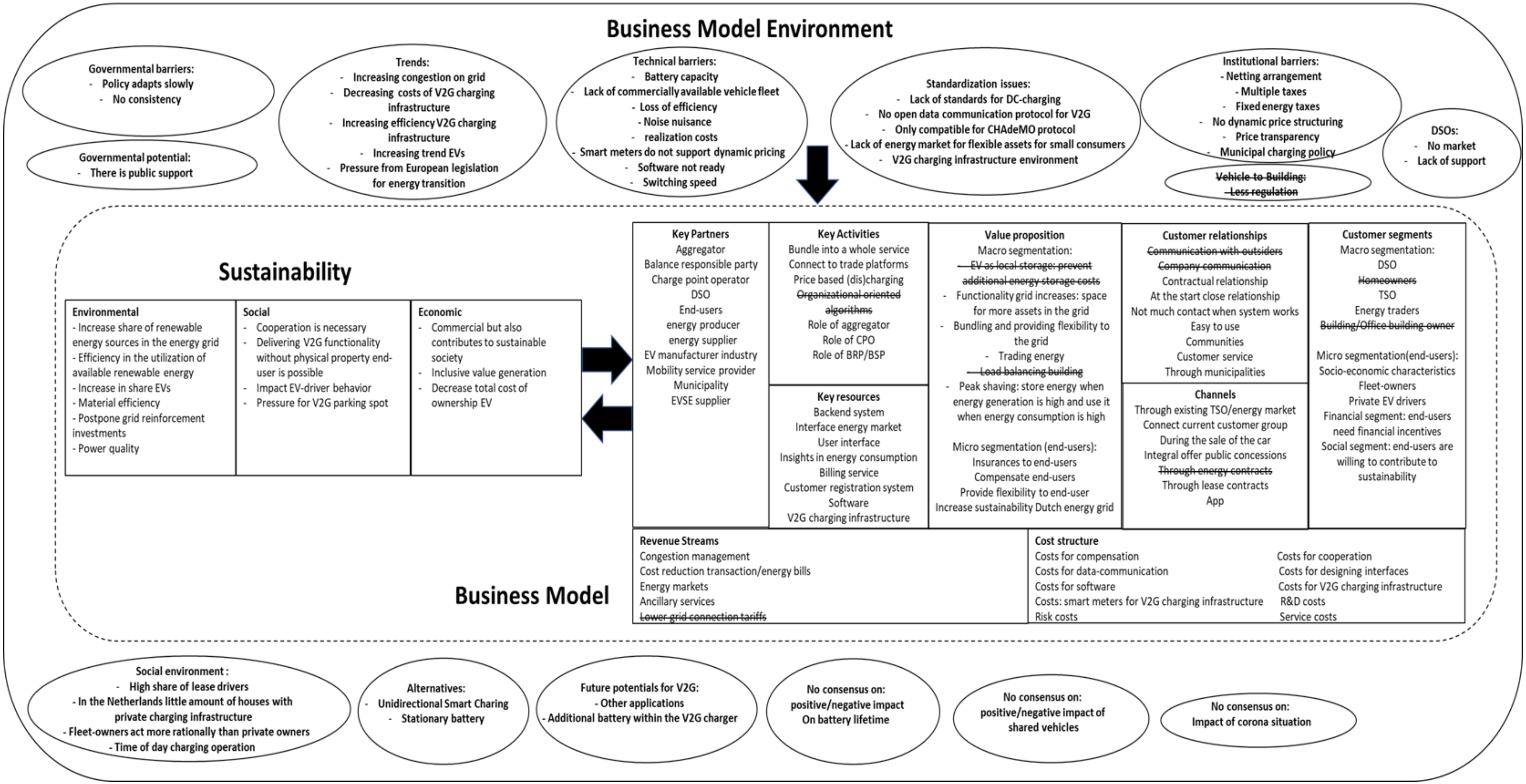

Figure 4: sustainable business model public V2G charging

Content

III. List of abbreviations

Alternating current (AC)

Authority for Consumers and Markets (ACM)

Autonomous vehicles (AVs)

Balance responsible party (BRP)

Balancing service provider (BSP)

Battery electric vehicle (BEV)

Central hub (CH)

Charge point operator (CPO)

Direct current (DC)

Distribution system operator (DSO)

Dutch knowledge centre of smart charging infrastructure (ElaadNL)

Electric vehicles (EVs)

European Union (EU)

Fuel cell electric vehicle (FCEV)

Hybrid-electric vehicle (HEV)

Mobility service provider (MSP)

Netherlands Enterprise Agency (RVO)

Netherlands Knowledge Platform for Public Charging Infrastructure (NKL)

Renewable energy sources (RES)

State of charge (SOC)

The Ministry of Economic Affairs and Climate Policy (EZK)

The Ministry of Infrastructure and Water Management (I&W)

Transmission system operator (TSO)

Unidirectional smart charging (Smart charging)

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1. Introduction

1.1 Background information

Due to the mass adoption of motor vehicles over the years, the current road mobility has many impacts on environmental pollution (Geels, 2012). Therefore, the electrification of the vehicle fleet gets high attention (Ke et al., 2017). In the Netherlands, the number of registered electric vehicles (EVs) increased to approximately 222,000 in June 2020, while this number was 29,000 in the year 2014 (RVO, 2020a). At the same time, the installed capacity of solar photovoltaics increased from 1,500 megawatts (MW) to 4,400 MW and wind energy generation rose by 4% to 36 petajoules (PJ) in 2018 (CBS, 2019). This increasing use of renewable energy sources (RES) and EVs have negative consequences for the electricity grid such as voltage deviations and larger peaks (Pillai & Bak-Jensen, 2010). For such reasons, the Vehicle-to-grid (V2G) pioneers Willett Kempton and Letendre (1997) developed the idea to use EVs for supporting the energy grid. The concept of V2G is that vehicles feed-in electricity, which is generated from their vehicle engine or an on-board battery system, by plugging them into a grid (Turton & Moura, 2008).

V2G can be utilized by applying one of the two possible configurations. The first method is an onboard charger, in which the EV includes a bi-directional converter (AC-charging). The second method of applying bidirectional charging is by placing the converter in the charging unit (DC-charging). Figure 5 shows the main differences between these methods.

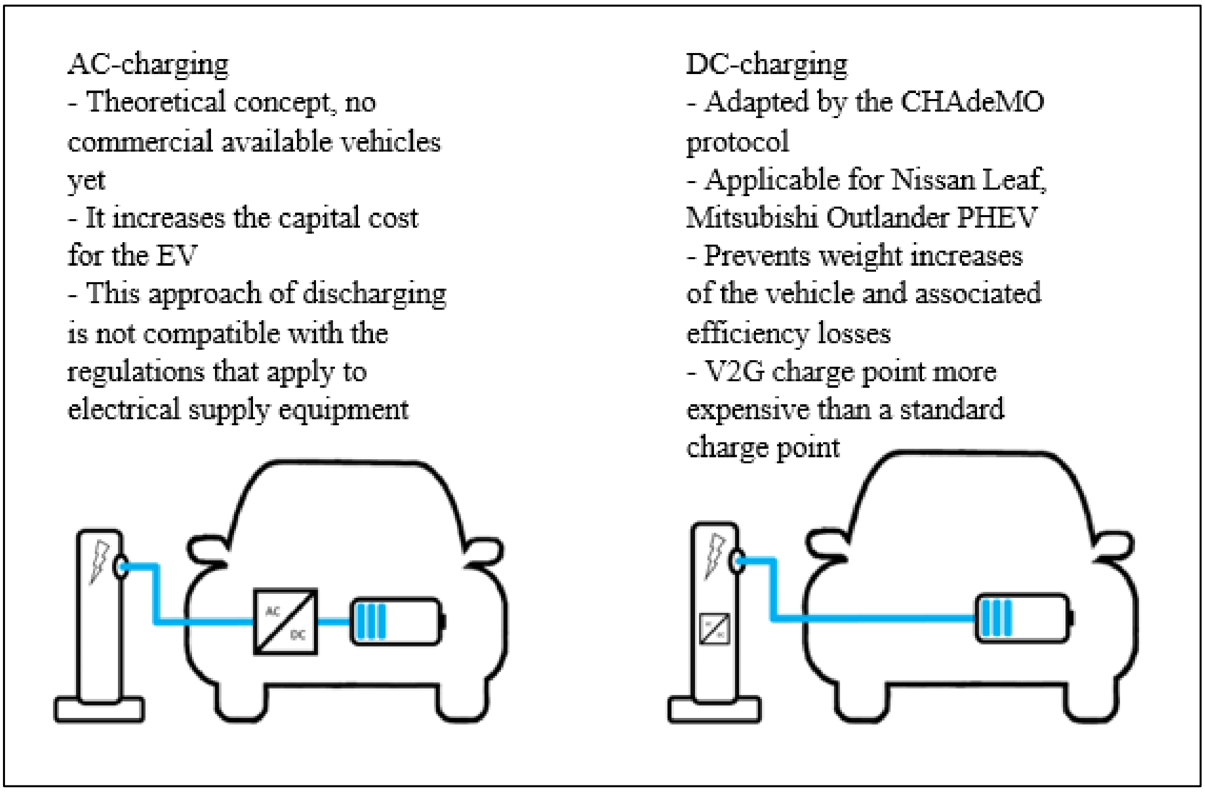

Figure 5: differences AC-charging and DC-charging (adapted from MacLeod and Cox (2018))

1.2 The importance of V2G technology

Through the interaction between EVs and the energy grid, advantages can be gathered. For instance, the integration of more RES, the improvement of the energy grid because of higher efficiency and reliability, and the decrease of the intensity of Greenhouse Gasses in the energy grid (García-Villalobos, Zamora, San Martín, Asensio, & Aperribay, 2014). However, these advantages depend on which smart charging strategy has been used (García-Villalobos et al., 2014).

V2G is a form of smart charging. There are two ways a smart charging can operate. One way is unidirectional smart charging (smart charging) in which EVs provide energy services by modulating their charging rates and another way is bidirectional smart charging in which EVs also discharge their batteries for injecting the energy back to the grid (X. Wang & Liang, 2015). In the literature bidirectional smart charging is usually referred to as V2G (Sovacool, Noel, Axsen, & Kempton, 2018).

Although the V2G technology has been around since the 90's, the EVs and energy systems did not have the position to utilize this technology fully. Consequently, the market focused on smart charging since this could be implemented immediately (MacLeod & Cox, 2018). Smart charging enables to provide energy services by optimizing time of use (price tariffs), managing network constraints, peak demand shaving, and optimizing use of renewables (MacLeod & Cox, 2018).

Although V2G faces more challenges than smart charging (Sortomme & El-Sharkawi, 2011), V2G can be seen as an extension of smart charging because of the ability to inject energy back to grid acting as a storage system (García-Villalobos et al., 2014). W. Kempton and Tomic (2005) addressed that this makes sense because EVs, which are initially intended to be used for transportation, are still idle for 96% of the time. Thereby, the attention towards V2G is increasing, which can be argued from the high number of pilot projects started after approximately 2010 (see appendix A) and the expected utilization rates of V2G by 2030 (Sovacool et al., 2018). Currently, V2G technology is also applicable due to CHAdeMO connectors at a limited number of EV models (MacLeod & Cox, 2018). These potentials make V2G an interesting topic to focus on. In particular, the development of business models that enable to clearly identify and target appropriate customer groups is hereby critical (MacLeod & Cox, 2018). V2G poses new challenges in business models (San Román, Momber, Abbad, & Miralles, 2011), but the attention towards V2G business models is low (Sovacool et al., 2018). Hence, this study focused on V2G business models which has been substantiated in detail in Section 3.

This thesis added value to a better understanding of the feasibility of V2G and especially towards the development of sustainable business models within the Netherlands. Namely, based on the literature review conducted in Section 3 there appeared knowledge gaps regarding the development of sustainable V2G business models. V2G is hereby used ad umbrella term for bidirectional smart charging.

1.3 Research question(s) and approach

To develop sustainable V2G business models three themes must be determined: the business environment, the business model itself, and sustainable archetypes (as explained in Paragraph 3.3). The literature review in Paragraph 3.4 helped to identify knowledge gaps in the market conditions in which the business model would be developed, relevant actors and relationships, most appropriate actor(s) for providing V2G services, the role of consumer groups related to business models, insights about current V2G business models, and the development of sustainable V2G business models. Research that fills these gaps could support the development of potential sustainable V2G business models within a predetermined market. This resulted in identifying the research question for this thesis as follows:

''What are the key components for potential sustainable Vehicle-to-Grid business models within the Dutch market conditions?''

In order to answer the main research question, a set of sub-questions were required. The applied sub-questions were as follow:

1. What is a theoretical framework that can be applied for V2G business models?
2. What is the actor's environment for V2G services within the Dutch energy market?
3. Which V2G business models are currently being applied?
4. What technological developments can influence the compatibility of sustainable V2G business models?
5. What are the perceptions of experts regarding the development of sustainable business models for V2G?

The objective of the research question was to obtain knowledge on potential sustainable business models for V2G within the Netherlands. This was done by applying a qualitative approach that focuses on the aforementioned knowledge gaps for V2G business models. The reason for choosing a qualitative rather than a quantitative approach was the aim of the research. In the stage of this research, the aim was more based on understanding complexity, constructing new insights, and deeply analyzing and developing V2G business models for the Netherlands. This aim characterized the use of a qualitative approach (Atieno, 2009).

To find an answer to the research question some intermediate steps were required, therefore the main research question was divided into sub-questions. In the first place, an answer regarding the development of sustainable business models had to be found. In order to do this, a theoretical framework was constructed that showed the elements for sustainable V2G business models.

Afterward, this theoretical framework was enriched by exploring the V2G market in the Netherlands. In order to do this, the market for V2G services was analysed. This contained also an analysis regarding the ways actors interrelate with each other and about which actors are potential providers for V2G services. Thereby, the role of consumers and their impact on V2G business models were clarified.

Furthermore, current business models with regards to V2G were analysed. This helped to gather insights on the experiences and business models of companies that are participating in V2G projects. This again helped to enrich the theoretical V2G framework on before of the expert-interviews.

Also some technological developments were explored because these factors can influence the compatibility of V2G. As described in Section 3 there are different types of EVs. It was important to analyse which type of EV appears to be appropriate for V2G and which type of EV is expected to get an upwards trend in the penetration rates. This is important because it could influence whether V2G continues with keeping potential for having a sustainable business model. Other externally technological developments such as the penetration of autonomous vehicles (AVs) could have influences as well. Therefore, knowledge was gathered regarding technological developments and their impacts on the potential of sustainable V2G business models.

By including these insights in the interview-question with experts, the main elements for developing a sustainable V2G business models were explored. In the end, these steps provided an answer to the main research question and proposed one or more potentially sustainable business models.

1.4 Scope: The Netherlands

Another important finding from the literature (Section 3) was that market conditions for V2G services matter. Each country/region could have different market conditions, and it is assumable that each country/region could have different involved actors. Therefore, determining a scope that focuses on a country or region was important.

A particularly interesting country to focus on was The Netherlands because of the following reasons: firstly the concept of V2G is interesting for the Netherlands because it is the third country with a highest penetration rate of EVs (6%) (Wagner, 2019) and as mentioned before there is an upwards trend in the use of RES. These shifts towards more use of EVs within the vehicle fleet and more use of RES in the utility industry characterizes the need for V2G (W. Kempton & Tomic, 2005). Secondly, as far as known, the literature does not focus on developing business models for V2G within the Dutch electricity market. This makes the Netherlands more interesting to focus on. Thirdly, in the Netherlands, there is relatively high attention towards V2G. This could be derived from the number of projects of V2G within the Netherlands such as NewMotion V2G project in Amsterdam, Amsterdam Vehicle2Grid in Lochem, Smart Solar Charging in Utrecht and Powerparking V2G at the Green Village (TU Delft) (Appendix A shows some more projects).

1.5 Structure thesis

The thesis continues with describing the methodology of how the research is conducted. The applied methods were literature reviews, an actor-analysis, cases studies, and semi-structured expert-interviews. Section 2 provides the content of these methods and how these are conducted. Section 3 presents the literature review which aimed to find knowledge gaps about V2G, with a particular focus on V2G business models. Based on the findings of the literature review the lack of sustainable V2G business models was addressed. The findings showed also the need for considering the actors environment and exploring current V2G business models for the development of sustainable V2G business models. Section 4 presents the actor-analysis which was important to explore key actors, relationships, role of consumers, the business environment, and to enrich the theoretical lens of the expert-interviews. Section 5 presents the case studies that aimed to explore current V2G business models which are applied. Thereafter, Section 6 presents technological developments which can influence the potential of V2G business models. The findings of these sections helped the enrich the theoretical lens of the expert-interview and to develop an interview protocol. Appendix A shows how each section contributed to the interview questions. Section 7 presents the results and the discussion of the experts interviews which in the end helped to provide a framework with the key components of sustainable V2G business models, including separate frameworks for three uses cases (Vehicle-to-Home, Vehicle-to-Building, public V2G charging). In final, Sections 8 presents the conclusion and discussion of this study. This section includes a discussion about the generalization to other markets/applications, dynamics, and a comparison to smart charging. Furthermore, it includes recommendation for policy makers and managerial implications. In the end, Section 8 present some limitations of this research and future research recommendations.

2. Methodology

As described before, this thesis followed a qualitative approach which helped to answer the proposed research question. Each sub-question was linked to a methodology which provided an answer to this sub-question. In mainlines, four kinds of methodologies were applied: literature review, actor analysis, case study and semi-structured interviews.

2.1 Literature review

In order to determine the knowledge gaps and a theoretical framework, a literature review has been conducted regarding studies about V2G. First, the literature has been searched for feasibility studies of V2G. Scopus, ScienceDirect and Google Scholar were used as databases since these databases contain scientific studies. Search terms as ‘’V2G, vehicle-to-grid, bidirectional vehicle-to-grid’’ and ‘’feasibility, applicability, readiness’’ were used to reach a wide range of studies regarding the feasibility of V2G. In order to answer sub-questions 1 and 4, a literature review was conducted as well. Scopus and ScienceDirect were again used as databases. For gathering additional information, studies are consulted from Google Scholar, student theses or other reports.

For sub-question 1, search terms as ‘’sustainable, profitable, viable’’ and ‘’business models’’ and ‘’Vehicle-to-Grid, V2G ‘’ had been used. Since the literature regarding sustainable V2G business model was scarce, the literature review had further also explored the basics and requirements for developing a sustainable business model. To find an appropriate theoretical framework, a literature review was conducted by using ‘’sustainable’’ and ‘’business models’’ as search terms and Scopus as database. Thereby, applying a snowballing technique supported to find supplementary documents via a key document. The findings of this literature was used to construct a framework that shows the elements for a sustainable V2G business model.

For sub-question 4, search terms as ‘’technology trends, technological development, technology progress’’ and “electric vehicles” were used. A literature review helped to focus on the technological developments and future trends of EVs. The development of the different types of EVs and other technologies, as well as their impacts on the potential of V2G, were explored.

2.2 Actor analysis

In order to answer sub-question 2, an actor analysis was applied. The reason for applying an actors analysis is the increasingly interconnected nature of technologies. The exploration of the actors environment, which influences the success of new technology, needs therefore high attention (Hermans & Thissen, 2009). This actor analysis explored the actors who are involved in the Dutch energy market, and particularly the actors within the EV charging and V2G market. Furthermore, the relationships are explored, which can differ from regulatory to commercial relationships. By doing this, the core actors and relationship for V2G services were determined. Additionally, the actor analysis helped to detect the actors who have the potential to provide V2G services.

Since the analysis was specified to the Dutch energy market, there was also a focus on non-scientific literature. The analysis was conducted by using governmental documents, acts and consultancy reports. Focusing on governmental reports and legislation provided insights in the involved actors and their relationships. Furthermore, the EV charging market and involved actors are researched by publications from research institutes such as Netherlands Enterprise Agency (RVO), the Netherlands Knowledge Platform for Public Charging Infrastructure (NKL), and the Dutch knowledge centre of smart charging infrastructure (ElaadNL). Additional consultancy reports focusing on EV market and V2G services were used as well. Sources and documents from determined actors had also been used. There was also a particular focus on consumer groups for which the scientific literature was searched.

2.3 Case study

For sub-question 3, the aim was to gather insights regarding current business models that are developed around V2G. Therefore, a case study was applied focusing on business models that are developed during pilot projects. The cases that has been used were companies which have participated in V2G pilot projects and which could share their insights regarding their business models. A case study was hereby helpful because the development of V2G business models is a fairly complex process. With the aid of this case study, the notion of a certain way of acting in a natural setting becomes more clear (Gerring, 2004). A case study approach observes a single phenomenon, which is experienced over a certain period of time, to enable more understanding for a larger group of similar phenomena (Gerring, 2004). By analysing these business models, insights were gathered to develop sustainable V2G business models within the Netherlands. These insights helped to enrich the theoretical V2G framework by adding categories and questions which needed answers on before of the expert-interviews.

For the case studies, interviews were conducted to understand the developed business models. These interviews were open interviews based on gathering information of the business model that is applied in the current project that a company is participating in. These business models of companies were used as cases. The selection of the cases started with first determining which pilot projects in the Netherlands is done or ongoing (Appendix shows this process). Thereafter, companies (or employees from these companies) that has been participated in one of these projects were contacted and asked whether they would like to share their business models which they have applied in their pilot projects. In final, three companies were used for the case studies. Although they had no business models determined yet, the respondents were able to provide insights on how their business models regarding V2G could look like.

2.4 Semi-structured interviews

For sub-question 5, the aim was to gather insights from experts. In this way, a thorough analysis was made regarding the development of sustainable V2G business models. Interviewing is a helpful data collection method to do this (Atieno, 2009). In general, there are three types of interviews: structured interviews which predetermine an order of specific question with a limited amount of response categories, narrative/unstructured interviews which follows an open-ended exploration with wide open-ended questions, and semi-structured interviews which combines predetermined questions with open-ended exploration (Stuckey, 2013). Based on the aim of this research a semi-structured interview method was applied. The semi-structured interview aims to obtain systematic information related to a central topic, while it allows exploring new emerging issues too. This is useful when there is to some extent knowledge about a topic that is under investigation but which still requires further details (Wilson, 2013). For obtaining detailed information regarding the development of sustainable V2G business model(s) this is important because the benefits of gaining information from experts was that previously unknown insights can be gathered. Semi-structured interviews make this more possible (Wilson, 2013).

2.4.1 Sampling

The sampling was focused on key actor groups that were determined from the actor analysis. From these actor groups, employees who have expertise about V2G were contacted . Thereby, people with V2G expertise from academia or research agencies were contacted. The sample group have as common that they have profound knowledge about the operation of V2G services and could provide in-depth information. The experts were contacted from e-mail or LinkedIn. Although experts from each relevant actors group was intended to be used for the interviews and were contacted, for some actor groups there were no experts founded, the request was forwarded or they did not react. This resulted in that from the TSO or municipalities no experts were included in this research. Appendix B shows the experts and their relation and expertise with V2G. In total eleven experts were interviewed. Most interviews took around 60 minutes, with some ranging from 35 to 70 minutes.

2.4.2 Interview set-up

The interview set-up was based on the constructed theoretical V2G framework. This framework worked as a theoretical lens to construct question. The Sections 4, 5, 6 were used to enrich this lens by generating additional questions. From the interviews, insights are gathered related on how the different elements of a sustainable V2G business model can be satisfied. Appendix B shows how the questions were derived from each section and to which category and theme the question is referring to.

2.4.3 Transcription and coding

The interviews has been recorded and thereafter transcribed verbatim. The transcriptions were sent to the participants with the request to approve the transcriptions within one week. On before of the interviews it was agreed, that it can be assumed as an approval if it is not approved within a week.
After conducting and transcribing the interviews, these transcriptions were coded. By coding and analysing these interviews, answer to sub-question 5 was given. The tool Atlas.ti was used during the coding and analysis of the interviews since this a commonly used software for collecting and coding qualitative data.

The coding process was iterative. First, with initial coding, codes were addressed. Thereafter, these codes were categorised. During the categorization, the codes were revised and merged or removed if some codes appeared to be the same or appeared to be not relevant. After the categorization, the categories were linked to themes. In Atlas.ti the codes were analysed with cross tabulation which showed how the codes are attributed to each expert. These results were exported to Excel. In the excel file some last amendments were made if necessary and then used in the analysis of the results.

2.5 Expert validation

After the interviews were analysed, an attempt was made to propose a model that shows the key components for a potential sustainable V2G business model. This model was validated by an expert. From the expert-interviews derived that some experts are working in parties which aim to be a V2G service provider. The expert that had been contacted was from such a party because such experts have thought more about business models from a V2G service provider's perspective. The validation was done by an online meeting in which a draft version of Figure 13 was shown to the expert and asked for feedback and second opinion. Thereafter, the last improvements were made and the final models were provided.

2.6 Research Flow Diagram

In order to provide an overview of the way the research was conducted, a Research Flow Diagram (RFD) is constructed. The RFD has been shown in Figure 6. This RFD presents for each research phase (purple), the corresponding data and theoretical input (blue), and the corresponding output that (red).

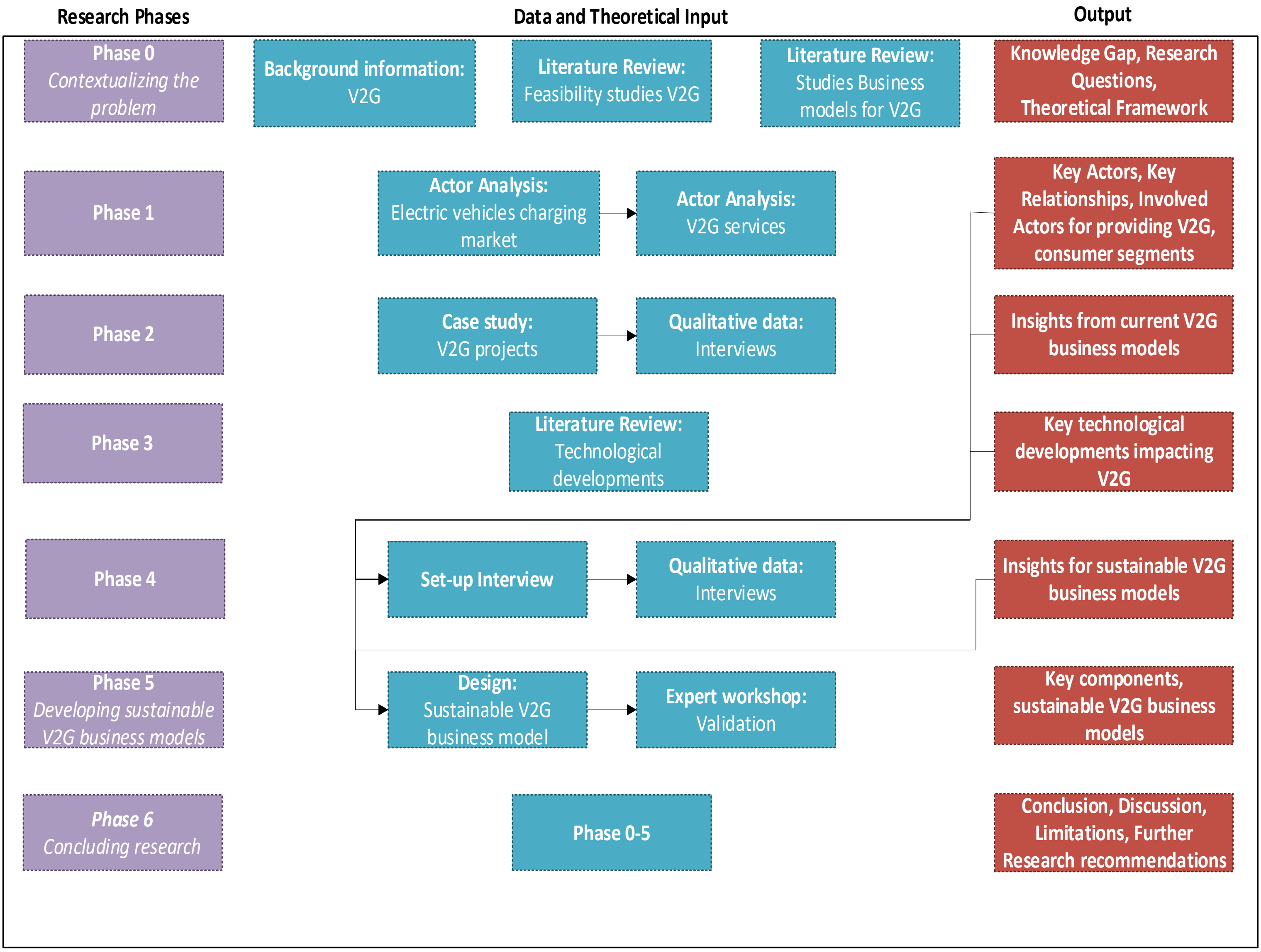

Figure 6: Research Flow Diagram

3. Literature review

In order to determine the knowledge gaps and a theoretical framework, a literature review has been conducted regarding studies about V2G. First, the literature has been searched for feasibility studies of V2G. Scopus, ScienceDirect and Google Scholar were used as databases since these databases contain scientific studies. Search terms as ‘’V2G, vehicle-to-grid, bidirectional vehicle-to-grid’’ and ‘’feasibility, applicability, readiness’’ were used . To scope down on business models a second step was taken with search terms as ‘’sustainable, profitable, viable’’ and ‘’business models’’ and ‘’Vehicle-to-Grid, V2G ‘’. The literature review had further also explored the basics and requirements for developing a sustainable business model. To find an appropriate theoretical framework, a literature review was conducted by using ‘’sustainable’’ and ‘’business models’’ as search terms and Scopus as database. Since the literature regarding sustainable V2G business model was scarce, this was required to understand how sustainable business models are defined and what the current status were regarding sustainable V2G business models.

3.1 Core concepts

In the literature V2G technologies could refer to the ability of utilizing several types of vehicles: hybrid-electric vehicles, fuel cell electric vehicles, and battery electric vehicles. Collectively this could be interpreted as EVs because of their capacity to produce motive power from electricity and not from internal combustion engines (Turton & Moura, 2008).

V2G utilizes EVs to provide power for specific electric markets (W. Kempton & Tomic, 2005). V2G operates with a bidirectional charger in which EVs also discharge their batteries for injecting the energy back to the grid (X. Wang & Liang, 2015).

3.1.1 Societal relevance and complexity

V2G has a large potential since it can have many advantages. One of them is that V2G proposes a way to stimulate the adoption rate of EVs ((Sortomme & El-Sharkawi, 2011); (X. Wang & Liang, 2015)). Furthermore, V2G can create additional benefits for increasing the share of RES such as solar photovoltaics and wind in the energy grid (Tarroja, Zhang, Wifvat, Shaffer, & Samuelsen, 2016). V2G also creates more efficiency in the utilization of available renewable generation when compared to stationary energy storage systems (Tarroja et al., 2016). Thereby, V2G can deliver voltage and frequency regulation services (Yilmaz & Krein, 2012). Moreover, V2G can deliver spinning reserves service, in which V2G supports the electricity grid during an unforeseen outrage or another emerging situation (Yilmaz & Krein, 2012). V2G reduces costs for grid operation and stabilizes electric load fluctuation as well (Drude, Pereira, & Ruther, 2014). For instance, V2G can charge the EVs during low demand for energy and discharge during daily peak hours (Yilmaz & Krein, 2012).

However, V2G is not without complexities. V2G still contains uncertainties related to economic, institutional and technological feasibility as well as reliability concerns. Institutional feasibility can refer to the ways how V2G can be institutionally embedded and socially constructed (Wolsink, 2012). Reliability concerns can refer to privacy issues and security requirements during transitions with V2G (H. Liu, Ning, Zhang, & Guizani, 2013). Economic feasibility can refer to finding the right charge curve that minimizes daily costs and maximizes the profit of vehicle owners (Rotering & Ilic, 2010
) Technological feasibility can focus on improved batteries and enhanced performances of hardware (Sovacool & Hirsh, 2009). However, like Sovacool and Hirsh (2009) mention, these technical improvements must be coupled with efforts to overcome legal, behavioural, cultural, infrastructural and economic barriers.

3.2 Feasibility studies

In order to overcome these complexities, there is a lot of attention for feasibility studies within the literature (Sovacool, Axsen, & Kempton, 2017). The feasibility of V2G is researched from different dimensions: technical dimension which embraces topics such as technology, hardware, and infrastructure. Financial dimension which refers to topics such as business models, economics, price signals, and regulatory tariffs. Socio-environmental dimension which refers to the broad costs and benefits for society. Lastly, the behavioural dimension which is about the perceptions, attitude, and behaviour of consumers and users. (Sovacool, Axsen, & Kempton, 2017)

3.2.1 Lack of focus on business model studies

The most applied dimension for feasibility studies of V2G is the technical dimension (Sovacool et al., 2018). Sovacool et al. (2018) described that technical studies mainly focus on load balancing, batteries, and storage of renewable energy. Furthermore, some studies focused on the technical feasibility of V2G in combination with wireless charging((Ahmad, Alam, & Chabaan, 2017), (Tachikawa, Kesler, & Atasoy, 2018)). The results of these studies showed that bidirectional wireless power transfer has benefits because it could create more grid interaction. However, on the other hand, it could decrease the efficiency of charging power ((Ahmad et al., 2017), (Tachikawa et al., 2018). Thereby, Han and Han (2012) assessed the V2G by its economic feasibility by taking into account the battery wear. The results showed that V2G is economically feasible because V2G incomes are able to overwhelm current battery prices (Han & Han, 2012). Another study focused on the economic feasibility and regulation, which concluded that additional regulatory incentives are required to make V2G profitable (Schuller, Dietz, Flath, & Weinhardt, 2014).

The study of Sovacool et al. (2018) provided an overview of the current state-of-art regarding feasibility studies of V2G. This study is a literature review based on 197 peer-reviewed studies published between January 2015 and April 2017: Besides the aforementioned large proportion of technical, regulatory, and economical related studies, some proportion of the studies (10%) focused on environmental effects such as the influence of V2G on the mitigation of climate change and noxious air pollution. The low percentage of attention towards this topic is surprising since the actual drive behind the V2G is climate change. An even lower proportion (4,6%) focused on financing and business models, which refer to the analysis of market segments and business mechanisms that capture the value of V2G services.

3.3 Sustainable business models

Before presenting the knowledge gaps regarding V2G business models, the basis for constructing such business models need clarification. Hereby, sustainable business models get attention because the availability of studies related to sustainable V2G business models was scarce (Paragraph, 3.4). Therefore , a literature review was conducted by using ‘’sustainable’’ and ‘’business models’’ as search terms and Scopus as database. Thereby, applying a snowballing technique supported to find supplementary documents via a key document.

The design of sustainable business models is a yet inadequately researched area (Boons & Lüdeke-Freund, 2013). Although researches towards sustainable innovation has expanded in the past decades (Boons & Lüdeke-Freund, 2013) and business models get attention since end 90s (Osterwalder, Pigneur, & Tucci, 2005), the attention to sustainable business models was pretty low in that period. Currently, as showed in Figure 7, the attention towards sustainable business models is growing more and more. Nevertheless, a commonly established framework is not developed yet (Nosratabadi et al., 2019). Therefore, the basis of the framework relies on conventional business models by including sustainable business model aspects. Paragraph 3.3.1 defines and elaborates on the concept of business model. Thereafter, Paragraph 3.3.2 emphasises on the requirements for sustainable business models.

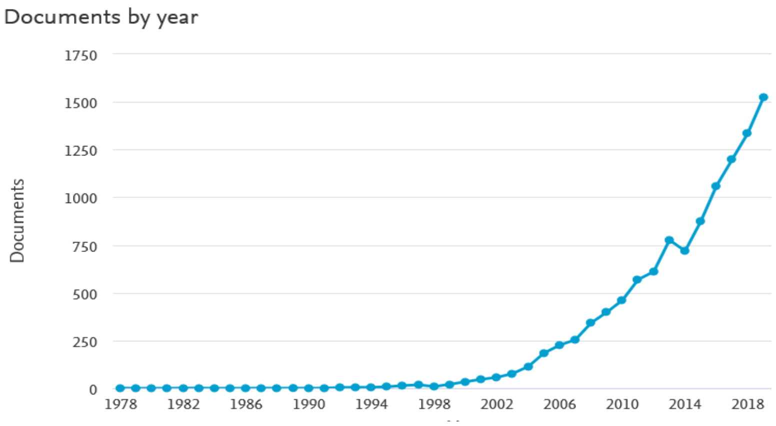

Figure 7: Search results for sustainable business models in article title, abstract keywords (Scopus)

3.3.1 Business models

The business model is a description of how parts of a business suit to each other. It is a powerful tool to improve execution by clearly communicating complex organizational values and align these values with everyone in the organization (Magretta, 2002). A business model is a tool that contains a simplified description representing the function and connection of value elements (Osterwalder et al., 2005). Basically, it conceptualizes the value flow and the interactions between value elements of an organization. In which value elements of an organization refer to value proposition, value creation and delivery, and value capture (Geissdoerfer, Vladimirova, & Evans, 2018).

Osterwalder et al. (2005) addresses four pillars for business models: the first pillar is about the product which looks to what business a company belongs to and which products and value propositions are offered to the market. The second pillar is about the customer interface which looks to who the target customers are, what distribution channels there are, and how strong relationships can be built with customers. The third pillar is about infrastructure management which focuses on what resources and activities can create value, and with whom. The last pillar is about the financial aspect which looks at the revenue model and cost structure. These pillars are further divided into nine building blocks. These building blocks formed the basis for the well-known business model canvas developed by Osterwalder and Pigneur (2010), which is shown in Figure 8.

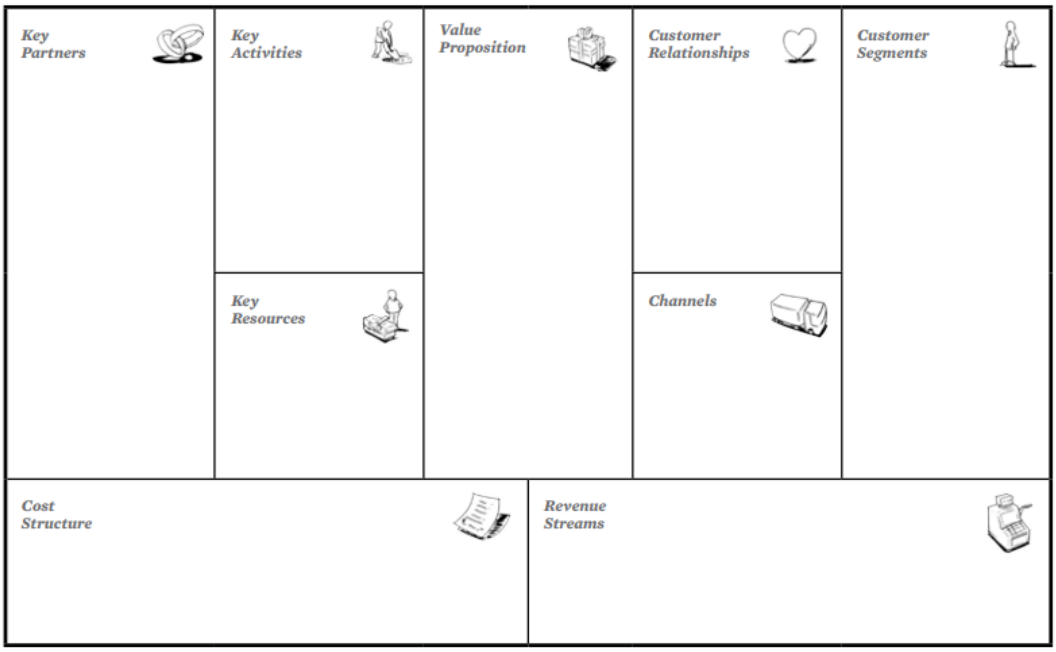

Figure 8: Business model canvas (Osterwalder & Pigneur, 2010)

However, conventional business models do not give attention to sustainability issues such as environmental and societal effects which impact society and nature (Nosratabadi et al., 2019). Such issues create more complexities that, in return, stimulate the need for sustainable business models. Namely, sustainable business models empower the drive to meet the goals for sustainable development without suffering the profitability and productivity of a company (Schaltegger, Hansen, & Lüdeke-Freund, 2016). The next paragraph focuses on the requirements for sustainable business models.

3.3.2 Sustainable business models

Based on the literature review of (Geissdoerfer et al., 2018), it seems that definitions for sustainable business models are not established yet. A possible working definition is as follows: ‘’sustainable business models are business models that incorporate pro-active multi-stakeholder management, the creation of monetary and non-monetary value for a broad range of stakeholders, and hold a long-term perspective.’’ (Geissdoerfer et al., 2018). An important modification regarding conventional business models noted hereby is the element of value capturing. For a sustainable business model, value capturing focuses on the way to transform a share of the value generated for a stakeholder towards a value that is useful for a company (Geissdoerfer et al., 2018).

Nosratabadi et al. (2019) also conducted a literature review towards sustainable models and clarified four approaches which appear to be important: ‘’ designing a sustainable value proposition, designing sustainable value creation, designing sustainable value delivering, and generating sustainable partnership networks for creating and delivering such sustainable value which can meet the social, environmental, and economic benefits at the same time.’’

As mentioned before, there is not a well-known framework yet for sustainable business models such as the business model canvas of Osterwalder and Pigneur (2010). Particularly, within the area of transport and mobility the contribution for frameworks is pretty low (Nosratabadi et al., 2019). Yunus, Moingeon, and Lehmann-Ortega (2010) intended to develop a framework by adding an extra component of the social profit equation which refers to environmental and social profits. However, the aim of this research was more based on developing a framework for social businesses than developing a general applicable sustainable business model. Bocken, Short, Rana, and Evans (2014) conducted a practice and literature review to develop archetypes for sustainable business models. The results showed nine archetypes that can be categorized into three groups: economic, social, and environmental. Reinhardt, Christodoulou, García, and Gassó-Domingo (2020) provided an overview of these groupings and corresponding archetypes, as shown in Table 1.

Table 1: overview of the sustainable business model archetypes (Reinhardt et al. 2020)

	Environmental			**Social**			**Economical**		
Archetypes	Maximise material & energy efficiency (1)	Closing resource loops (2)	Substitute with renewables and natural processes (3)	Deliver functionality, not ownership (4)	Adopt a steward-ship role (5)	Encourage sufficiency (6)	Repurpose for society/environment (7)	Inclusive value creation (8)	Develop sustainable scale up solutions (9)
Definition	Do more with fewer resources Generate less waste, emissions, and pollution	Reuse materials and products. Turn waste into feedstocks for other products/processes	Use of non-finite materials and energy sources.	Provide services that satisfy users' needs without their having to own physical products	Proactively engage with all stakeholders to ensure their long-term health and well-being	Solutions that actively seek to reduce end-user consumption	Seek to create positive value for all stakeholders, in particular society and environment	Sharing resources, knowledge, ownership, and wealth creation, inclusive value generation	Delivering sustainable solutions at a large scale to maximise benefits for society and the environment

Furthermore, Reinhardt et al. (2020) developed a conceptual framework applicable to sustainable business models. Although the aim was in the first place to develop a framework for battery second use services, the developed framework could be applied for other sustainable technologies. The framework developed by Reinhardt et al. (2020) consist of three main elements: the business environment, sustainable archetypes, and business model. The idea of this framework is to detect which archetypes matter for an actor/company and what the associating elements are regarding the business model in terms of value proposition, value creation and delivery, and value capture.

3.4 Knowledge gaps business model studies

Currently, financial studies mostly focus on reviewing the effects of V2G. Habib, Kamran, and Rashid (2015) determined and reviewed the various benefits in terms of more reliable, efficient, and stable grids and impediments such as battery degradation. Moreover, the study of Niesten and Alkemade (2016) described that additional benefits could be gathered related to financial and environmental aspects as well as more participation in electricity systems. There are also a couple of studies that monetized the effects of V2G by modelling methods, but as Sovacool et al. (2018) mentioned, the result of these studies could be inconsistent. While some of these studies showed clear cost-saving and net revenue potentials (Salpakari, Rasku, Lindgren, and Lund (2017); Noori, Zhao, Onat, Gardner, and Tatari (2016)), other studies showed slighter cost-savings (L. Wang, Sharkh, & Chipperfield, 2016) and even more costs for aggregators in some situations (Kiaee, Cruden, & Sharkh, 2015). However, there are indirect effects which are not monetized and the potential of V2G strongly depends on which market conditions and revenue streams are considered (Kiaee et al. (2015); (L. Wang et al., 2016)). Therefore, it is important to develop a business model that should be able to provide optimal revenue streams under certain market conditions.

The development of an appropriate business model that could satisfy a sustainable V2G service does not get a lot of attention. The reason for the importance of sustainable business models is because V2G enables society to become more sustainable and have more than only economic profits (Niesten & Alkemade, 2016). Such technologies can be defined as sustainable innovations and therefore they need sustainable business models in order to be able to penetrate the market (Boons & Lüdeke-Freund, 2013). However, the attention towards sustainable V2G business models is low. The study of San Román et al. (2011) intended to provide a regulatory framework and needs for business models in terms of infrastructure, involved actors, and commercial relationships. Still, this study did not aim to develop a sustainable business model. Although Brandt, Wagner, and Neumann (2017) developed and evaluated a business model for V2G, this study is based on the economic perspective of garage operators and Germany is used as a use case. Toquica, De Oliveira-De Jesus, and Cadena (2020) researched business opportunities for an EV aggregator and the ways to maximize its profit. Nevertheless, this research was from a regulatory perspective in which only one firm acts as an aggregator and Colombia is used as a use case. Y. Wang et al. (2017) built an evaluation system for smart grid services and evaluated two types of business models that are related to such services. However, to evaluate a business model for another country, it must be on beforehand established that such a business model features the requirements within that country.

Furthermore, the study of Niesten and Alkemade (2016) concluded that studies related to business models lack to include the roles of different actors, which is important by developing a business model for V2G. This study was a literature review about business models for V2G and showed the value streams considered for consumers, system operators, and aggregators. This study made clear that not all actors and relevant partnerships for V2G services are discussed in the literature. Thereby, Sovacool et al. (2018) described that V2G consists of different market segments that interrelate with consumer behaviour, which could result in separate business models. But this is omitted in studies as well (Sovacool et al., 2018).

3.4.1 Knowledge gaps

The main findings showed that the development of sustainable V2G business models is poorly addressed while developing sustainable business models for V2G services appeared to be important. Considering relevant actors and relationships are assumed necessary in the literature but at the same time this does not get a lot of attention in business model studies. Which consumer groups are involved are neglected either, while this is significant since it could result in different business models. There is also a lack of insights about V2G business models in practice, which could be due to a lack of commercially available V2G services. However, the situations about current V2G business models that are applied could provide insights into developing sustainable V2G business models. Furthermore, insights from experts or key market players are missing, while these insights are important for exploring the feasibility of novel technologies. In researching a potential sustainable V2G business model, these insights from experts could be helpful because there is currently no sustainable V2G business model on the market yet.

3.5 Theoretical V2G framework

As addressed before, there is not an established and directly applicable sustainable business model framework for V2G. The sustainable business model is an area that is under research and more elaboration for a widely applicable theoretical framework is still needed. Nevertheless, the business model canvas is a well-known and widely applied tool for business models and next to that there are insights for a sustainable business model framework. Therefore, merging these insights with the business model canvas could be helpful to develop a theoretical V2G framework. This theoretical V2G framework has further been used as a lens for the expert-interviews.

The business model canvas was used because it is comprehensive, widely applied, and it provides additional attention to customer segments and key partnerships which appeared to be unattended in current V2G business model studies. Therefore, using the business model canvas could be helpful to explore additional insights which are not addressed before. Thereby, the provided sustainable archetypes (Table 1) are reduced on beforehand due to the lack of potential to be applicable for V2G. This counts for the archetypes closing resource loops and encourage sufficiency. V2G technology has no ability to reuse materials and it does not seek to reduce end-user consumption. Hence, using these archetypes in the theoretical framework seemed unnecessary. The theoretical framework that further was used to develop the V2G business model(s) is presented in Figure 9.

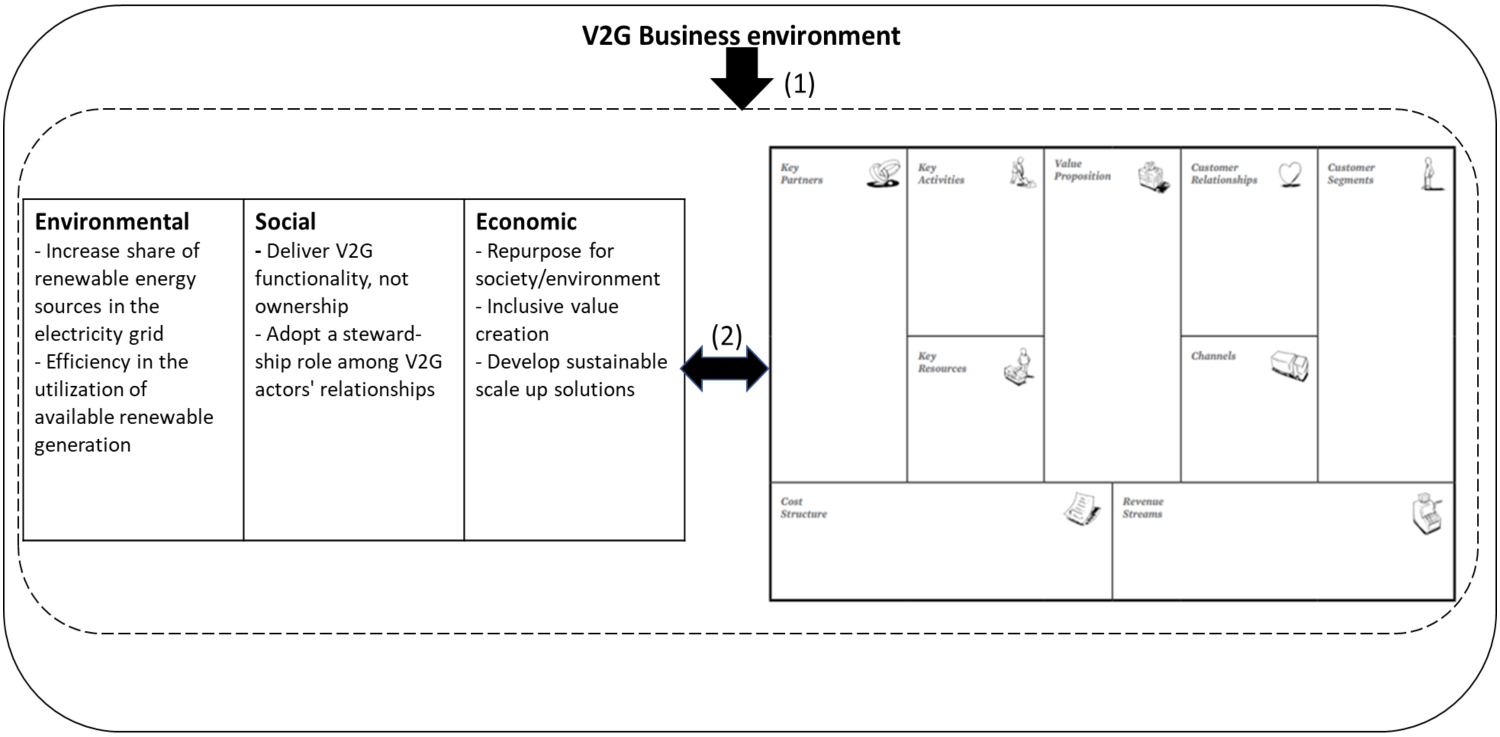

Figure 9: Theoretical framework for V2G business model

The aim was to fulfil these elements presented in the framework (Figure 1) by addressing the sustainable archetypes that are relevant to V2G and the associating content for the elements within the business model canvas. Thereby, exploration was needed for the factors of the business environment in which the underlying business model could be developed.

(1) This arrow represents the impact of factors in the business environment on a sustainable V2G business model. Business activities can be related to the business environment. This results in organizational activities that are conforming the business environment and therefore have an impact on sustainable business models (Reinhardt et al., 2020). This could be factors such as regulatory policies, market trends, or macro-economic factors (Reinhardt et al., 2020). The business environment could in a way create hinders or potentials for the underlying business model (Boons & Lüdeke-Freund, 2013). Hence, engaging in interaction with the business environment requires extra efforts during the creation of sustainable business models (Evans et al., 2017). The following sections, consisting of an actor-analysis, case studies, and an analysis of the technological developments, detailed the V2G business environment.

(2) This arrow represents the interaction of the business model with sustainable archetypes. When researching sustainable business models, these archetypes are needed to broaden and unify the research agenda for making business models more sustainable (Bocken et al., 2014). There is a possibility that none of these archetypes, a combination of archetypes, or all of the archetypes exist for a company (Reinhardt et al., 2020). The initial sustainable V2G archetypes in the theoretical V2G framework are further used in the expert-interviews (see appendix C). The aim was to explore which of these or other sustainable archetypes apply for a V2G service provider, to what extent they matter, and which of them are essential to have as evaluation criteria.

To explore the business environment as well as the important components for a sustainable V2G business model, attention to the V2G actors environment was given. Section 4 shows the V2G actors environment.

4. V2G actors environment

Determining the roles of different actors are important by developing a V2G business model (Niesten & Alkemade, 2016). For sustainable business models, the interaction with different stakeholders is also a challenging factor which needs extra efforts to be determined (Evans et al., 2017). Therefore, an actor-analysis was needed during the research to sustainable V2G business models. This actor analysis helped to get a better understanding of the key actors, relationships, and V2G business environment, which proved to be important in Section 3.

To do this, it was required to understand the V2G market. Respectively the Dutch energy market and EV charging were explored. The V2G market is closely interrelated with these markets, which makes these markets important in exploring the V2G market and the corresponding key actors, relationships, and V2G business environment.

4.1 Dutch energy market

The Dutch energy market consists of many actors and relationships. The main categories of actors are governmental agencies, energy market players, and end-users (customers). Figure 10 provides the main actors within each category and the institutional relationships.

Figure 10 has been prepared by the institutional relationships between actors that are involved in energy market. The Dutch Electricity Act[1] was the basis of the preparation of Figure 10. From this act, some relevant actors, their position, and the legislation of the market was explored. The actors specified from this act, was further analysed by exploring their own documents and webpages. Based on this analysis, a comprehensive view of the Dutch energy market and the relation with the EV market was explored and presented in Figure 10.

The actors and their relationships are further described in the following paragraphs. It was important to consider these institutional relationships because those relationships affects in which business environment the V2G business model will operate in. Question could be derived based on the influence of these relationships and the institutional elements for the development of sustainable V2G business models. This was used to enrich the theoretical V2G framework for the expert-interviews.

[1] Elektriciteitswet 1998. https://wetten.overheid.nl/BWBR0009755/2020-02-01

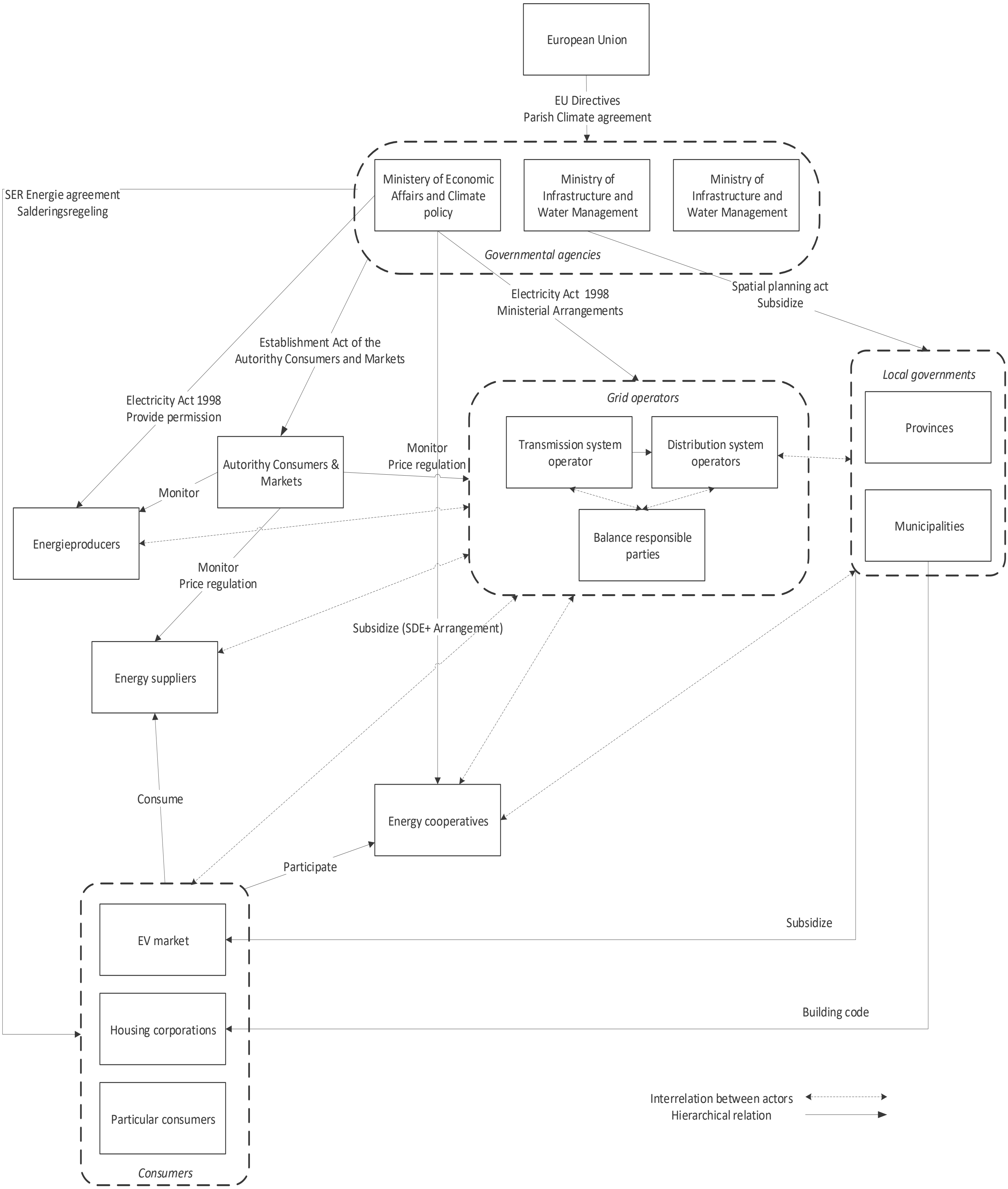

Figure 10: Formal chart (Actors and institutional relationships within the Dutch energy market, Own illustration)

4.1.1 Governmental agencies

Governmental agencies are actively involved with activities regarding regulating, subsidizing, and monitoring the energy market. Two ministries are mainly responsible or involved in such kind of activities: the Ministry of Infrastructure and Water Management (I&W) and the Ministry of Economic Affairs and Climate Policy (Dutch: Ministerie an Economishce Zaken en Klimaat (EZK)). Additionally, there is the European Union (EU) that legislates the electricity market. For instance, Directive 2019/944 of the European Parliament concerns common rules for the internal market in electricity within Europe EUR (2019) and the Paris Climate Agreement concerns an agreement in which the Netherlands has to reduce the Dutch CO_2 significantly (Wiebes, 2019).

The ministry of I&W is not directly involved in the regulation of the energy market. However, it stimulates sustainable energy transition by helping local governments with guidelines to prioritize renewable energy in spatial planning (Rijksoverheid, 2020). The ministry can also provide grants to municipalities that can be used for investments, which stimulate the use of sustainable energy. For instance, the ministry of I&W granted twenty million euros for pilot projects regarding climate adaptation (Nieuwenhuizen, 2020) and five million euros to twenty-one municipalities for smart charging poles (Rijksoverheid, 2019). This means that municipalities and local governments are involved in the Dutch energy market as well.

The ministry of EZK has an SDE+ arrangement which subsidizes institutions to produce sustainable energy (RVO, 2020b). Moreover, the ministry of EZK is directly involved in the regulation of the Dutch electricity market. The Electricity Act 1998 is concerned with the governing provisions of the Ministry of EZK. This act contains rules regarding the production, transportation and supply of electricity[2]. It also states that energy producers and suppliers must pay attention to the protection of the environment. Furthermore, the ministry of EZK imposes ministerial regulations concerning the financial management of grid operators[3].

The ministry of EZK has provided authority to the Authority for Consumers and Markets (ACM) to monitor the grid operators of the Dutch electricity market [4]. With this authority, ACM also establishes that a company will be given the position of a grid operator. Thereby, ACM has the authority to set tariffs for the distribution of electricity and to encourage grid operators for maintaining the quality of the electricity grid.

4.1.2 Grid operators

Grid operators are responsible for installing, managing and maintaining the electricity grid. Additionally, they have the responsibility to connect customers to the electricity network without prejudice (TenneT, 2020b). These grid operators can be categorized into a transmission system operator (TSO) and distribution system operator (DSO). In the Netherlands, TSO operates at the national level and DSO's operate at the regional level.

The TSO is often monopolistic and heavily regulated. TenneT is designated as the TSO for the Netherlands. The function of TenneT for the Dutch electricity grid is to operate the national high-voltage grid. The transmission of low-voltage electricity, which is 150 kV or less, is operated by regional grid operators (DSO's). Because TenneT has been designated as TSO of the high-voltage grid Netherlands, it has additional statutory duties. These duties include responsibility to provide system services. System services means that TenneT must resolve large-scale interruptions in the transport of electricity and maintain the energy balance between electricity supply and demand. The duties include also responsibilities for securing a reliable and safe electricity supply, importing and exporting electricity, and maintaining the system of programme responsible parties (TenneT, 2020b). TenneT can place responsibility to recognized Balancing Responsible Parties (BRPs) to ensure the balance of electricity

[2] Elektriciteitswet 1998. https://wetten.overheid.nl/BWBR0009755/2020-02-01
[3] Besluit financieel beheer netbeheerder. https://wetten.overheid.nl/BWBR0024376/2010-09-15
[4] Art. 5, second paragraph of Elektriciteitswet 1998. https://wetten.overheid.nl/BWBR0009755/2020-02-01#Hoofdstuk2

production and demand (TenneT, 2020a). These BRPs inform TenneT (daily) about the planned transactions for the next day and the grid network they will use for transport. The sum of all transactions of each BRP is named as energy program. The DSOs inform TenneT about the actual values of electricity which are consumed and imported per BRP. The difference between the energy program and the actual measured values is the imbalance. Imbalance leads to power shortages and surpluses which must be prevented and which makes balancing therefore necessary (TenneT, 2020a).

DSOs are responsible to carry electricity from the substation to the end-users (customers). As mentioned, they carry low-voltage electricity and operate in regional level. DSOs have to maintain the affordability, security of supply, and safety of the energy grid. In the Dutch energy market, seven parties operate as DSO: Coteq Netbeheer, Enduris, Enexis, Liander, RENDO Netwerken, Stedin and Westland Infra (Energieleveranciers, 2020).

4.1.3 Other market players and customers

Besides grid operators, the Dutch energy market consists of other players such as energy suppliers and energy producers. It is not permitted for a grid operator to act as an energy producer or supplier and vice versa[5]. Energy producers are organizations that generate electricity from power sources. Energy suppliers are responsible for offering energy to the customer and need permission which is regulated by the ACM. For providing this permission, the ACM has set-up requirements, which are based on reliable service, secure supply, supply obligation, and reasonable prices, conditions and customer treatment (ACM, 2020).

Furthermore, there are energy cooperatives that aim to contribute to local energy generation and energy saving. In the view of energy cooperatives, these obtained energy profits create benefits for the community (PBL, 2014). The research of PBL (2014) provided an overview of the activities of energy cooperatives, which mainly consist of operating a help desk for information, campaigning for the purchase of solar panels and the conversation of small scale-energy of private homeowners, and reselling of electricity. Due to such decentralized energy generation, customers can participate in the energy market by generating energy either. However, this could destabilize the grid, which creates issues for the TSO and DSO's (Slootweg, 2010).

The customers can be categorized into different groups in terms of particular consumers, housing corporations, companies and the EV market. The latest is particularly interesting for the aim of this research, which is based on V2G. Paragraph 4.2 scrutinizes the actors and organizational relationships during the operation of EV charging .

4.2 EV charging market

To understand the market for V2G, some additional actors who are involved in the EV charging market need to be addressed. Since these actors also will be involved in V2G services. These actors are the (e-)mobility service provider (MSP), the central hub (CH), charge location owner and charge point operator (CPO). Based on the reports of RVO (2019a) and Klapwijk (2018), the functions of these actors are defined. Some actors are responsible to develop compatible equipment. These actors are the automotive industry (EV OEM) and electric vehicle supply equipment (EVSE) manufacturers, whose functions are defined as well. EV drivers are actors who need to charge their cars and are the consumers for V2G services.

4.2.1 CPO

The CPO is an actor who bears technical and administrative responsibility for managing, maintaining and operating the charging station. The administrative responsibility of the CPO is based on the operation of administrative procedures such as providing access, roaming, and billing to MSP. The technical responsibility is based on technical maintenance, which is often done by the manufacturer.

[5] Elektriciteitswet 1998. https://wetten.overheid.nl/BWBR0009755/2020-02-01#Hoofdstuk3

4.2.2 Charge location owner

The charge location owner is the actor who owns the location and often also the charge points. Depending on the location (private or public), the energy at the charge point is provided by the location owner or by the CPO. Possible charge location owners are the municipality, parking garage owners, a company that has a charging station in its parking lot, or a homeowner.

4.2.3 MSP

When using a public charging station there are various CPOs. To still get one bill at the end of the month, it is required for EV drivers to identify themselves by using a unique id at charging stations. This id is provided by MSP's. MSP is an actor with who the EV driver has a contract. This contract concerns all services which are related to the EV operation. It is typical that the MSP includes some other actors, like an energy supplier or CPO, and has a close relationship with a DSO. A car manufacturer could satisfy such a role as well. The MSP verifies contract IDs from its customers received from the clearinghouse, other MSPs or CPOs.

4.2.4 Central hub

The cooperation of MSPs and CPOs can create many communication channels. To prevent this, a central hub can be used. The operator of the central hub connects different actors to create a digital and cross-border charging network for EVs.

4.2.5 EVSE

EVSE must be compatible to charge EVs by a charge station which features appropriate hardware and software. EVSE manufacturers are the producers of this hard- and software. Although EVs are increasingly penetrating the market, the EV share within the vehicle fleet is still low. Which makes the demand for EVSE low (Ghotge, van Wijk, & Lukszo, 2019). At the moment, there is a lack of commercially compatible V2G EVSE (MacLeod & Cox, 2018).

4.2.6 EV OEM

The state of the market for V2G compatible cars is low either. Currently, the variety of commercially available vehicles for V2G is very restricted and the major EV OEMs do not advertise their timescales to implement V2G (MacLeod & Cox, 2018). There are also warranty issues for EV OEMs regarding V2G operation such as the provision of warranty for the car battery. MacLeod and Cox (2018) provided the current V2G compatible vehicles in Europe: Mitsubishi Outlander PHEV sports utility vehicle, Nissan Leaf BEV passenger car and the Nissan ENV-200 BEV light commercial vehicle. While the Mitsubishi has no warranty, the Nissan cars have partially been provided warranty in the UK.

4.3 V2G market

After the Dutch electricity market and EV market is understood, the V2G market can be made more clear. The V2G market includes more actors and relationships, which makes the V2G market more complex. Additional actors who need to be addressed are an EV aggregator and a V2G service provider.

4.3.1 EV aggregator

EV aggregator can play a key role in V2G services (San Román et al., 2011). An EV aggregator enables the optimization of EV resources, by storing it and thereafter charging or discharging it in certain periods, restricted to driving constraints that are imposed by EV owners. The advantages of an EV aggregator are that it can take responsibility for software functionality, equipment and regulatory interactions as well as take risks for issues that are associated with underperformance (Noori et al., 2016). Aggregators create and capture value by aggregating supply and demand for EV electricity and by intermediating transactions between different consumers of V2G services (Niesten & Alkemade, 2016).

4.3.2 V2G service provider

During traditional EV charging, the charging operation starts when the car is connected to the charge point and ends when the battery is fully charged. With V2G, on the other hand, the V2G service operator knows if there is a power peak by communication channels with the grid. For example, the V2G service operator gets informed when there is a lot of energy generation from wind turbines. By communication with the DSO, it can also be known if there is high demand for power. For instance, the V2G service operator gets informed, when many people start connecting their cars at the same time as they use electricity at home. With these communication flows and additional communication with EV drivers, the V2G service operator can manage the power consumption. This role of a V2G service operator can also be satisfied by a company that already has the role of a CPO and/or MSP (evRoaming4EU, 2020).

4.3.3 V2G operation

The aforementioned actors and relationships co-operate to provide V2G services. A possible way of what actors are involved during V2G operation is represented in Figure 11. Figure 11 shows the actors and relevant relationships (from the perspective of a single charge point), which can differ from just data exchange and communication to really an interrelated collaboration. These relations are the basis of the partnerships that must be made to make the business model work.

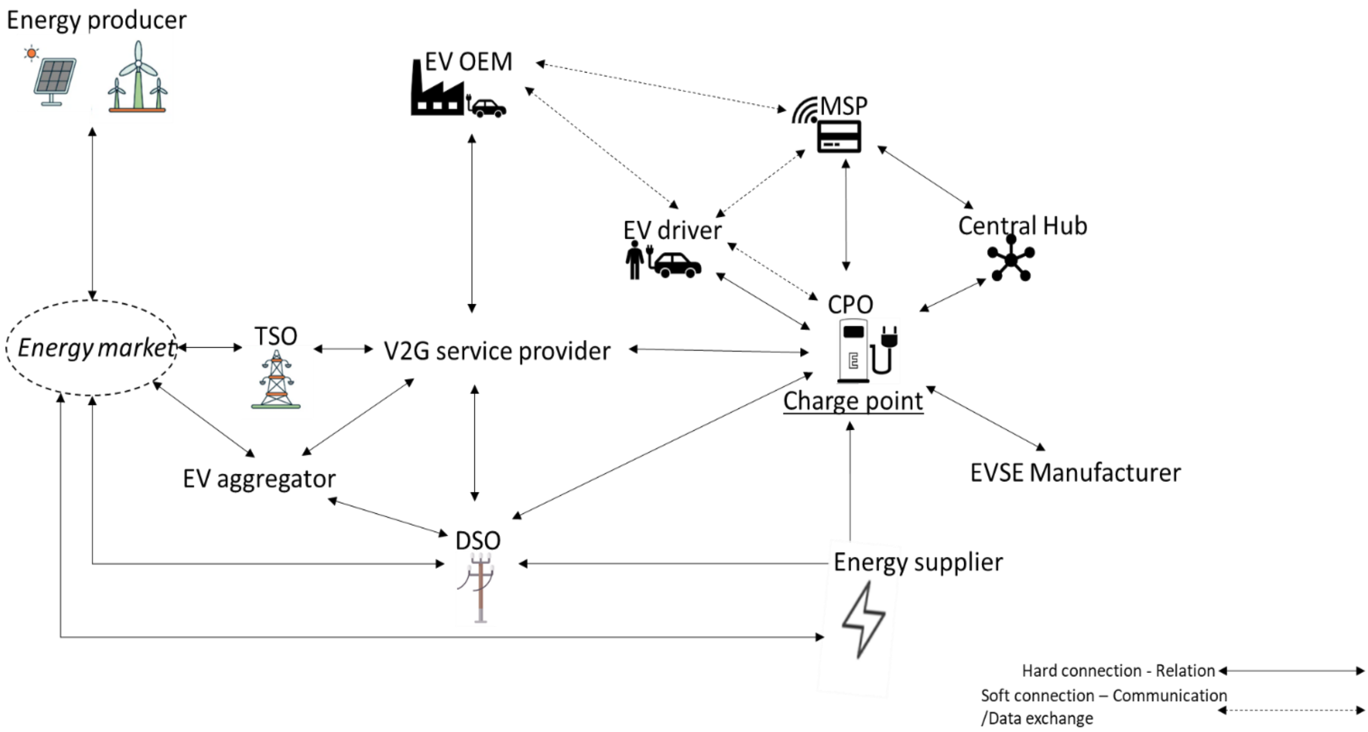

Figure 11: V2G market (adapted from evRoaming4EU (2020))

4.4 Actors for providing V2G services

As appeared from this section, the party who is responsible for providing V2G services is the V2G service provider. So, the V2G service provider is the one who needs to develop a sustainable V2G business model. Based on the literature (Section 3) there is not a determined actor who can fulfil the role as V2G service provider within the Netherlands. From the insights of the actor analysis some possibilities can be determined.

Providing V2G services is associated by participation of different actors such as the TSO, DSO's, and EV drivers. Because of current legislation, it is not expectable that parties from TSO or DSOs can fulfil the role of V2G service provider. Hence, this role must be satisfied by different parties.

Derived from Section 4 some possibilities can be addressed. One possibility is, as provided in Figure 11, the V2G service provider will be a new party. This means that there is an additional party involved and that revenues must be divided among more parties. As mentioned before, another possibility is that the CPO or MSP fulfils this role of the V2G service operator. This means that the current EV market does not directly involve another actor. The third possibility is that the EV aggregator fulfils this role. An EV aggregator emerges as an important actor for V2G services but for now, an aggregator is seen as an intermediate player. As shown in Figure 11, the relationships with which an EV aggregator has to operate associates to the role of V2G service provider either. So, an EV aggregator who fulfils the role as a V2G service provider is also a possibility.

4.5 Institutional barriers

The interrelation of Figure 10 and 11 is mainly the multiple institutional barriers which could hamper the potential of V2G business models. These barriers are above the operational level, which means that they cannot be satisfied by actors who will provide V2G services. These barriers need satisfaction from both the national and international levels. The three actors who are mainly associated with these barriers are the governmental agencies, EU, and EV OEM. The reports of PWC (2017), RVO (2019b) and Ghotge et al. (2019) presented some legislative and institutional bottlenecks. Based on these reports, this paragraph shows the main challenges that are relevant for the Dutch market and need to be satisfied in relatively short term to successfully implement V2G.

4.5.1 Price regulation

As shown in Figure 10, the energy market experiences regulation by governmental agencies. In particular, the regulation of prices creates challenges. In the current institutional environment, the V2G leads to multiple taxes. Every time the car is recharged after discharging, energy tax must be paid on every charged kWh. This may hinder the upscaling of temporary energy storage in EV batteries. Ministry of I&W and ministry of EZK, as well as the ministry of Finance, need to collaborate with grid operators and market players to prevent multiple taxations. Thereby, more dynamic price structuring regarding consumers is required to create capacity management. At the moment, prices are linked to the installed amount of capacity. This creates inflexibility, which is less advantageous for V2G. By applying dynamic price structuring, flexibility can be created. However, there is a barrier due to the ACM regulation of prices and the current electricity act, which means that it is helpful to revise this regulation through a collaboration of ACM and the ministry of EZK.

4.5.2 Lack of incentives for EV drivers

Due to current legislation (netting arrangement) there is a lack of incentives for EV drivers to consume sustainable energy at the right time. EV drivers who have solar panels can store the self-generated electricity virtually to the electricity grid because there is no additional costs associated with it. This means that an EV driver, who have a private charge point, has no incentive to optimize the self-generated electricity such as storing it in his/her EV for later use. Subsequently, the possibilities arise of a supply peak when energy is generated from solar power which is not used immediately and of a demand peak when the electric vehicles is being charged. The netting arrangement will be reviewed in 2023 and the ministry of EZK and Finance must search for opportunities.

4.5.3 Legislation Grid operators

The capacity of the electricity grid and the locations for the generation of sustainable energy do not yet play a role in the installation of public charging infrastructure. There is a need for integrated planning in the field of smart charging which is linked to the generation of sustainable energy and the development of the electricity grid. Therefore, DSOs must play a larger role in the EVSE rollout. However, it is within the current regulation prohibited that DSOs get access to EVSE.

Thereby, there is also no clear incentive for grid operators to use flexible capacity as an alternative to grid reinforcement, even though it may be cheaper in some scenarios. This requires agreements regarding the ways flexibility can be valued and traded on behalf of preventing congestion. Although there has been some guidance given on how grid operators can do this, still research is required in order to establish guidelines.

4.5.4 EU guidelines

Another challenge is that the EU does not have particular directives for V2G. With the new EU directives (EUR, 2019) issues such as the aforementioned multiple taxation in the energy market is forbidden but how this will relate to V2G is not specified. The EU agencies also need to clarify their attitude towards V2G in terms of whether and to what extent they will incentivize V2G. Moreover, guidelines need to be created for the ways EV OEM's can get a warranty for EV batteries.

4.5.5 ICT protocols and safety

Open protocols are important to achieve a user-friendly charging process since it helps EV drivers by getting universal access, roaming, switching of service providers, and getting bills more easily. Although there are many available protocols, the V2G market and even the (conventional) EV market are not yet mature enough to achieve this. Hence, ICT protocols need to be developed that make ICT appropriate for EV drivers to ensure user-friendly operations. Cybersecurity is another important issue that needs research. Currently, charging infrastructure and CPOs are sensitive to be hacked. If such an attack happens, this could have serious consequences such as power outages in large parts of the Netherlands. The ministry of I&W needs to develop agreements about cybersecurity in collaboration with other ministries.

4.6 Role of consumers

Consumers contain the key to the success of any business model. The customer segments define the different types of consumers with common needs and behaviour. A company, in this case the V2G service provider, intends to reach and serve these customer segments. It is important for a V2G service provider to decide which segments to serve and which segments to ignore. Although the role of consumers and associated customer segments seems essential, the business model studies regarding V2G intend to overlook the customer segments (see Section 3). Hence, this paragraph emphasises on the role of consumers for V2G services. Hereby, the role of consumers for conventional EV charging is also addressed.

Before, it is helpful to be aware of the difference between conventional charging and V2G charging in the literature when taking into account the research to the role of consumers. Although both charging methods approach EV drivers as their consumers, there is a difference that must be noticed for determining the market segments. Namely, V2G charging has yet to penetrate the market. Therefore, the customer segments related to conventional EV charging are to a large extent visible in contrast to V2G charging which still needs research. This results in observed data with regards to conventional EV charging, while there is less focus on the role of consumers for V2G.

4.6.1 Customer segments conventional EV charging

Customer segments strongly depend on the focus group of a company. Flath, Gottwalt, and Ilg (2012) distinguished the customers into two general segments. One segment represents a group for regular charging demand such as commuters who charge their EVs after work. Another segment represents a group for short-term charging demand such as drivers who prepare for a spontaneous trip. When taking into account the EV consumer profile, it is possible to divide customers into commercial and private segments as well (Laurischkat, Viertelhausen, & Jandt, 2016). Private EV owners have personal needs such as commuting, taking short trips, or unexpected drives. Commercial owners, on the other hand, own vehicle fleets and often have circular trips (Laurischkat et al., 2016).

Plenter (2017) conducted a market analysis of the customer segments that current companies within the market of EV charging focus on. In summary, four customer segments have been addressed: One segment is a group of individual EV drivers that desires to find charging stations nearly to their home or workplace as well as in unfamiliar areas during a long trip. This group prefers a high availability of free charging stations. A second segment is a group that seeks to commercially own or already own charging infrastructure. Examples of this segment are garage operators, utilities, fleet owners, or any other example who owns charging infrastructure. The private owner of a charge point, who is an individual EV driver, is also a segment. The fourth segment that is addressed consists of a group of privates owners, which want to offer their charge point to other EV drivers during times they do not use it.

Briones et al. (2012) provided an overview of the current EV charging environment that satisfy the demand of five customers segments: Residential charging which refers to the charging location at a person's home or a charging location for primarily overnight parking (1), employer facility charging which refers to charging station at a person's place of employment (2), fleet charging which refers to charging stations at workplaces of fleet owners (3), commercial charging which refers to charging location at commercial places such as theatres, shopping malls or restaurants (4), and fast charging which refers to the principle of performing a similar function as gasoline stations in terms of rapidly charging EVs (5).

4.6.2 Consumer acceptance factors V2G

Whereas the utilization of conventional EV charging could be observed, the acceptability among EV drivers for V2G charging is still under research. Therefore, it is useful to get insights into the consumer acceptance factors in order to understand the customer segments for V2G services. From the perspective of consumers there are multiple factors that could be a facilitator or barrier to using V2G.

One factor is user-inflexibility. During V2G operation, EV drivers agree to have their EVs plugged in for a certain time. EV drivers who become obliged to such an agreement could perceive this as a limitation to their flexibility (Broneske & Wozabal, 2017).

Another factor is the way and amount of compensation. Due to the inflexibility, V2G creates to some extent a cost of discomfort for consumers who therefore expect to be compensated (Kubli, Loock, & Wüstenhagen, 2018). The way and amount of compensation could be in different manners like reduction in energy bills, battery prices, and EV purchase price or like free parking in public places (Niesten & Alkemade, 2016).

Other factors that play a role are reliability in terms of privacy and safe usage (Bailey & Axsen, 2015), battery degradation in terms of reduced battery wear (D. Wang, Coignard, Zeng, Zhang, & Saxena, 2016), and familiarity in terms of experience and awareness (Noel, Zarazua de Rubens, Kester, & Sovacool, 2019).

Range anxiety and minimum range are also factors that play a role in consumer acceptance. When a V2G charge point is operating, it is beneficial to postpone charging or to discharge the EV within high electricity price conditions. This could create situations in which the EV battery is not charged sufficiently, which causes range anxiety (Geske & Schumann, 2018). Hence, it is suggested to provide an EV driver the possibility to specify the timing and duration of his/her next trip as well as to specify a minimum range which an EV must drive (Geske & Schumann, 2018).

The consumer acceptance factors lead to different possibilities of V2G contracts. The aim of such kind of contracts is to satisfy the needs of both the consumers and the V2G service provider itself. Therefore, the consumer acceptance factors must be structured in contract elements for V2G contracts which result in value propositions for V2G. The literature has addressed several contract elements that are relevant for V2G (Meijssen (2019); Kubli et al. (2018); Zonneveld (2019)):

Remuneration is hereby an important element. It refers to any form of compensation to satisfy the EV drivers, who experience to some extent a cost of discomfort because of a V2G agreement;

Plug-in time is an element that refers to the duration that an EV is plugged into the grid and can be utilized by the V2G service provider. This provides predictability to the V2G service provider;

Guaranteed minimum energy or range is the lower bound of the state of charge (SOC). If this lower bound is achieved, it is not allowed to take energy from the EV anymore. In this way, there is space for unexpected trips and range anxiety becomes less problematic;

The number of discharging cycles is an element to provide an EV drive the possibility to limit the number of discharging cycles per day. In this way a unit for battery degradation is considered during V2G services. Although it has not yet been determined that V2G impacts battery degradation (D. Wang et al., 2016), this element has been seen necessary for the decision of EV drivers (Meijssen, 2019);

Contract duration is an element that refers to the length of the agreement between the V2G service provider and the EV driver.

These contract elements have to be used to configure the company's value proposition to the consumers. Khan and Bohnsack (2020) described three possibilities for configuring value propositions, which gives an indication of the ways a value proposition for V2G can be applied:

A possible value proposition is to provide less flexibility and affordability to the customers. In this case, the V2G service provider offers a contract in which the customer signs up for a contract duration (e.g. a monthly plan) in which she/he agrees to provide the battery of her/his EV as storage on a level of minimum range and/or Plug-in time. This could result in a prolonged charging time. In return, the customer receives a fixed monetary payment.

Another possibility is to provide high flexibility and memberships to customers. In such a value proposition, the customer becomes a member and collects credits instead of fixed payments. In this case, each time a customer has been asked for flexibility (e.g. when is how much range required) to which the V2G service provider can utilize the EV as storage. The amount of credits depends on the extent of flexibility. The customers can use these credits to freely charge their EVs or to turn them into air miles.

A third possibility is to provide flexibility including relocation functionality. In such a value proposition, the customers become a member of a community. Besides that customers collect points, they can compare their points with other members and can ask other members to relocate their fully charged EVs from charge places.

The configuration of the value proposition can differ and its mainly associated with the customer segments which the V2G service operator will approach. The research continues by exploring how different value propositions are associated with different customer segments.

4.6.3 Customer segments V2G

Before determining the customer segments for V2G, differences with conventional V2G charging need attention. The customer segments addressed for conventional EV charging basically matters to V2G, except for the customer segment of fast charging. Because this customer segment prefers short plug-in times, while V2G services prefer long plug-in time (Briones et al., 2012). Another difference is that V2G can also attract non EV drivers, which means that non EV drivers can appear as a customer segment as well (de Rubens, 2019).

Moreover, there are individual differences among EV drivers towards the acceptability of V2G. This results in additional segments for V2G services. Khan and Bohnsack (2020) addressed six clusters of customers that differ in characteristics such as income, education, attitude towards innovativeness, and EV drivers' experience. These six clusters can be merged into two customer segments that associate with the value propositions which can be offered. The first customer segment prefers flexibility and membership. The second customer segment focuses on affordability and is satisfied with low flexibility as long as it contributes to lower costs for EV charging. This segment also capture non EV-drivers due to the additional income they can earn.

Based on these findings and the study of Bohnsack, Van den Hoed, and Oude Reimer (2015) three customer segments can be addressed: functional, financial and social. The functional segment considers functional attributes like the ease of use, sufficient range, comfortability and flexibility as important attributes during V2G services. These attributes increase the willingness to adopt V2G technology and are therefore important to determine the value proposition of it. The financial segment emphasises on financial attributes such as high remuneration and low cost. The social segment considers social attributes like environmental contribution, image and trend as important.

4.7 Key findings actors environment

This actor analysis helped to find actors who are important for a sustainable V2G business model. This importance could be because of the institutional relationships as shown in Figure 10 or because of potential partnerships with a V2G service provider as shown in Figure 11. These actors were further used for contacting experts. The actors that appeared to be important were CPOs, MSPs, DSOs, TSO, BRPs, governmental agencies, energy suppliers, EVSE suppliers, EV OEMs, aggregators, EV drivers and municipalities. Thereby, which actors should satisfy the role of V2G service provider could not be determined yet.

Furthermore, the actor analysis showed insights about the business environment in which there are institutional and also standardization issues which could create barriers for sustainable V2G business models.

The ways that consumers (EV-drivers) play a role in a V2G business model is determined, for which three segmentations could be made: financial segment which gives more importance to financial incentives, social segment which gives more importance to incentives like contributing to a sustainable world, and functional segment which gives more importance to having flexibility in the choices whether and how to use its EV for V2G.

These issues have been used to enrich the theoretical V2G framework in the interview-questions for the expert-interviews. How this section contributed to the interview-questions has been addressed in appendix C.

5. Case studies

Section 5 aimed to gather insight from current V2G business model by conducting a case study. The cases were selected from pilot projects in the Netherlands (see appendix A). Companies who participated in such pilot projects were contacted. This case study provided the opportunity to gather insights from real experiences. It helped to gather insights of the current V2G business environment, which appeared to be important from Section 3. Insights from different cases were used to learn lessons and to determine key issues for V2G business models, which are helpful to being understood while developing sustainable V2G business models. This all helped to enrich the questions for the expert-interviews as well.

5.1 Case: MijnDomein Energy

MijnDomein Energy is an organization that focuses on various aspects of the energy market including the supply of energy and EV charging equipment (EVSE). Since about 1,5 years ago they are working on V2G technologies in which they are responsible for providing V2G EVSE. MijnDomein explores ways to penetrate the energy market with V2G technologies by participating in pilot projects. In this report, the business model of MijnDomein is investigated with the support of a personal communication with a respondent from MijnDomein. Although a business model is not yet determined because the market develops continuously, meaningful insights were gathered. This paragraph describes the main findings from the interview with a respondent from MijnDomein including some additional information from the webpage of DeeldeZon (2020).

5.1.1 Pilot projects

There are two types of V2G projects in which MijnDomein is participating. The first project is the DeeldeZon project. The realization of the DeeldeZon project is granted by Interreg Flanders-Netherlands. In this project shared EVs are charged with the energy of solar roofs via V2G chargers, which means that the energy in the EVs can also be discharged to satisfy the high demand for electricity. The second project which is expected to be implemented can be called a Vehicle-to-Building implication. In this project, MijnDomein will install V2G chargers, which have a V2G connection with the office of MijnDomein.

5.1.2 Partner- and relationships

To successfully operate in the market, working together with different parties is necessary. Besides MijnDomein Energie, there are 6 other Flemish and Dutch consortium partners that work on the DeeldeZon project: Zonnova, Buurauto, Zuidtrant, i.LECO, Pajopower, and Over Morgen. These partners have responsibilities such as project management, sharing knowledge, solar power generation, communication, and arrange shared EVs. In the second project, there are no additional parties involved since MijnDomein will be the supplier of the V2G EVSE and use its own office.

Moreover, MijnDomein has a close connection with TSOs and DSOs. In order to operate in the primary and secondary market and to balance the grid, MijnDomein has contact with the Dutch TSO TenneT. This partnership is necessary in order to prevent that rules or regulations, which can make the use of V2G in the market difficult, enter surreptitiously. Within the DeeldeZon project, MijnDomein has also contact with Enexis which is a DSO. MijnDomein has also a collaboration with another DSO (Stedin) regarding congestion management in Rotterdam. Within this collaboration, the aim is to use EVs to reduce local congestion. However, in this project, a business model is too uncertain because the revenue structure is still unclear.

Furthermore, there is a collaboration with Fluctis and Last mile solutions that take the responsibility as CPO and MSP. As far as the role of the aggregator is concerned, it is still in an experimental phase and there is no permanent party that fulfils this role. Fluctis and Last mile solutions are responsible for arranging this.

5.1.3 Customers

For now, the projects are on small scale and there is no high demand for V2G services that is mainly related to the netting arrangement. During the DeeldeZon project, the municipalities mostly act as the customers. In the second project, MijnDomein will use its own office. This means that MijnDomein will be the customer of its V2G services.

5.1.4 Value Proposition

The DeeldeZon project consists of a network with 80 sunroofs, and 150 shared EVs, and 80 V2G EVSE. The shared EVs store the energy generated using V2G chargers in a sustainable and flexible way and return it when the demand for electricity is high. The second project aims to install 10 V2G EVSE at the office of MijnDomein. The electricity generated from the solar roofs of MijnDomein's office will be used to store energy to the EVs and use this energy when needed for its office. The EVs that are used during both projects are the Nissan Leafs.

5.1.5 Cost Structure and Revenue Streams

The revenue streams in the DeeldeZon project are mostly based on peak shaving. Due to the cost of V2G charging equipment, it is in the current conditions not expectable to be economically feasible. The current costs for a single V2G EVSE are between the 5.000-7.000 euros while installing a single conventional EVSE is approximately 2.000 euros. This makes the V2G charge point an expensive investment and for now too costly.

The second project aims to install 10 Vehicle-to-Grid charging equipment, which means a respectable investment when considering the costs of 5.000-7.000 euros for single V2G EVSE. The expected revenue streams in is partially through peak shaving and mainly by reducing the imbalance in the grid. The aim is to deal with EPEX and gather some revenue. However, these revenue streams can only capture a low proportion of the costs that are made. Without grants, it is therefore not possible to develop a profitable business model in certain project conditions. Hence, the aim of the business model is not economical. The business model of MijnDomein aims to understand the V2G technology in practice and to find an appropriate position to take for V2G services. There is an exploration to see what the benefits are for the regional and national grid and what the associating compensations are.

In the future, the aim is to participate in the primary- and secondary reserve market. TenneT is also starting to launch a platform for blockchain Equigy. This allows individuals to earn money from the power of their solar panels that they store in a battery or EV. MijnDomein plans to make use of this in order to earn more from V2G.

5.1.6 Barriers

A barrier, which is experienced during the projects, is that the Nissan Leaf is the only V2G compatible car that contains warranty. This create issues with the large-scale use of V2G. Nissan also requires having a certificate for V2G EVSE in order to provide warranty for their cars. So, the V2G EVSE must be approved by Nissan leaf which creates additional effort. Thereby, the costs to apply for V2G EVSE is too costly at the moment. Consequently, it can be noticed that the use of V2G EVSE experiences barriers which need to be overcome.

There are also still uncertainties that need to be figured out. Now it must be determined which specifications for V2G EVSE is necessary and which market can be participated in with this technology. What requirements the market puts on the product and whether it becomes expensive to enter the market must be explored as well. In the future, it is needed to combine certain markets such as the primary- and secondary reserve market, congestion management, and peak shaving to make V2G profitable. However, during current projects, it is more useful to focus on one type of market to understand how the market and V2G work at this moment. So, gathering more understanding in how the V2G could be used in the energy market is still required. The netting arrangement creates barriers too. If the netting arrangement expires in the future, V2G can help prevent imbalances but for now this arrangement does not incentivize the use of V2G.

5.2 Case: Jedlix

Jedlix is a software company that produces software to optimize EV charging and make it cheaper, smarter, and more sustainable. They operate as an aggregator to provide smart charging services from which V2G is a variant of. Therefore, Jedlix could be a key player in the operation of V2G and they are currently experimenting in V2G pilot projects. This case study focuses on the insights from Jedlix regarding V2G business models. The information is gathered from a personal communication with a respondent from Jedlix.

5.2.1 Pilot Project

Jedlix participates within the smart solar charging project. Smart Solar Charging is a project that uses V2G technology in the district of Utrecht. The project combines the production of renewable energy with V2G-charging points and shared EVs. Another characteristic of this project is the use of an AC system for V2G services. There are no compatible cars yet on the market for such AC systems. Therefore, the project uses prototype cars that are manufactured by Renault.

In the project, Jedlix operates as an aggregator. The business model of Jedlix will not differ when they participate in V2G. The primary function of Jedlix during smart charging is to carry the activity of EV charging to a logical moment which reduces peak loads on the grid. However, Jedlix does not discharge the EVs because there are not many cars that are compatible, and for the ones which are compatible it is for now too expensive. The use of V2G adds value due to more flexibility that it will offer. Within the smart solar charging project, this can be tested but the smart solar charging project mainly focuses on the protocols and not really on establishing a business model. Nevertheless, meaningful insights are gathered.

5.2.2 Partner- and relationship

Within the smart solar charging projects, there are a lot of parties involved. An interesting party to mention is We Drive Solar that functions as a mobility operator and arrange the shared EVs (SmartSolarCharging, 2020). Therefore, they arrange customers who make use of these EVs and V2G technology.

For Jedlix, there are primarily two groups of parties with whom the collaboration is central during the operation of V2G as well as regular smart charging. One group consists of parties from the energy supply chain such as utilities and balancing responsible parties which focuses on balancing activities. The second group consists of EV manufacturers (EV OEM) or charge point operators (CPOs) with whom collaboration is necessary to optimize the EV charging for as many EVs as possible. Furthermore, Jedlix needs contact with the TSO and DSOs to offer V2G services and gather value of it.

For V2G services, it is a challenge to determine who will be the V2G service provider. In the current situation, many energy suppliers act also as CPOs. Some car manufacturers are also starting to act as CPOs. Within the smart solar charging project, both of these parties act as a V2G service provider and Jedlix acts as an enabler. Jedlix intends to enable both parties in order to deliver V2G services and create benefits.

5.2.3 Customers

As mentioned before, Jedlix is not concerned about arranging and dealing with customers within the Smart Solar Charging project. However, there is within the project five linked pilot areas that approach different customer segments: A residential area with limited parking and various types of housing (1), an area combining a school complex with a Park & Ride (2), an area combining business, housing and education (3), an area characterized with high density and a mix of passer-by, recreation, living and working (4), and a mixed area that contains an important public transit hub (5) (SmartSolarCharging, 2020).

As regards to Jedlix, the customer segment that they are primarily dealing with are EV drivers who own private charge points. The reason for dealing with this customer segment is because they are in majority at the moment. However, it is expected that there also will be opportunities to deal with users of shared EVs and fleet owners in the near future.

5.2.4 Value proposition

The service that Jedlix offers to its customers is to control the charging operation via connected EVs or charge points based on a schedule devised by their algorithms. Thereafter the coordination is made with the EV drivers which is realized through the use of an application or white label variant of the application. In this way, flexibility is created to energy parties like TSO (TenneT) or energy suppliers in a cost-effective and environmentally friendly way. In return, Jedlix gathers revenues and shares this also with the EV drivers. So, the EV drivers get rewarded for providing flexibility with their cars.

5.2.5 Cost structure and revenue streams

V2G offers the opportunity to gather revenue by providing balancing services to TenneT, participating in day-ahead or intraday market via EPEX, and offering flexibility to support DSOs with congestion management. However, regarding congestion management, there is no market from which revenue can be obtained at this moment. Revenues can also be gathered via other cases such as self-consumption. Furthermore, V2G provides the opportunity to do more with peak shaving than regular smart charging.

Although these revenue streams are all possible, the definitive added value is difficult to predict due to the difficulty of predicting the value for the flexibility of EVs. Namely, predicting flexibility depends on parameters such as the limits to discharge EVs, the extent of acceptability of EV drivers to discharge their EVs, or the number of EVs are in driving conditions. In the case of shared EVs this is even more difficult because it is not a regular way of driving like an individual car. These issues make it difficult to determine the definitive revenues in practice, in particular for congestion management. With offering services to TenneT and the energy market, it is possible to gather a revenue of 300 euros per year for one EV if it is not driven too often.

Consequently, the question arises regarding ways to share these revenue streams. A possible case to consider is a case of an individual EV driver, who has leased or purchased an EV and use a private charge point. The revenues gathered must be shared among the V2G service provider, EV driver, and possibly a utility which provides access to the energy market. As mentioned before, with regards to the V2G service provider, it is also the challenge to determine which party will fulfil this role. Thereby, the issue of sharing revenues becomes more complex when taking into account a public charge point or shared EVs like in the Smart Solar Charging project.

Regarding the cost structure, it is expectable that there should be costs for the charging infrastructure. With AC charging, as applied in the Smart Charging Project, this cost may be less but then costs have to be made to the car. With DC charging the costs for charging infrastructure rise with a few thousand euros.

The degradation of batteries must be considered too. Although it is expected that costs for battery degradation can be limited within the right boundaries, there could still be a possibility for additional costs. The battery degradation costs can be considered through the residual value of the car. However, these costs can be under the responsibility of the owner of the EV, car manufacturer, or leasing company. Who will bear the costs is therefore difficult to determine. A certain warranty must be given to the car. An option could be that a car manufacturer creates and imposes a whole package in which they also do the service for the battery. Nevertheless, this could create issues because the customer become enforced to do the service with the car manufacturer. If a working owner leases a car and every car manufacturer imposes to do the service with them, it can be difficult to manage a fleet.

All in all, it is clear that determining the costs and revenues is difficult. It is also an issue to determine how to share these revenues and costs among the involved parties. Consequently, it’s questionable whether profit remains for a V2G service operator.

5.2.6 Barriers and opportunities

The realization of V2G in practice experiences some barriers that need to be satisfied. One barrier is that the values which can be obtained from discharging the batteries are not so obvious. Concerning this, the way to share these values among involved parties is challenging too. As addressed before, several value pools could create revenue streams and it is also possible to combine these revenues. However, which parties are needed in practice to enable these revenue streams and whether revenue remains is questionable since each party which participates also wants to have a share in it.

Another barrier is that the process of making V2G compatible including all the required protocols could slow down the realization of V2G. The perspective of car manufacturers could also be a barrier. While the one perspective believes that the EVs must be capable to discharge with alternating current (AC), the other perspective believes that an off-board charger should convert it to AC to make it less complicated for the EV.

To create opportunities for V2G, the organization between the involved parties must be better aligned. Furthermore, combining cases in terms of V2G applications like vehicle-to-home, vehicle-to-office, etc. as well as discovering niche applications such as vehicle-to-appliance can seriously affect the success of V2G. The increase in the number of EVs is a serious opportunity either. There is also an opportunity regarding battery degradation which is in the literature seen as an important barrier for V2G. Whereas the assumption is made that V2G deteriorates the battery, there is an opportunity to disprove this if V2G (dis)charges within the correct bandwidths. Lastly, tax incentives offer an opportunity to encourage EV drivers for using V2G.

5.3 Case: SBPF

Stichting Beheer Publieke faciliteiten (SBPF) is a foundation that has been established to support municipalities with issues related to the balancing of supply and demand of energy that is offered to third parties in the public space. From the event industry, there came the idea of whether the power within vehicles could be used as power sources. From this, the V2X technology came forward and SBPF participated in a V2X project focusing on events and festivals. By personal communication with an respondent from SBPF and additional information from the webpage of AirQon (2020), meaningful insights are gathered.

5.3.1 Pilot Project

SBPF has participated in the AirQon project. It is a European project in which a subsidy of approximately 3 million euros has been granted and in which SBPF will have to determine a business case somewhere in the middle of next year. This means that there is not a business model yet.
AirQon is a promising sustainable project initiated by the Municipality of Breda. This project aims to replace the supply of electricity at events from diesel generators to EVs, which are preferably from visitors. A characteristic of the AirQon project is that it operates off-the-grid, which means that V2X technology is used without a connection to the electricity grid.

Currently, there has been already about 40 pilots realized in cases for basically everything up to 5000 watts such as empowering a sound system, cooling system, electric barbecue, or a finish line arch during a running competition. Although the AirQon project is in its last stage, there are now no festivals or events because of the corona crisis. That is why the project is now more focusing on the construction sector. However, some events are slowly coming up which means that the pilots will be done at festivals or events again.

5.3.2 Partnerships and customers

There are in total 10 partnerships varying from event companies, shared EV providers, and car dealers. SBPF is mainly involved in the technical side. At the moment, SBPF focuses on fleet owners and leasing companies as consumers because the number of particular EV owners is significantly low. It is usually that the demand for using such a V2X application arises from events. Thereafter, SBPF talks with the associating event company and arrange the services to offer V2X opportunities.

5.3.3 Value proposition

SBPF offers the technical services that are required by enabling the use of a V2G charge point. The V2G charge point is placed separately at each event which means it is placed each time at a different location. So, the V2G charge point is mobile in which the installation of such a charge point takes not much time.

SBPF completely arranges the consumers who use these charge points either. This is because there are no certified devices that could deliver vehicle-to-off-grid services. To use a V2G charging point to deliver such off-grid services, this responsibility is taken by SBPF. However, the intention is that the step of arranging consumers will be taken by event holders themselves in the future.

5.3.4 Cost- and revenue structure

The V2G chargers themselves create high costs because they are at the moment very expensive. A single certified V2G charger costs approximately 7,000/8,000. However, it is expected that in a few years these costs will decrease to an amount of approximately 3,000 euros. Then it becomes more interesting.

SBPF supplies events with electricity in places where there is no power. This means that SBPF takes the position of a generator. Normally, there is a generator fueled by diesel that an event company rents, which costs money. With a V2G charge point and EVs, SBPF ensures that events obtain cleaner energy supply at the same price or maybe for cheaper. So, the revenue stream is that cars are used as moving batteries to supply electricity to events instead of using generators, which is quicker and easier to transport.

5.3.5 Barriers and opportunities

The main barrier that it is experienced is the low number of commercially available cars that support V2G. For instance, in a city like Breda, it is already difficult to find just ten V2G applicable EV owners who would participate.

Furthermore, at the start of the project the equipment to discharge the EVs was not available in The Netherlands. This was contradicting the expectations because when SBPF started two years ago there were already big advertisements going on for V2G. However, there were no V2G capable chargers for sale in the Netherlands. SBPF had to wait over a year for their first charger and in the meantime, they used equipment that was purchased from China. Recently, the hardware is also available in the Netherlands and the experience shows that V2G chargers are working well. However, as mentioned before, they are still very expensive which makes the development of a profitable business model difficult.

On the other hand, some opportunities could encourage the potential of V2G. A promising lesson learned from the project is that people find the idea of V2X very interesting. Through the project, it is noticed that people are starting to consider that a car is much more than something that you use for driving. Their urge for independence from an energy supplier is also very great. It is expected that the society would like the idea to store the energy of their solar panels in their cars and then use it by themselves. V2G is a technology in which the social acceptance is crucial, such support which is experienced in the project encourages the potential of V2G. An additional opportunity for SBPF is that getting a profitable business model for the application of Vehicle-to-Event is much easier. Whereas for homes the value of a kWh is 20 Eurocents, for events the value of a kWh is €1,50. So, the energy in EVs is in the case of events more valuable.

5.4 Key findings case studies

The case studies showed insights about current V2G business models, including insights from the V2G business environment and V2G business model components.

At this moment, it can be noticed that business models around V2G are not determined yet. Companies are still in the research phase and the aim is mainly about understanding the technology and its impact. The role of the V2G service provider is neither determined, which also appeared from Section 4. Thereby, the pilot projects commonly use shared vehicles in their pilots. This is an interesting combination that is addressed in more detail in Section 6.

The SBPF case also showed that the bi-directionality of V2G could be used beyond its original intention. Whereas V2G is a technology that is triggered by supporting the energy grid, the SBPF case showed that a bi-directional charger could be used for cases as vehicle-to-off-grid.

The Jedlix case showed the issue of whether to use AC- or DC-charging. While AC-charging believes that the EVs must be capable of discharging with alternating current (AC), DC-charging believes that an off-board charger should convert it to AC to make it less complicated for the EV.

Thereby, it appeared that technical barriers in terms of V2G infrastructure costs and availability could still be problematic. Institutional barriers in terms of legislation were addressed as well. Standardization issues in terms of unready protocols have also been experienced in these pilot projects. Furthermore, from the case studies, it appeared that it is not clear whether revenue can be gathered by supporting DSOs with congestion management.

These issues have been used to enrich the interview-questions for the expert-interviews. How this section contributed to the interview-questions has been addressed in Appendix C.

6. Technological developments

As appeared from the previous sections, the business environment of V2G is an important aspect (as appeared from Section 3), and experience barriers and opportunities (as appeared from Section 4 and 5). Whereas Section 4 provided the actors environment and institutional barriers and Section 5 provided the current cases with V2G business models, this section gives attention to the technological developments. V2G is a technology that has potential but if the market and technological developments are not to the advantage of V2G, the potential of it could disappear. Hence, awareness to these developments and their effects need attention. The future trends that are addressed from the literature and could affect the V2G technology is distinguished into two type of developments.

First, the trends in EV types need attention. As mentioned in Section 3, an EV mainly can be classified in three types which can be a hybrid-electric vehicle (HEV), fuel cell electric vehicle (FCEV), and battery electric vehicle (BEV). However, how these three type of EVs compare towards V2G and which will get a rise in the penetration is not addressed. This is important to consider since each type contains some different characteristics that can differently impact V2G.

Then, there are other technologies that could affect the potential of V2G-technology. This is because V2G is a subject to smart mobility, which embraces other technological developments as wireless charging, autonomous vehicles, and shared vehicles too. All of these technologies go parallel with the electrification of the vehicle fleet. This make these technologies someway interrelated towards each other. Hence, this section explored the developments of these technologies and their impacts on V2G.

6.1 Electric vehicle types

The three type of EVs referred as HEV, FCEV, and BEV can further be classified since HEV can be distinguished in pure HEVs and plug-in hybrid electric vehicles (PHEVs). However, only the BEV, PHEV, and FCEV make use of energy sources that can be used for V2G (C. Liu, Chau, Wu, & Gao, 2013). This means that these three type of vehicles can be used for V2G, while HEV cannot because a HEV cannot directly be plugged to the energy grid to extract electricity from (C. Liu et al., 2013).

The BEV, PHEV, and FCEV have each difference characteristic that may play a role in the potential of V2G (Chan, 2007). BEVs are known as EVs in which the drive train is only powered by batteries. This makes the range directly dependent on the battery capacity. PHEVs use both the internal combustion engines (ICE) as well as electric power trains like HEVs. However, PHEVs differ themselves from HEVs by using electric propulsion as their primary driving force which means that they need bigger battery capacities. FCEVs contain fuel cells which convert hydrogen to electricity by using chemical reactions. The generated electricity moves to an electric motor and the excess energy gets stored in batteries or other storage systems.

Whereas PHEVs use the ICEs to extend their range and therefore have a longer range than BEVs, the capacity of energy storage is much lower when compared to the BEVs (Un-Noor, Padmanaban, Mihet-Popa, Mollah, & Hossain, 2017). Due to the higher ranges, PHEVs can reduce the range anxiety which does matter for potential V2G users (Paragraph, 4.6.2). However, less storage capacity of these vehicles makes it less useful for V2G. This should mean that related to V2G the number of PHEV type cars this must be much higher than if it was the case with BEV type cars.

According to the study of Thomas (2009) the advantages of FCEVs over BEVs are that they weigh less, not take much space, have longer ranges, and take less time to refuel. On the other hand, for BEVs the fuel costs are lower per kilometre and the access to fuelling capability is greater. Consequently, it is expected that the system costs for BEVs are lower in short transport distances than FCEVs but in long transport distances FCEVs are expected to be less costly (Sundén, 2019). In overall, the literature shows that positive value can be gathered with V2G while using FCEVs (Robledo, Poorte, Mathijssen, van der Veen, & van Wijk, 2019), BEVs (Tarroja et al., 2016), or PHEVs Rotering and Ilic (2010
). Hence, the development of these EV types and the Dutch mobility behaviour towards it need attention. For instance, Pollet, Staffell, and Shang (2012) addressed that for FCEVs the expected fast progress is

less likely because some OEMs redeployed their focus from fuel cells to battery technology. Thereby, according to some OEMs the technology investment in the supply chain of fuel is declining (Pollet et al., 2012). Moreover, the number of commercially available FCEVs models is low and its only expected for the year 2030 that there will be a respectable amount of FCEVs on the road (Sundén, 2019).

Based on the numbers of (RVO, 2020a), there is an increasing trend in the penetration of EVs (Table 2). Particularly, the penetration of BEV gets a lot of interest and the attention towards FCEV is pretty low at this moment. Although the registration of FCEVs is low, there is an increasing trend in the penetration rates which means that the potential of FCEV exists. The same counts for the hydrogen fuelling stations from which there is now a low number of but is expected to increase. Currently, there are 5 operating stations and there are 17 in realisation phase (H2Platform, 2020). The number of PHEVs, on the other hand, is relatively high but there is no increasing trend visible (Table 2).

Overall, from these findings it is assumable that FCEVs are for now not compatible for V2G but in the long-term it could have benefits due to its increasing number and ability to reduce range anxiety. At the moment, V2G has market for BEV and PHEV. However, if this penetration pattern remains, it is expectable that the BEVs will be the mainstream market for V2G in the near future.

Table 2: new registration passenger cars (RVO, 2020)

Registration period	**2016**	**2017**	**2018**	**2019**
Total registrations	384.320 (100%)	417.849 (100%)	450.097 (100%)	452.875 (100%)
Of which EV registrations	22.680 (6,7%)	9.194 (2,2%)	27.983 (6,5%)	67.318 (14,9%)
- Of which FCEV	7 (0,0%)	5 (0,0%)	13 (0,0%)	156 (0,1%)
- Of which BEV	4.054 (1,1%)	9.194 (1,9%)	24.434 (5,4%)	62.004 (13,7%)
- Of which PHEV	18.619 (4,8%)	1.130 (0,3%)	3.536 (0,8%)	5.518 (1,1%)

6.2 Other technologies

According to N. V. Jayadharashini (2019) the mobility sector experiences trends that impacts the mobility of the future. One trend is the electrification of the vehicle fleet. This is naturally in the advantage of V2G since the main reason behind V2G is the increasing trend of V2G and their impact on the energy grid. Another trends that were mentioned are the rise of shared mobility and autonomous vehicles. These concepts are in development in parallel to V2G but what the effects could be are unrevealed. Another concept which is in development is wireless charging. In the literature review (Paragraph 3.2) was showed that this technology in combination with V2G is already under research. Therefore, the effect of these technological developments need attention. Taiebat and Xu (2019) mentioned also the importance of the synergy between these technologies of V2G, automation, shared vehicles, and wireless charging.

6.2.1 Shared Autonomous vehicles

Shared vehicles could be considered as a flexible option for mobility by offering the use of a private car without obliging the requirements needed for a private vehicle ownership (Krueger, Rashidi, & Rose, 2016). With shared vehicles multi-model travel behavior could be facilitated and in the long term private vehicle ownership could be reduced (Krueger et al., 2016). In the literature shared vehicles and autonomous vehicles (AVs) are often integrated (Krueger et al., 2016). According to SAE there are six autonomy levels (0-5) in which level 0 is no automation and level 5 is full automation. From level 3 on a vehicle can be considered autonomous because then it can take over driving functions (SAE, 2016). AVs have broad societal effect such as power consumption, road safety, and air pollution (Gatzert & Osterrieder, 2020). Shared AVs could also ease congestion and reduce parking needs (Gatzert & Osterrieder, 2020). This could contradict to the need for V2G to have more EVs that are parked and are able to be used. However, the feasibility of fully AVs in the Netherlands seems in the short not much possible. Commercially available AVs are expected to be in the Dutch market between a time period of 2025 and 2045 and the penetration rates are expected to vary between 7% and 61% in 2050 (Milakis, Snelder, van Arem, van Wee, & de Almeida Correia, 2017). For conditionally AVs these time frames could be shorter (Milakis et al., 2017).

6.2.2 Wireless charging

Wireless charging of EV is one of the emerging transportation technologies in which the battery of EVs are charged via technology that enables wireless power transfer. Jang (2018) provided a possible classification of wireless charging; the first type is stationary in which the EV is not operational and parked at a parking place, the second type is quasi-dynamic in which the EV is operational at a low speed during the charging session, and the third type is dynamic in which the EV is in full motion during the charging session. Whereas the stationary type could be applied for V2G, the other two type are not because it is in the benefit of V2G that EVs are parked for a long period. With the other two types the cars will not be parked, which means that the application for V2G will get more difficult.

6.2.3 Integration of technologies

The study of Taiebat and Xu (2019) showed that there are recently not many studies that focus on synergetic impacts of emerging technologies. This means that there is no much insight what the results are of integrating these studies.

Iacobucci, McLellan, and Tezuka (2018) researched the effects of shared AVs with also integrating V2G technology in Tokyo. Results showed that 7 out 10 private cars can be replaced and by car scheduling algorithms the cost for transport can be reduced. Thanks to V2G the cost savings could rise up to 40%. As Iacobucci, McLellan, and Tezuka (2019) described, the case of shared AVs is fundamentally different then private vehicles due to different dynamics. Private vehicles are likely to be connected during the night and disconnected during the day. Shared EVs, on the other hand, can be connected at any time if they are not transporting passengers. Moreover, the connection of shared EVs can be controlled and planned. Constraints from individual vehicle charging does not matter either because passengers can take another vehicle on their return trip. Charge scheduling for shared EVs adds also the complexity of the trade-off between wait times minimization and charging cost minimization, in particular in the case of highly variable electricity price (Iacobucci et al., 2018).

Regarding the use of wireless charging for V2G technology there is also potential ((Ahmad et al., 2017); (Madawala & Thrimawithana, 2011); (Tachikawa et al., 2018)). However, as far as researched, about whether this technology will influence the potential of a V2G business model is not much known.

6.3 Key findings analysis of technological developments

There are two ways the technological developments could influence a V2G business model. One way is the development of electric vehicle types. Although the potential of BEVs seems the highest because of the increasing trend in numbers and battery capacity, the FCEV and PHEV still have benefits like the reduction of range anxiety.

The second way is the development of other technologies that could influence a V2G business model. The emerging technologies which associate with V2G are shared vehicles, autonomous vehicles, and wireless charging. Although these technologies are under research, studies have no much attention to the integration of these technologies with V2G.

This creates still question in how these technological developments will influence the potential of sustainable V2G business models in the Netherlands. These issues have been used to enrich the interview-questions for the expert-interviews. How this section contributed to the interview-questions has been addressed in appendix C.

7. Results

Appendix C shows how each of the previous sections has contributed to the interview questions. These questions were used during the expert interviews. This section provides the results of these interviews. The results are analysed in three themes: the business model, the sustainability, and the business environment where the V2G business model will operate in. Each theme contains associating categories and key components within each category. Thereafter, a synthesis has been made of these components, categories, and themes. This resulted into a design of a sustainable V2G business model containing the key components.

7.1 Code saturation

In total eleven expert interviews has been conducted. Appendix B shows the expert codes and their relation and expertise regarding V2G. Six of the eleven experts had a quite positive attitude towards the feasibility V2G, E.AC was quite skeptical, and the other experts had no recognizable attitude. The first iteration showed that the first six interviews identified the biggest part of the codes (Figure 12). In the first iteration 281 codes were identified.

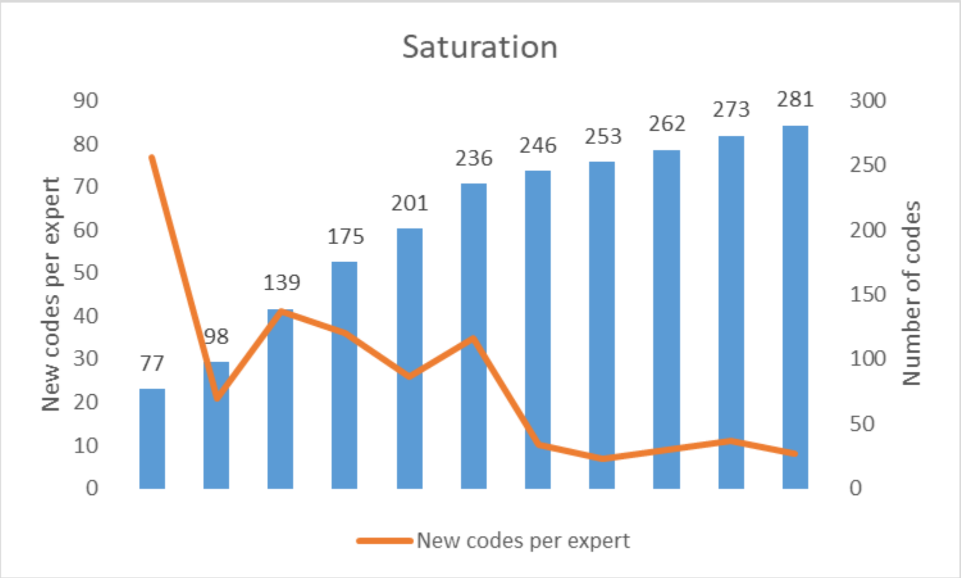

Figure 12: Code saturation

In the second iteration codes were merged because the content was the same or an overarching code could be applied. The second iteration resulted in 229 unique codes. Thereafter these codes has been categorized within the themes of business model, sustainability, or business environment.

7.2 Business model

The theme of business model has been analysed by using the nine building blocks of the business model canvas: customer segment, value proposition, channel, customer relationships, revenue stream, key resources, key activities, key partnerships, and cost structure.

7.2.1 Customer segments

Within the actor-analysis (Section 4), an introduction was given on how customer segments are relevant for V2G. This was mainly based on the role of consumers. Although the term consumer was used to address the EV drivers who make use of V2G, the experts used the term end-user. From the insights of experts, the end-user does not particularly have to refer to the customers from whom revenue will be gathered. For instance, for public V2G charging, the end-user will not pay for the services. However, to deliver V2G services, these end-users need to be convinced. Therefore, the customer segment is distinguished into the macro- and micro level. The macro-level covers the different customers to whom the service is offered and from whom revenue can be gathered. The micro-level covers the different characteristics of end-users who have to be reached and convinced to participate in V2G services.

Table 3: overview codes customer segments

Codes for customer segments	**E.ES**	**E.EC1**	**E.AC**	**E.KI**	**E.U**	**E.EC2**	**E.BRP**	**E.EC3**	**E.GA**	**E.DSO**	**E.M**	**Total**
Macro-level												
Distribution system operator (DSO)			**X**			**X**				**X**		**3**
Homeowners			**X**		**X**			**X**			**X**	**4**
Transmission system operator (TSO)			**X**			**X**				**X**		**3**
Energy traders			**X**							**X**		
Building/Office building owner		**X**	**X**		**X**	**X**			**X**		**X**	**6**
Micro-level												
Financial segment: end-users need financial incentives	**X**	**X**		**X**		**X**		**X**	**X**	**X**	**X**	**8**
Financial segment: sustainable benefit besides financial incentives is always fine								**X**				**1**
Financial segment reflects other segments							**X**					**1**
Social segment: end-users are willing to contribute to sustainability			**X**	**X**		**X**		**X**	**X**		**X**	**6**
Social segment: are also helped with financial compensation					**X**							**1**
Capture early adopters				**X**		**X**			**X**		**X**	**4**
Socio-economic mobility characteristics of end-users					**X**					**X**		**2**
The segmentation of lease and private EV drivers		**X**								**X**		**2**
Fleet-owners	**X**			**X**			**X**	**X**		**X**		**5**
Private EV owners				**X**					**X**			**2**

The macro-level consists of five main streams groups to whom the V2G service can be offered and from whom revenue can be gathered:

- Three experts mentioned the possibility to gather revenue from DSOs. DSOs have to deal with local congestion. By applying V2G this local congestion can be managed better. E.DSO described this as follow:

[E.DSO] ‘’ We have to deal with congestion on the grid, there is simply not enough capacity to supply all the power in a certain district. Cables are simply too thin for this. Then we could say that in the case of a local district where a lot of solar energy is produced during the day and this energy cannot get out of this district because of too thin cables, let's put it in those cars and then you can use it for the grid at a later time.’’

- Four experts described homeowners as a customer segment. A homeowner with private V2G charging infrastructure could use an EV and solar panels to store energy in their EVs and to balance the local energy grid. This use case of V2G is also called Vehicle-to-Home.

- TSO is as the national high voltage grid operator responsible to balance the grid. Therefore, the TSO can apply V2G for its balancing services and which makes it a possible customer segment for V2G. Three experts mentioned the TSO.

- Energy traders are parties that are trading with energy and flexible assets. They can buy V2G services to use this for trading on the energy market. Two out of the eleven actors mentioned them as possible customer segments.

- Six experts mentioned building/office-building owner as a customer segment. In this case, the charging infrastructure is connected to a building. As shown Table 3, this customer segment has been mentioned the most by the experts. E.EC1 mentioned even that V2G is only feasible in such a case of Vehicle-to-Building.

The micro level shows the characterises within the customer groups that does matter for V2G services. On two type of differentiations can be emphasised related to the insights gathered from the expert interviews.

- The financial segment has been addressed by almost all experts. The financial incentive will be the main reason for end-users to participate in V2G. E.BRP mentioned that the financial segment reflects all other segments and is therefore in line with the social segment.

[E.BRP] ''You have the option to charge when electricity prices are, which means that there is a financial incentive for the customer. But that is typical at times when there is a lot of sustainable energy generation, which means that it includes also a sustainability component''

- However, E.EC3 mentioned that in experience sustainable benefit besides financial incentives are always fine and E.EC3 mentioned that the social segment is also helped with financial compensation. So, the social and financial segment are not contradicting to each other. Thereby, the social segment is addressed as important by six experts. Four of them emphasized on the importance of capturing early adopters. The social segment is characterized by accepting longer payback times and they could adopt this technology during its early stages. So, both segments can be addressed as important and therefore for both segments value must be created.

- Regarding public V2G charging, two experts mentioned private EV owners as a possible end-user to target. Whereas private EV drivers are a legitimate segment for public V2G charging infrastructure, lease drivers are not suitable because of the charging prices which does not matter for them. As E.EC1 described:

[E.EC1] '' Lease drivers are not interested in the charging prices. You can see that in their charging behaviour. Sometimes people charge for enormous amounts because the boss reimburses it anyway.''

Hence, the incentive for using V2G does not go to the lease driver but to the fleet-owner. In the case of public V2G infrastructure it does not make sense to target lease drivers. Private EV owners, on the other hand, are an option that could be targeted. However, experts E.EC1 and E.DSO mentioned that private EV owners are not an interesting target group either.

- Five experts mentioned the possibility of fleet-owners. Fleet-owners could refer to owners of a vehicle fleet such as taxi companies, lease companies, and shared vehicles providers. Regarding E.ES is the application of V2G suitable for such customer segment because scheduling in such cases is easier:

[E.ES] '' If you look at the Dutch market, I think that in general you would rather like to offer V2G to groups than to individuals. This can in many ways. As soon as you can charge multiple cars at a certain point at the same time. V2G can be considered interesting depending also on how the grid is loaded. It can be seen that these vehicle are relatively often idle and from a planning perspective you can make easier predictions of when a car is at a standstill. This allows you to match it very well with the energy grid.''

- Another differentiation on micro-level are mentioned by E.KI and E.DSO and are referred to the socio-economic characteristic of end-users like how many vehicles they have, what their travel patterns are, and what their commuting distances are. Thereby, E.KI and E.DSO mentioned also the difference in lease drivers and private drivers. As described before with regards to public charging infrastructure, the difference in whether an end-user is a lease driver or private driver does matter.

7.2.2 Value proposition

The value proposition describes the bundle of services that a V2G service must deliver to create value for the customers.

Table 4: overview codes value proposition

Codes for value proposition	**E.ES**	**E.EC1**	**E.AC**	**E.KI**	**E.U**	**E.EC2**	**E.BRP**	**E.EC3**	**E.GA**	**E.DSO**	**E.M**	**Total**
Macro-level												
EV as local storage: prevent additional energy storage costs	**X**			**X**		**X**						**3**
Functionality grid increases: availability to serve more assets on the grid				**X**		**X**				**X**		**3**
Value proposition: bundling and providing flexibility to the grid						**X**	**X**	**X**	**X**		**X**	**5**
Load balancing: lower grid connection		**X**			**X**							**2**
Peak shaving: store energy when energy generation is high and use it when energy consumption is high	**X**				**X**	**X**						**3**
Micro-level												
Insurances to end-users	**X**									**X**		**2**
Compensate end-users			**X**	**X**		**X**	**X**	**X**	**X**	**X**	**X**	**8**
Provide choice flexibility to end-user				**X**			**X**	**X**	**X**	**X**		**5**
Increase sustainability Dutch energy grid			**X**				**X**	**X**			**X**	**4**

The value that V2G offers to its customers could again be divided into macro and micro levels. On macro-level it is about the value that is offered to the customers who pay for the V2G services and on micro-level it is about the end-users that need to be convinced.

- Three experts described peak shaving as a value proposition. So, charging the EVs when the generation of renewable energy is high and discharging when there is a peak load in the consumption. In this way, the demand and supply gap for energy can be matched.

- Three experts mentioned the value of using EVs as local storage assets to capture the generated renewable energy instead of using stationary batteries. By using EVs as local storage, the need for purchasing additional stationary batteries can be satisfied. This prevents additional costs for energy storage.

- Three experts described the value of increasing the functionality of the Dutch energy grid. Currently, situations occur that there is no capacity on the grid resulting in a bottleneck that no additional assets can be connected to grid. With V2G you can create space for assets because of the provided flexibility.

- The flexibility that V2G creates is on itself a value. The flexibility of one single EV does not add much value. However, the proposition of bundling the flexibility of all the available EV and providing this bundled flexibility to its customers is from high value. Five experts addressed that bundling and providing flexibility to the grid as a value proposition which a V2G service provider must offer.

- E.EC1 and E.U described load balancing for buildings as a value proposition since V2G can create a reduction of the capacity on the grid of a building. As E.U described:

[E.U] ''You can balance the demand for energy with regards to the need of the building and to the need of EVs.''

The value that must be offered on micro-level must be in the advantage of the end-user. Based on the expert interviews the general perspective is that end-user must at least not be disadvantaged.

- Eight experts explicitly mentioned the compensation of end-users. So, the end-users should get financial rewarded for using their EV for V2G. This can differ in ways such as fixed remuneration, remuneration based on real-time prices, or discount on charging sessions. However, the overarching proposition is to offer a financial incentive to convince end-users to make use of V2G.

- Four experts mentioned the increase of the sustainability of the Dutch energy grid as the value that must be offered to the end-users. This is mainly to capture the social segment of end-users.

E.EC3 described how both value propositions can matter for the end-user.

[E.EC3] '' On the one hand the value is the sustainability, so the idea for people to help solve the fossil fuel problem. That's the way we put it in. We use electric driving, smart charging and in the future V2G as a solution to the fossil fuel problem. That is on the one hand the value and on the other hand the value is the financial incentive that they get for it.''

- Five experts described the importance of providing flexibility to the end-user. Providing flexibility refers to the option that the end-users can decide how they will use their EVs for V2G. For example, whether they put theirs EVs in for V2G, between which bandwidths the EV can be (dis)charged, and/or the preference of a SOC for a predetermined time.

- E.ES and E.DSO described the need for insurances or other type of warranties to provide assurance that if V2G creates issues or damage to their EVs that this will be taken care of. An example given by E.DSO:

[E.DSO] ''You should also offer insurance. You have to think about who pays those risks. So suppose that car catches fire because it charges or discharges too quickly, who is responsible for that. Also the battery degradation. how do you process that in your proposition, how do you ensure that the battery does not suffer too much from the process of charging and discharging.''

7.2.3 Channels

The ways to communicate and reach the customer segments for delivering a value proposition is described in channels.

Table 5: overview codes for channels

Codes for Channels	E.ES	E.EC1	E.AC	E.KI	E.U	E.EC2	E.BRP	E.EC3	E.GA	E.DSO	E.M	Total
Reach customers												
Through existing TSO/energy market						**X**						**1**
Connect current customer group			**X**									**1**
During the sale of the car	**X**							**X**	**X**	**X**	**X**	**5**
Emphasizing on benefits not on how it works								**X**	**X**			**2**
Integral offer public concessions						**X**					**X**	**2**
Through big companies that facilitate lease vehicles for their employee											**X**	**1**
Through energy contracts	**X**	**X**	**X**			**X**			**X**			**5**
Through events			**X**									**1**
Through lease contracts			**X**					**X**		**X**	**X**	**4**
Through resellers											**X**	**1**
Through system integration		**X**										**1**
Through webpages			**X**									**1**
Communication												
V2G card		**X**		**X**								**2**
Communication is via an app	**X**	**X**			**X**		**X**		**X**	**X**	**X**	**8**
Communication through the car										**X**		**1**

As shown in Table 5, reaching customers could be in many ways. Three ways of reaching the customers were addressed by multiple experts. Those are during the sale of the car, through energy contracts, and through lease contracts.

- During the sale of car is addressed by five experts. This includes that when a person or entity buys a car from an EV OEM/car dealer that they get an offer to participate for V2G services directly. E.EC3 phrased this as follow:

[E.EC3] ‘’ we actually want that a salesperson from a car manufacturer or a car dealer is able to say when someone buys an electric car that (s)he is able to contribute to a sustainable energy grid or make money from here/his car by using it for V2G and that (s)he can take it all with her/him. I think that would be ideal that a customer could immediately go through it in one place and that is the ideal channel.’’

- Five experts mentioned energy contracts as a channel. The V2G service is then integrated or offered in the energy contract of a person or business. Homeowners or building owners can in this way be approached and in an energy contract an option can be offered for using V2G services.

- Through lease contracts is also an option addressed by fours experts. In this approach the value is offered to lease companies, thereafter they reach end-users by integrating the V2G service in their lease contracts with end-users.

- A channel that is also possible is an integral offer for a public concession. This counts only for public V2G charging infrastructure. In this case, a municipality grants concession to a party that place an offer for public charging. An integral offer of using V2G charging infrastructure makes it possible to reach EV drivers who make use of public charging infrastructure.

- E.EC3 and E.GA described also that when reaching customers it is important to emphasize on the benefits of V2G and not on how it works. To understand how V2G actually works is quite difficult. For this reason, the experts mentioned that the approach must be to emphasize on what benefits the customer can get rather than explaining the customer how it all works.

The communication with customers can be in three ways: with a V2G card, an app, or through the car.

- Eight experts mentioned the use of an app as a way of communicating with the customers. Using a app can therefore be seen as the most meaningful.

- E.EC1 and E.KI mentioned also a V2G card as a way to communicate. This is a mobility card that you can use at a charge point to register and start the charging process.

- E.DSO mentioned that communication can occur through the car too.

[E.DSO] ‘’ I have a Tesla myself, you can just set up when the car should be charged and you can even set up how fast it must be charged to a certain extent. So, I can imagine that there will be software in the car where you can make those kinds of settings and can also make agreements with the parties that make use of V2G.’’

7.2.4 Customer relationship

The customer relationships is the way the relationship for V2G services can be established with the customer segments.

Table 6: overview codes customer relationship

Customer relationship	**E.ES**	**E.EC1**	**E.AC**	**E.KI**	**E.U**	**E.EC2**	**E.BRP**	**E.EC3**	**E.GA**	**E.DSO**	**E.M**	**Total**
Communication with outsiders		**X**										**1**
Business communication		**X**										**1**
Contractual relationship				**X**								**1**
At the start close relationship			**X**								**X**	**2**
Not much contact			**X**					**X**	**X**		**X**	**4**
Easy to use	**X**		**X**				**X**	**X**				**4**
Communities											**X**	**1**
Customer service			**X**	**X**							**X**	**3**
Relationships end-users public V2G Charging: through municipalities						**X**						**1**

- E.EC1 described that in the case of a building owner you have to communicate with the company that owns the building. This is required in order to know everyone who comes to the office or building and know which EVs for how long can be used. It is also needed to communicate with outsiders who are not from the office or building. Because it must be made clear that the V2G charge point are not allowed to be used for outsiders. Another option is that the V2G charging infrastructure must be able to recognize that the charge point is occupied by an outsider and then does not use that charge point for discharging.

- E.KI mentioned the need for a V2G contract in order to get permission for discharging an EV. So, an contractual relationship is required.

- E.AC and E.M described to start with close relationships with customers that has been acquired. As E.M described that it is required to have a launching customer in which the technology can be tested and complemented. E.AC described the need as follow:

[E.AC] ''If you have acquired customers, you should certainly check how things are going in the beginning. We have had things in our projects that did not go well, it is therefore important that you maintain contact.''

- However, both experts mentioned also that not much contact is needed anymore after the system is working. In total four experts mentioned that the relationship must be based on as less contact as possible. Otherwise, the customers must make much effort which makes them less enthusiastic.

- Four experts mentioned that V2G must be easy to use. This means that it must be easy accessible, user-friendly and automated. E.ES mentioned this even as one of the most important component.

[E.ES] ''I think the most important thing is to make it easy.''

- Furthermore, E.M mentioned that for a good relation the possibility could be provided to customers to give feedback through communities.

- Thereby, E.M, E.AC, and E.KI addressed that via a customer service complaints or problems must be received. So, customers need to know where they have to been in problematic situations.

- E.EC2 described that in the case of public charging infrastructure there is not direct contact with the end-users because those are unknown for the service provider. Therefore, it does make more sense to build up the relationship through municipalities.

7.2.5 Revenue streams

The revenue streams represent the possible cash flows that can be generated from the customers.

Table 7: overview codes revenue streams

Revenue streams	**E.ES**	**E.EC1**	**E.AC**	**E.KI**	**E.U**	**E.EC2**	**E.BRP**	**E.EC3**	**E.GA**	**E.DSO**	**E.M**	**Total**
Revenue stream: congestion management	**X**			**X**		**X**	**X**			**X**		**5**
Revenue stream: cost reduction transaction/energy bills			**X**	**X**				**X**	**X**		**X**	**5**
Revenue stream: energy markets			**X**		**X**	**X**	**X**			**X**	**X**	**6**
Revenue stream: ancillary services			**X**	**X**		**X**	**X**	**X**		**X**	**X**	**7**
Revenue stream: lower grid connection		**X**		**X**								**2**
Sharing revenue												
Revenue sharing					**X**		**X**	**X**	**X**	**X**		**5**
Revenue sharing: degree of contribution	**X**										**X**	**2**

There are potentially five type of revenue streams that could be derived from the expert interviews.

- Congestion management is a revenue stream which can be gathered from DSO but which is for now not concrete. Five experts mentioned the potential of congestion management and to gather revenue from it. However, four experts mentioned also that there is currently not a market for DSOs to pay for such services. For instance, E.KI and E.EC2 mentioned the potential of congestion management but addressed also that there is no an associating revenue streams. A possible reason is that there is no dynamic price structuring allowed and that the use of batteries are not allowed for DSOs.

[E.KI] '' There is currently no possibility to gather revenue from congestion management. On the first place because a DSO itself may not use batteries and therefore also not the batteries of private individuals.''

A possibility was mentioned by E.EC3 to trade from of a trade platform such as GOPACS in which the needs of DSO are shared. However, E.M pointed out that these platforms are too small to gather really cash from it.

E.DSO described that it is indeed difficult to gather revenue from DSOs for V2G but as DSO E.DSO mentioned they are certainly willing to pay for flexibility.

[E.DSO] '' We can make agreements with people in an area with congestion, for example with large users, about when they provide flexibility. I do not see why that would be very different with V2G, except that we would not want to make separate agreements with 1000 cars. Then we are more likely to ask an aggregator to arrange this for us in such an area but it will not happen very often because it is quite complicated and there should be a lot of cars in that area.

- Five experts mentioned the cost reduction for energy/transaction bills. Which means that when V2G is used the cost for a charging transaction can be reduced and if it is connected to someone's energy contract then the energy bill will get reduced. A share of this cost reduction ends up by a V2G service provider who therefore gathers revenue.

- Six experts mentioned revenues from the energy marker as revenue streams. So, the revenue of trading electricity in the day-ahead or intraday market.

- Seven experts addressed that revenue can be gathered from TenneT by delivering ancillary services. This can be from the FCR (primary reserve power) market or the aFRR (regulating power) market.

- E.EC1 and E4 described that in the case of a building connection, revenues can be gathered from lower grid connection. By using V2G a building owner can use lower grid connection which reduces the costs. A share of this cost reduction can flow to the V2G service provider as revenue.

So, there are several ways to generate cash flows. How a share of these cash flows ends up as revenue for the V2G service provider depends on revenue sharing.

- Six experts described that the generated revenue must be shared among all the involved parties in order to keep the incentive for all parties to participate.

- E.ES and E.M described that the degree of contribution of an involved party during V2G services matters on how the share the revenue. The party that puts the most effort on generating the revenue gets also the most share of it.

7.2.6 Key resources

To make the business model work, assets are required from which the most important ones are the key resources.

Table 8: overview codes key resources

Key resources	E.ES	E.EC1	E.AC	E.KI	E.U	E.EC2	E.BRP	E.EC3	E.GA	E.DSO	E.M	Total
Backend system	**X**		**X**				**X**	**X**				**4**
Interface energy market	**X**	**X**	**X**	**X**		**X**	**X**		**X**	**X**	**X**	**9**
Resources: billing service				**X**				**X**				**2**
Resources: Customer registration system				**X**								**1**
Resources: Insights in energy consumption					**X**							**1**
Software	**X**	**X**	**X**	**X**				**X**		**X**	**X**	**7**
User interface	**X**	**X**	**X**	**X**		**X**	**X**		**X**	**X**	**X**	**9**
V2G charging infrastructure			**X**	**X**				**X**			**X**	**4**

- Four experts mentioned that the V2G charging infrastructure is needed as hardware in order to enable that EVs can be connected for charging or discharging operations.

- Nine experts described the need for an user interface. This user interface allows end-users to interact with the control algorithms that apply to it. In this way the availability of the vehicle can be explored and the needs of the end-users can be taken into account.

- Nine experts described also the need for an interface with the energy market. This is needed in order to receive signal from the energy market like the day-ahead market or from the TenneT for ancillary services.

- Four experts described that a backend system is required. This required to have control about the V2G charging infrastructure and the connected EVs.

[E.AC] ‘’ I think a V2G service provider should have a back-end system suitable for V2G. They need to have control over the charging infrastructure and have a back-end to manage it’’

- To connect al these interfaces to the backend system, software is needed. Seven experts mentioned that software is needed to explore from the received signals for which reasons you want to charge or discharge the connected EVs and under which condition in terms of EVs availability this is possible. Example phrases from experts:

[E.EC3]’’ I think the resources are mainly software.’’

[E.KI] ‘’ You need control algorithms that can receive all possible need from the customers and this must be incorporated into the controlling at that moment.’’

[E.AC] ‘’ What you need is an aggregation software that is able to monitor and charge and discharge different charge points at the same time based on signals from the energy market.’’

- E.KI and E.GA also described that you have to arrange the financial administration for which a billing service is needed. E.KI mentioned the need for a customer registration system as well.

7.2.7 Key activities

The key activities are the most important things a V2G service provider must do to make the business model work.

Table 9: overview codes key activities

Key activities	**E.ES**	**E.EC1**	**E.AC**	**E.KI**	**E.U**	**E.EC2**	**E.BRP**	**E.EC3**	**E.GA**	**E.DSO**	**E.M**	**Total**
Activities: price based (dis)charging											**X**	**1**
Activities: connect to trade platforms				**X**		**X**						**2**
Activities: bundle in whole service			**X**		**X**			**X**			**X**	**4**
Activities: organizational oriented algorithms		**X**										**1**
Activities: role of BRP/BSP							**X**				**X**	**2**
Activities: trade in in energy market							**X**					**1**
Activities: role of CPO	**X**			**X**								**2**
Activities: the role of aggregator				**X**	**X**	**X**		**X**	**X**	**X**		**6**

Although the key activities that the experts described seems diversified, the experts cross each other particularly for activities of bundling in a whole service and the role of aggregator.

- Bundling in a whole service is addressed by four experts and it means that the V2G service provider must bundle all activities that are needed for V2G. In this case, the V2G service provider enters into partnerships with parties that are required for V2G services and bundles these activities towards one service. So, the V2G service provider does not directly do any activity within the cooperation but comes out as one provider who delivers the whole service.

- The role of aggregator is addressed by six experts. This concerns activities as pooling the many end-users and offering a platform where supply and demand can be matched.

- Two experts mentioned the connection of customers to the trade platforms such as GOPACS or USEF as an activity that a V2G service provider must do.

- Two experts mentioned the role of CPO as activity, which contains the purchase, installment, operation and maintenance of the V2G charging infrastructure.

- E.BRP and E.M mentioned the role of BRP/BSP as an activity that has to be made. This activity refers to be active in the market for delivering ancillary services to TenneT. E.BRP mentioned also the activity of trading in the energy market (day-ahead and intraday market).

- Other activities have only been mentioned by one of the experts. Organizational oriented algorithms is an activity described by E.EC1 which is about the case of an office building:

[E.EC1] ‘’As a V2G service provider you have to indicate that you will go inside the organization and that you will make the algorithm more interesting step by step.’’

- E.M mentioned also the activity of price based charging or discharging. So, charging when the energy prices are low and discharging when energy prices are high.

As a V2G service provider you must be able to do these activities. If it cannot, then it must enter into a partnership with parties who can do these activities.

7.2.8 Key partnerships

The partnerships are the suppliers and partners who are needed to make the business model work.

Table 10: overview codes key partnerships

Key partnerships	**E.ES**	**E.EC1**	**E.AC**	**E.KI**	**E.U**	**E.EC2**	**E.BRP**	**E.EC3**	**E.GA**	**E.DSO**	**E.M**	**Total**
Partnership: aggregator	**X**	**X**	**X**	**X**	**X**		**X**				**X**	**7**
Partnership: BRP/BSP						**X**	**X**	**X**				**3**
Partnership: CPO		**X**		**X**	**X**	**X**		**X**			**X**	**6**
Partnership: DSO	**X**		**X**									**2**
Partnership: end-users	**X**					**X**	**X**		**X**			**4**
Partnership: energy producer						**X**						**1**
Partnership: energy supplier	**X**				**X**			**X**	**X**		**X**	**5**
Partnership: EV OEM											**X**	**1**
Partnership: garage operators										**X**		**1**
Partnership: MSP				**X**	**X**							**2**
Partnership: municipalities					**X**	**X**						**2**
Partnership: TSO	**X**		**X**									**2**
Partnerships: EVSE supplier	**X**							**X**				**2**

The partnerships that are addressed by the experts corresponds mostly to the actors discussed at the actor-analysis (Section 4).

- The partnerships that are most often addressed by the experts are the partnerships with aggregators, CPOs, and energy suppliers. When looking in mainlines the partnerships are from both the mobility and the energy sector. E.AC described V2G service as a nice example of a cross-industrial partnership.

[E.AC] ‘’ I think that V2G is a good example of a cross-industrial partnership, if you are a mobility party you should also look for an energy partner and vice versa.’’

So, what partnerships will be establish depends mainly on what type of actor will take the role of V2G service provider.

- E.U and E.EC2 mentioned also that a partnership with the municipalities is needed. In particular, in the case of public V2G charging.

[E.EC2]’’I think that at public charging infrastructure, a partnership must be made with the asset owner of the asset which is often the municipality.’’

7.2.9 The role of V2G service provider

Table 11 shows the view of experts about which actor should take the role of V2G service provider.

Table 11: overview codes for the role of V2G service provider

The actor for the role of V2G service provider	**E.ES**	**E.EC1**	**E.AC**	**E.KI**	**E.U**	**E.EC2**	**E.BRP**	**E.EC3**	**E.GA**	**E.DSO**	**E.M**	**Total**
V2G service provider: aggregators							**X**					**1**
V2G service provider: BRP						**X**						**1**
V2G service provider: cooperation of CPO, MSP and aggregator				**X**								**1**
V2G service provider: combination of energy supplier and mobility provider	**X**											**1**
V2G service provider: CPO			**X**							**X**		**2**
V2G service provider: energy supplier					**X**							**1**
V2G service provider: EV OEMs									**X**			**1**
V2G service provider: grid operator					**X**							**1**
V2G service provider: MSP										**X**		**1**
V2G service provider: system integrators		**X**										**1**
V2G service provider: fulfills as many roles as possible								**X**				**1**

- Whereas the aggregator seemed to fit the role of V2G service provider in the actor-analysis, the expert insights does not show the same. Only E.BRP mentioned the aggregator for the role of V2G service provider. E.EC3 described the role of aggregator as a minimal activity to do, but that it is more likely that a V2G service provider who fulfils as many roles as possible is more competitive. E.GA considered that the aggregator fits to the role of V2G service provider but the expectation is that the EV OEMs would fulfill this role.

[E.GA] ‘’ I think an aggregator is the most suitable party because it can really focus on this and it will be its only task. But I think once car manufacturers realize the added value of this and offer the complete package (so a car with a V2G charging infrastructure) that they will reach so much mass and quantities so quickly that an aggregator will no longer compete.’’

- Furthermore, three experts addressed more than one actor to satisfy this role of V2G service provider. E.KI mentioned that it must be a cooperation of CPO, MSP, and aggregator. E.ES mentioned that it must be a combination of an energy supplier and mobility providers. This means a new actor which is in-between the energy and mobility sectors. E.EC3 mentioned that a V2G service provider must fulfill as many roles as possible.

As derived from the insights regarding the partnerships and activities that a service V2G needs, there are many actors required in order to enable a V2G service. Thereby, the partnerships that must be established depends on what type of actor the V2G service provider is. When the V2G service provider is fulfilled by an party that satisfies one actor role then there is need for more partnerships. Derived from the part of revenue streams, revenue sharing is needed to keep the incentive for partners to participate. So, if there are more partnerships involved, the revenue must be shared between more parties. Therefore, a V2G service provider who fulfills more roles is more competitive.

7.2.10 Cost structure

All costs that are incurred for the operation of a V2G business model is described by the cost structure.

Table 12: overview codes cost structure

Cost structure	**E.ES**	**E.EC1**	**E.AC**	**E.KI**	**E.U**	**E.EC2**	**E.BRP**	**E.EC3**	**E.GA**	**E.DSO**	**E.M**	**Total**
Costs for compensation battery degradation				**X**								**1**
Costs for compensation loss of comfort				**X**	**X**		**X**					**3**
Costs for cooperation					**X**							**2**
Costs for data-communication				**X**								**2**
Costs for designing interfaces		**X**			**X**	**X**	**X**			**X**		**5**
Costs for software	**X**	**X**					**X**	**X**		**X**		**5**
Costs for V2G charging infrastructure		**X**	**X**	**X**	**X**	**X**		**X**	**X**	**X**	**X**	**9**
Costs: smart meters for V2G charging infrastructure						**X**	**X**					**2**
R&D costs	**X**										**X**	**2**
Risk costs	**X**											**1**
Service costs									**X**			**1**
Sharing costs												
Sharing costs					**X**							**1**
Sharing costs: V2G service provider mainly takes cares of the costs						**X**	**X**				**X**	**3**
There must remain revenue for end-user	**X**								**X**		**X**	**3**

Table 12 shows that there are many cost items.

- Costs for compensation is mentioned by three experts. The remuneration is needed because the end-user offers some comfort to the V2G services. The loss of comfort in terms of flexibility (range, time, etc.) has a value and the compensation of it means that the V2G service provider must make costs. E.KI mentioned that also additional compensation is needed for the battery degradation.

- E.U that enabling a cooperation with different parties needs also costs. To bring all the actors that are needed together in order to offer V2G service needs also effort and costs.

- In order to create the platform in which the decisions for charging or discharging are made, interfaces with the end-users and energy market is needed. Five experts mentioned the design of these interfaces as a cost item. E.KI mentioned also that the real-time data that is needed links with more data traffic which means costs.

- Five experts mentioned the software as cost item. In order to control the V2G charging infrastructure based on the signals received from the interfaces and real-time data, a backend system is required for which software costs must be made.

- Nine experts mentioned the costs for V2G charging infrastructure. These costs are significantly higher than traditional charging infrastructure because V2G needs a AC/DC inverter which is for now pretty expensive.

- E.EC2 and E.BRP mentioned that not every charging infrastructure is equipped by smart meters. Therefore, to roll out smart meters is considered helpful. E.EC2 described this as a cost component either.

- E.ES and E.M described also the R&D costs.

[E.M] Regarding costs: ''It is a lot of R&D, you have to do hardware development and you have to test a lot.''

- E.ES mentioned also the costs for risks because the predictability of what the government will do is not high and there is to some extent inconsistency. According to E.ES this is not useful and create risks.

- E.DSO expects that a V2G service provider has to do more work than what was the case for traditional charging. So, this means additional service costs.

How the costs needs to be shared depends on how the revenue will be generated. So, the experts did not go into much detail regarding the sharing of costs.

- E.U expects that these costs will be shared and it will be joint investment because the costs for V2G charging infrastructure is for now expensive.

- Three experts mentioned that the loss or savings ends up at the end-users. So, there must remain revenue for the end-user. If this is not case, V2G does not have much potential.

[E.ES] ''It does not matter how the costs are shared out. In the end, the end user pays the bill or gets a saving.''

7.3 Sustainability

The sustainability has been analysed based on the three categories for sustainability archetypes: environmental, social, and economic.

7.3.1 Environmental

Table 13 shows an overview of potential environmental components that a V2G business model contains. Two environmental archetypes was on before adapted and asked to the experts. These were the increase of the share of renewable energy sources in the energy grid and the efficiency in the utilization of available renewable energy sources. The other environmental archetypes derived from the insights of the expert-interviews.

Table 13: overview codes environmental archetypes

Environmental	**E.ES**	**E.EC1**	**E.AC**	**E.KI**	**E.U**	**E.EC2**	**E.BRP**	**E.EC3**	**E.GA**	**E.DSO**	**E.M**	**Total**
Environmental: increase share of renewable energy sources in the energy grid	**X**		**X**	**X**		**X**	**X**	**X**		**X**	**X**	**8**
Environmental: Efficiency in the utilization of available renewable energy	**X**			**X**	**X**	**X**		**X**		**X**	**X**	**7**
Environmental: battery degradation					**X**			**X**				**2**
Environmental: increase in share EVs			**X**	**X**				**X**	**X**			**4**
Environmental: material efficiency						**X**				**X**		**2**
Environmental: postpone grid reinforcement investments		**X**		**X**	**X**	**X**	**X**		**X**			**6**
Environmental: power quality	**X**											**1**

- Eight experts mentioned that V2G contributes to the increase of the share of RES in the energy grid. Currently, if there is no renewable energy generation because of situation such at night when there is no sunshine then you need gas or coal-fired power plants to generate power. However, with V2G the intermittency can be captured and the need for unsustainable energy generation reduces.

  However E.EC1 do not expect that V2G contributes to this and E.DSO is not sure either. The main reason for this, is that people use EVs also for mobility. If they use their EVs for mobility when there is also high generation of renewable energy sources then you cannot capture this energy and therefore do not contribute to an increase in the share of RES.

- Seven experts mentioned that V2G contributes to more efficiency in the utilization of available renewable energy. Currently, renewable energy that is generated through a building or home ends up in the grid if it has not been used. With V2G this energy can be captured and used at a later time when it is needed. Thereby, situation could occur that solar- or wind-parks must be turned off because of too much generation. With V2G, these parks do not have to turned off at moments when there is high renewable energy generation.

- Two experts mentioned also the battery degradation as an environmental archetype. This means that V2G also could have a negative environmental impact.

- Four experts mentioned that V2G could contribute to the increase in the share of EVs. The experts sees the electrification of the vehicle fleet also as a contribution to the environment. Therefore this is addressed as a sustainable archetype.

- E.EC2 and E.DSO described that the use of EV batteries are more sustainability because it has been already used for mobility. So, when these batteries are also used for storage this contributes to the efficiency of materials. E.DSO described this as follow:

[E.DSO] ‘’ Solar cells in themselves already have a major environmental impact in terms that they are difficult to recycle because a lot of rare metals are used and that actually also applies to batteries. At the moment you do not have to install extra batteries, because you can use the batteries of your car which is already there, that saves in the amount of batteries you use. For example, you now see that large companies install stand-alone batteries which are extra batteries. So, when you can use car batteries which are already there then you save in the amount of batteries you put down and that is an environmental effect.’’

- Six experts mentioned that thanks to V2G the grid reinforcement can be postponed and the realization of the reinforcement can be spread over time. This means an advantage for the DSO int terms of financial investment but also for the environment such as that streets not have to be broken up for the realization of it.

- E.ES mentioned also that V2G is a way to increase the power quality

[E.ES] it's about power quality (how's my reactive current, how's my power factor and things like that). The great thing is that V2G is suitable for solving that.

7.3.2 Social

For analyzing the social category the predetermined archetypes which were asked were whether end-users need physical property to take part in V2G services and whether a V2G service provider must proactively engage with all stakeholders. The other social archetypes derived from the insights of the expert-interviews.

Table 14: overview codes social archetypes

Social	**E.ES**	**E.EC1**	**E.AC**	**E.KI**	**E.U**	**E.EC2**	**E.BRP**	**E.EC3**	**E.GA**	**E.DSO**	**E.M**	**Total**
Cooperation is necessary			**X**		**X**	**X**		**X**	**X**	**X**	**X**	**7**
Social: no need to communicate with everyone		**X**					**X**					**2**
No physical property end-user: garage										**X**		**1**
No physical property end-user: package deal car dealers									**X**			**1**
No physical property end-user: provide V2G charge point via lease company			**X**									**1**
No physical property end-user: through contract MSP				**X**								**1**
No physical property end-user: at work						**X**						**1**
No physical property end-user: public charging	**X**				**X**	**X**	**X**	**X**	**X**	**X**		**7**
Social: sharing society	**X**											**1**
Social: impact EV-driver behaviour		**X**			**X**	**X**						**3**
Social: make use of someone’s car						**X**						**1**
Social: pressure for V2G parking spot					**X**					**X**		**2**
Social: V2G contributes to independency of energy consumers											**X**	**1**

- Seven experts mentioned the importance of cooperation. This means that V2G service provider must engage with other actors in order to deliver the V2G service. In particular, in these early stages where the V2G market is not developed, experts mentions that there is need to communicate and cooperate. E.EC1 and E.BRP, on the other hand, do not think that it is necessary to communicate with everyone. E.EC1 described that it is about convincing the building owner by defining a proposition that satisfies its needs. E.BRP expects that it will be the part of market forces and in the future the market will automatically share the information needed to know the value of V2G and how to participate.

- Nine experts mentioned the possibility to take part in V2G without having a physical property (like a private V2G charge infrastructure). E.M mentioned that it is possible but it is more advantageous to have a private one. Seven experts mentioned hereby that the public charging infrastructure is a possible option in which end-users could participate in V2G services without having a private V2G charging infrastructure.

- Three experts described that V2G impacts the behavior of an end-user.

[E.EC1] '' what is also very important with this type of system is that you can influence the behavior of the EV-driver''

- E.EC2 mentioned also that with V2G, a service provider make use of someone's car which is in itself also a social aspect.

- E.U and E.DSO described that, in particular for public charging, there will be pressure for the use of a V2G parking spot. For V2G, it is useful that an EV is connected for a long time. When someone connects its EV, this could take up a charging parking sport for very long time. This could irritate other neighbors or EV drivers who want to park or charge their cars.

- E.M mentioned that V2G contributes to the independency of energy consumers.

[E.M] '' I think that decentralization provides a kind of democratization of the whole energy system. In which consumers play a more important role and that it is no longer a matter of a few large energy suppliers with large thermal power plants, but that everyone becomes their own mini factory with their solar panels on the roof, V2X charging and stationary battery.''

7.3.3 Economic

Table 15 shows the economic archetypes for a sustainable V2G business model.

Table 15: overview codes economic archetypes

Economic	**E.ES**	**E.EC1**	**E.AC**	**E.KI**	**E.U**	**E.EC2**	**E.BRP**	**E.EC3**	**E.GA**	**E.DSO**	**E.M**	**Total**
Economical: decrease total cost of ownership EV			**X**	**X**								**2**
Economical: economically independent	**X**		**X**		**X**	**X**	**X**	**X**		**X**	**X**	**8**
Economical: repurpose for society	**X**		**X**	**X**	**X**	**X**	**X**	**X**	**X**		**X**	**9**
Economical: V2G is commercial		**X**							**X**	**X**	**X**	**4**
Inclusive value generation	**X**				**X**	**X**	**X**	**X**	**X**	**X**		**7**

- E.AC and E.KI mentioned that V2G contributes to the decrease of total cost of ownership for an EV.

[E.KI] ''What is also favorable for a car owner is that he will experience a kind of price reduction on the purchase of his car, because at some point you can earn money with it. With a normal car you can never make money and that costs only money, but if you can deal well with the electricity in your battery, that actually makes owning an electric car more favorable.''

- Eight experts mentioned that the V2G service provider must act economically independent. This means that the V2G service provider must deliver V2G services on its own without expecting governmental support in economic terms.

- Nine experts addressed also that a V2G service must be repurposed for the society. So, it must generate value for all stakeholders including the society and environment. The experts are convinced that when this technology has successfully penetrated the market that it will contribute for a sustainable society.

  E.EC1, on the other hand, addressed that V2G is commercial and does not add much value for the society

[E.EC1] '' V2G is something commercial, the world is not going to get better of it''

  Four experts pointed out that V2G is commercial.

- Seven experts mentioned that for V2G there is inclusive value generation. According to these experts the cooperation and sharing of resources is vital for the generation of value and indispensable in a working a business model.

7.4 Business environment

The business environment consists of eleven categories.

7.4.1 Technical barriers

Table 16: overview codes technical barriers

Technical barrier	E.ES	E.EC1	E.AC	E.KI	E.U	E.EC2	E.BRP	E.EC3	E.GA	E.DSO	E.M	Total
Technical barrier: battery degradation			**X**					**X**				**2**
Technical matter: battery degradation maybe not an issue									**X**		**X**	**2**
Technical barrier: battery capacity		**X**					**X**					**2**
Technical barrier: lack of commercially available vehicle fleet	**X**			**X**	**X**		**X**	**X**	**X**	**X**	**X**	**8**
Technical barrier: loss of efficiency			**X**					**X**			**X**	**3**
Technical barrier: noise nuisance				**X**								**1**
Technical barrier: V2G infrastructure costs	**X**	**X**		**X**		**X**				**X**		**5**
Technical barrier: smart meters do not support dynamic pricing	**X**											**1**
Technical barrier: software not ready	**X**	**X**										**2**
Technical barrier: switching speed		**X**										**1**

- The technical barrier that is mentioned mostly is the lack of a commercially available vehicle fleet. The numbers of EVs and that there are for now only three models (Nissan leaf, Nissan ENV-200, and Mitsubishi Outlander) capable of V2G make commercially available vehicle fleet limited. Experts addressed this as too less and therefore as a technical barrier.

- A technical barrier that hampers getting a sustainable V2G business model is the V2G infrastructure costs. A charge point with V2G capability is significantly more expensive than a traditional charging point. Five experts explicitly that this additional are too much for getting a working V2G business model.

- Battery degradation is an issue in which there is no consensus between experts. E.AC and E.EC3 experts mentioned that this is a barrier. E.GA addressed this as a matter for which scientific evidence and consensus is needed. E.M mentioned even that the battery life time could be increased with applying V2G between the right ranges.

- Three experts that V2G creates loss of efficiency. However, E.ES addressed that V2G charging infrastructures are now able to work between 95-98 percent efficiently and the solution has actually already been reached.

- E.AC addressed noise nuisance as a technical barrier. This barrier is not addressed by other experts but seems an important barrier because of creating nuisance for the local residents.

[E.AC] ‘’ A limitation is also that these charging points are quite large due to the conversion of alternating current to direct current which takes place in the charging infrastructure and therefore it also contains all kinds of cooling elements. So, it makes noise compared to a traditional charging point. Experience shows that this can result to irritations, especially in residential areas, because the V2G car never stops making noise because it is charging and discharging continuously.’’

- E.ES and E.AC addressed also that the software for V2G is also not ready yet. E.ES mentioned this as currently the main challenge.

- Thereby, E.EC1 addressed that the switching speed from going to charging to discharging could be barrier to participate in the TSO market for delivering ancillary services.

7.4.2 Standardization issues

Table 17: overview codes standardization issues

Standardization issues	**E.ES**	**E.EC1**	**E.AC**	**E.KI**	**E.U**	**E.EC2**	**E.BRP**	**E.EC3**	**E.GA**	**E.DSO**	**E.M**	**Total**
Standardization issue: lack of energy market for flexible assets for small consumers			**X**		**X**							**2**
Standardization issue: lack of standards for DC-charging	**X**											**1**
Standardization issue: no open data communication protocol for V2G/ISO-15118 not ready	**X**		**X**	**X**	**X**	**X**		**X**	**X**	**X**	**X**	**7**
Standardization issue: only compatible for CHAdeMO protocol	**X**		**X**	**X**		**X**		**X**			**X**	**6**
Standardization issue: V2G charging infrastructure environment					**X**	**X**	**X**			**X**		**4**

Most of the experts addressed three main issues with standardization.

- The most addressed issue is that there is no open data communication protocol to communicate with the charging point. V2G is only compatible with the CHAdeMO protocol using closed protocol which could limit the widespread use of V2G. The ISO-15118 is a protocol that is aimed to enable an open communication but this protocol is not ready yet.

- A associated issue addressed by six experts is the fact of only the CHAdeMO protocol can be used for V2G. Whereas the Tesla and CCS charging connecters are commonly applied in Europe. So, this contributes negatively to getting a commercially available vehicle fleet.

- Four experts mentioned also that there is lack of a V2G charging infrastructure environment. There are no many charging point which have the ability to apply V2G charging.

7.4.3 Institutional barriers

Table 18: overview codes institutional barriers

Institutional barriers	**E.ES**	**E.EC1**	**E.AC**	**E.KI**	**E.U**	**E.EC2**	**E.BRP**	**E.EC3**	**E.GA**	**E.DSO**	**E.M**	**Total**
Institutional barrier: energy taxes fixed											**X**	**1**
Institutional barrier: multiple taxes				**X**					**X**	**X**	**X**	**4**
Institutional barrier: municipal charging policy					**X**				**X**			**2**
Institutional barrier: dynamic price structuring not possible for distribution grid	**X**	**X**		**X**		**X**	**X**				**X**	**6**
Institutional barrier: price transparency									**X**			**1**
Institutional barrier: netting arrangement	**X**	**X**	**X**	**X**		**X**				**X**	**X**	**7**

- Seven experts addressed the netting arrangement as an institutional barrier. This is particularly bothering Vehicle-to-Home cases because homeowners can generate energy with their solar panels and virtually store it in the grid which makes the use of V2G or stationary batteries unnecessary.

- Two experts mentioned municipal charging policy as an institutional barrier. Some municipalities apply restrictions concerning parking duration in order to prevent occupation for long times. However, longer connection times of EVs to the V2G infrastructure is in the benefit of a V2G service. Therefore, such municipal policies could be contradicting the needs of a V2G service and create barriers.

- Another institutional barrier which is mentioned multiple times is that dynamic price structuring for the connection to grid is not possible. This creates a barrier to apply V2G for congestion management.

- Four experts mentioned multiple taxes as an institutional barrier. Every time the car is recharged after discharging, energy taxes has to be paid. This is creating an issue for using V2G.

7.4.4 Trends

Table 19: overview codes trends

Trends in the benefit of V2G business models	**E.ES**	**E.EC1**	**E.AC**	**E.KI**	**E.U**	**E.EC2**	**E.BRP**	**E.EC3**	**E.GA**	**E.DSO**	**E.M**	**Total**
Trend: congestion on grid is increasing						**X**	**X**					**3**
Trend: decreasing costs of V2G charging infrastructure	**X**											**1**
Trend: increasing efficiency V2G charging infrastructure	**X**											**1**
Trend: increasing trend EVs	**X**					**X**	**X**					**3**
Trend: pressure from European legislation for energy transition						**X**						**1**

Some experts addressed trends which could positively impact a sustainable V2G business model.

- E.ES mentioned the decrease of the costs for V2G charging infrastructure.

[E.ES] ‘’ A charger costs now around the 8000 euros, and I think in 5 years it will cost around the 4000 euros or perhaps less. What we see in pilot projects where we receive a 50% subsidy is that you can make business models which is profitable. So, we know roughly that the price has to drop so much to get models that are achievable.’’

- Experts addressed also that the increasing trend EVs, increasing congestion on the grid, increasing pressure from Europeans legislation for energy transitions will empower the need of V2G.

7.4.5 Impact technological developments

Table 20: overview codes of impacts technological developments

Impact technological developments	**E.ES**	**E.EC1**	**E.AC**	**E.KI**	**E.U**	**E.EC2**	**E.BRP**	**E.EC3**	**E.GA**	**E.DSO**	**E.M**	**Total**
EV types												
PHEV not optimal	**X**	**X**	**X**	**X**	**X**				**X**	**X**	**X**	**8**
Sceptical about FCEV in passenger mobility			**X**	**X**	**X**	**X**		**X**	**X**	**X**	**X**	**8**
BEV for V2G	**X**	**X**	**X**	**X**	**X**	**X**		**X**	**X**	**X**	**X**	**10**
Impact other technologies												
Autonomous vehicle be a part of shared mobility	**X**		**X**	**X**			**X**				**X**	**5**
No contribution shared vehicles to V2G		**X**			**X**		**X**		**X**	**X**	**X**	**6**
Positive impact autonomous vehicles	**X**			**X**		**X**						**3**
Positive impact shared vehicles	**X**			**X**		**X**						**3**
Positive impact wireless charging	**X**			**X**		**X**			**X**			**4**
Wireless charging: Temporary no high expectations	**X**	**X**	**X**		**X**		**X**		**X**			**6**

- Almost all of the experts were skeptical about FCEV in passenger mobility. For the Dutch market conditions, PHEV is assumed not to be optimal for a V2G business model to rely on because of the low battery capacity. In general, the experts were convinced that BEVs are the future and that this type is most appropriate for V2G.

- Five experts mentioned that autonomous vehicles will be a part of the shared vehicle concept. Three experts mentioned that AVs could have a positive impact but that AVs are only feasible at long term. With regards to wireless charging six experts expect for now not a lot from wireless charging either. However, four mentioned that wireless charging will have a positive impact if they are feasible.

- About shared vehicles there is no consensus between the experts. Three experts mentioned that shared vehicles will have a positive impact because they do not drive too often, scheduling goes easier, V2G charging infrastructure can be placed further away from residential areas, and factors from end-user acceptance such as range anxiety and battery degradation do not apply. On the other hand, six experts mentioned that the shared vehicle concept is successful when it is driven as much as possible. These cars make more kilometers per day and when those are connected to the charge point, the intention is to charge it quickly which conflicts with V2G. Therefore, the experts do not expect that shared vehicle fits to a V2G business model.

7.4.6 AC/DC-charging

In the short term AC-charging has not been seen applicable for V2G business models. E.ES and E.AC expect that it will become DC-charging. However, it depends also on how the EV OEMs will shape the market. E.EC2 described AC-charging as more valuable but E.EC2 sees more potential in DC for now because AC-charging is not ready. The same counts for E.M, who phrased this as follow:

[E.M] ‘’ We have now DC charging points. However, if at some point there is a movement that OEMs go for AC, then it becomes AC.’’

7.4.7 Government

Table 21: overview codes government

Role of government	**E.ES**	**E.EC1**	**E.AC**	**E.KI**	**E.U**	**E.EC2**	**E.BRP**	**E.EC3**	**E.GA**	**E.DSO**	**E.M**	**Total**
Government: no consistency	X											1
Government: existing public support			X						X			2
Government: policy adapts slowly						X		X			X	3
Expectations from government												
Governmental support: no expectations about high support					X							1
Governmental support: Chicken-Egg problem		X		X						X		3
Governmental support: facilitate with finding bottlenecks in the grid							X					1
Governmental support: incentivize until V2G is commercial			X	X		X		X	X	X	X	7
Governmental support: enable using vehicle data						X			X		X	3
Governmental support: solve institutional issues	X	X							X	X	X	5

The role and support of the government is by most of the experts addressed as important. The role of government can be separated into the current attitude of government and into what the expectations are of the experts from the government. The current attitude is a category that belongs to a sustainable V2G business model because this attitude could positively/negatively impact the working of a potential sustainable V2G business model. The expectations of the experts are more policy recommendations on how the government can support V2G service providers in realizing a sustainable V2G business model.

- Currently, E.ES mentioned that there are risks because it is unpredictable how the government behave with regards to V2G.

- E.AC and E.GA mentioned that there is currently municipalities which are willing and proactively participating with V2G projects such as Amsterdam and Utrecht. This shows there are to some extent public support which is a positive signal.

- Three expert mentioned that the policy adapts slowly to the needs of V2G. E.M described that this could be due to a lack of knowledge and understanding. E.EC3 described that the governmental is always behind the technological development. E.EC2 addressed that the government not would act too quick because they prefer to see how the market develops before changing legislation.

- Except of E.U who not expect high support from the government, the experts consider governmental support at the start as necessary. Three expert addressed V2G as chicken-and-egg problem: there are no many EVs and therefore the demand is low, which makes it unattractive to develop and install V2G charging infrastructure. And because there is no many V2G charging infrastructure, the EV drivers are not aware and not interested on it. This results in a not developing V2G market.

- In total seven experts think that the government should incentive at the start the use of V2G. This can be in ways as granting subsidies for the use of V2G and R&D.

- Five experts mentioned that the government need to solve the institutional barriers which are addressed before. Three experts mentioned also that the government must enable the sharing of data from vehicles. Ways to do this is by convincing the EV OEMs to make use of open protocols, by legislation to provide EV-drivers more rights about the data of their vehicles, or by obliging EV OEMs to provide the data from the vehicles.

7.4.8 Impact Corona situation

Table 22: overview codes of impact Corona situation

Impact Corona situation	**E.ES**	**E.EC1**	**E.AC**	**E.KI**	**E.U**	**E.EC2**	**E.BRP**	**E.EC3**	**E.GA**	**E.DSO**	**E.M**	**Total**
Negative impact: less EV sales									**X**			**1**
Negative impact: less use of public transport										**X**		**1**
Negative impact: postpone investment plans				**X**		**X**			**X**			**3**
Positive impact: more at home			**X**				**X**	**X**		**X**	**X**	**5**
Positive impact: more awareness for sustainability											**X**	**1**
Positive impact: more desire for independence									**X**			**1**
No long-term effects						**X**					**X**	**2**

About the impact of Corona there is no consensus.

- Five experts addressed that the consequences of corona to stay more at home is a positive effect for a V2G business model. E.EC3 described this as follow:

[E.EC3] '' It would be very positive on V2G. We now only apply it as smart charging. What we have noticed is that the cars are often idle and when the cars are fully charged we can no longer use them. If you work often at home and the car is on the charger, you can always use it with bi-directional charging. It will greatly increase the potential of bi-directional charging.''

- E.M mentioned that there is more awareness for sustainability and E.GA mentioned also that there is more desire in the society for independence from the outside world and to being local. These impacts are in the benefit of V2G.

- However, three experts mentioned that the Corona situation results in the postponement of investment plans, which is expected to delay the development V2G. E.GA addressed that it reduces the sale of EVs as well. E.DSO mentioned also that people are maybe more worried about using public transport and therefore will use their own vehicles.

- E.EC2 and E.M mentioned that they do not think that the impacts will last for too long. E.EC2 addressed that it maybe will contribute to a delay for few years but not much. E.M expects that when everything returns to normal, that people will quickly forget the awareness for sustainability. So, both the positive and negative impacts are not expected too last for too long by these experts.

7.4.9 Social environment characteristics

Through the expert-interviews also some social environment characteristics are addressed.

Table 23: overview codes social environment characteristics

Social environment: high share of lease drivers
Social environment: fleet-owners act more rationally than private owners
Social environment: in the Netherlands little amount of houses with private charging infrastructure
Social environment: The Netherlands is a destination charging country
Social environment: time of day charging operation

7.4.10 The importance of the EV OEM

Six experts addressed the importance of the EV OEMs regarding the production of V2G compatible vehicles and to provide and share the data of their vehicles.

Three experts addressed also that Tesla could be an important actor because of their capability to deliver the whole V2G service by themselves. E.M described that Tesla has an understanding of vehicles, charging processes, and also of the energy markets. However, the attitude of Tesla towards V2G is for now not optimistic and their vehicles are not V2G compatible. Whereas Tesla has a big market in the Netherlands, their attitude could have a significant impact on V2G business models.

7.4.11 Future potentials and alternatives

There are also future potentials for V2G which could influence sustainable V2G business models. E.ES described that they are developing a battery system under the V2G charging infrastructure that can still store energy if the vehicle is not there. E.DSO addressed the use of V2G for other applications than only EVs such as electric sailing boats, forklift trucks or buses.

E.EC1 and E.EC2 mentioned that unidirectional smart charging is an alternative which also achieves the same goal. E.EC1 described also the stationary battery as an alternative. The increase of these alternatives could limit the potential of V2G business models.

7.5 Models with key components for sustainable V2G business models

It must be noted that in the current stage of V2G technology, it is not possible to propose a dominant business model because the market is still in development and the costs are too high for now. However, the most important components could be determined in order to have a sustainable V2G business model.

By making a synthesis of the results the key components for a sustainable V2G business model were provided in Figure 13. After developing a draft version of Figure 13, this figure was validated by an expert with an online meeting. The expert emphasized that distinguishing the business model to customer segments would provide a better overview, since not each value proposition matters for each customer segment. Thereafter, the business model in Figure 13 was divided into three use cases.

One use case was the Vehicle-to-Home application. Figure 14 shows a sustainable V2G business model for a Vehicle-to-Home use case.

Another use case was the Vehicle-to-Building application which is shown in Figure 15. These two use cases are assumed to be applied locally (microgrid), which includes that V2G business model would focus on peak shaving (storing energy when energy generation is high and using it when energy consumption is high) and load balancing of an office/building (balancing energy need of charge points and building). Vehicle-to-Home approaches homeowners as customer segment and Vehicle-to-Building approaches office/building owners as customer segment.

The third use case was public V2G charging which is shown in Figure 16. Public V2G charging is about applying V2G services in public charge points and serving the energy market, TSO, and DSOs.

There was also a distinction made in the value proposition and customers categories called macro and micro segmentation. The macro segmentation represents the customers to who the V2G service is offered and from who revenue is expected to be generated from. The micro segmentation represents the end-users who need to be convinced to make use of V2G services.

Hereby, in the use cases of Vehicle-to-Building and public V2G charging, the term end-user does not particularly have to refer to a private EV driver. It could also refer to a fleet-owner like a lease driver, in such a case it is better to make agreements with the lease company. This counts also in other forms in which the EV driver is not the private owner of the vehicle and there is a fleet-owner. The micro segmentation covers also the social and financial segment of end-users which were derived from Paragraph 4.6 and addressed by the experts. Socio-economic characteristics are also covered in the micro-segmentation.

The relationship of the themes, business environment, sustainability, and business models are represented by arrows:

(1) The first arrow represents the impact of the business environment on the business model. The business environments impacts the potential of sustainable business models. The categories in the business environment represent a set of components to which a V2G service provider must take into account. These categories could impact the underlying business model on a positive as well as on a negative way.

    Categories like trends, governmental support, future potentials could positively impact the potential of a sustainable V2G business model.

    On the other hand, categories like institutional, standardization and technical barriers have a negative impact. Thereby, DSOs who currently not have a market suitable for V2G and their lack of support also create issues for public V2G charging.

    There are also some categories for which there are no consensus on between experts with regards to whether it will have positive or negative impacts. This counts for categories as battery degradation, corona situation, and shared vehicles (for public V2G charging). The impact of shared vehicles on Vehicle-to-Home and Vehicle-to-Building could be assumed negative because shared vehicle contributes to less vehicle ownership which means less parking on home or work.

    For components, to which there is no consensus on, more research and evidence are needed. The category about social environment represents the social environmental characteristics to which the underling business model must be alert on.

(2) The second arrow represents the sustainable archetypes that are underlying to the V2G business model or that are a result of a working sustainable V2G business model.

    Environmental:
    The increase of the share of RES in the energy is the underlying factor for the value proposition of increasing the sustainability of the Dutch energy grid. Efficiency in the utilization of available renewable energy is the underlying factor for the value proposition of peak shaving and load balancing. Postponing grid reinforcement investments is the underlying factor for creating space for more assets in the grid and it is also the result of a sustainable V2G business model. Material efficiency, power quality, and increase in share EVs are expected environmental results of a sustainable V2G business model.

Social:
There are also factors from the social category that must be represented in the V2G business model. That cooperation is necessary is a underlying factor for the high numbers of partnerships, and activities for which the role of different actors must be satisfied.

Delivering V2G functionality to end-users without them having a physical property is possible because in the use cases of Vehicle-to-Building and public V2G charging the end-users do not have the need a private V2G charge point.

The result of a potential sustainable V2G business model is also that the behaviors of EV-drivers are impacted. For public V2G charging a result could also be that there consists pressure for a V2G parking spot between EV-drivers, this means public V2G charging could also negatively contribute to the social category of sustainability.

Economic:
The economic category consists of that V2G is commercial but also contributes to a sustainable society. The generation of revenues is therefore an important category for a sustainable V2G business model and therefore most of the value propositions focus on generating revenue or decreasing of costs. To contribute to a sustainable society is an underlying factor as well, because the ways to generate value are also ways to contribute to a sustainable society. For example, peak shaving, load balancing of office/buildings, or providing flexibility to the energy grid could contribute to the generation of revenue but they also contribute to sustainability.

Inclusive value generation is required which could be derived from the number of partnerships, activities, and resources which are needed from other actors such as interfaces. Decrease total cost of ownership of an EV is also an economical result of a sustainable V2G business because of the possibility to earn money from the EV.

(3) The third arrow represents the evaluative criteria of the sustainability categories which a business model must satisfy, at least, to penetrate the market. Hereby, the economical category could be of crucial importance for a sustainable V2G business model. V2G is expected to be a commercial product, which means that a V2G service provider must be economically independent in which the revenues must be higher than the costs. Without having this realised the realization of a sustainable V2G business model does not seem feasible. Once it is commercially ready, it is to large extent, believed that V2G contributes to a sustainable society. So, the component that V2G is commercial and also contributes to a sustainable society is a leading criterion to have been satisfied.

If the V2G service provider is not capable of doing the key activities by itself, good cooperation and inclusive value generation are conditions that must be satisfied as well. Otherwise, delivering V2G services will not be optimal creating a decrease in the potential of V2G business models.

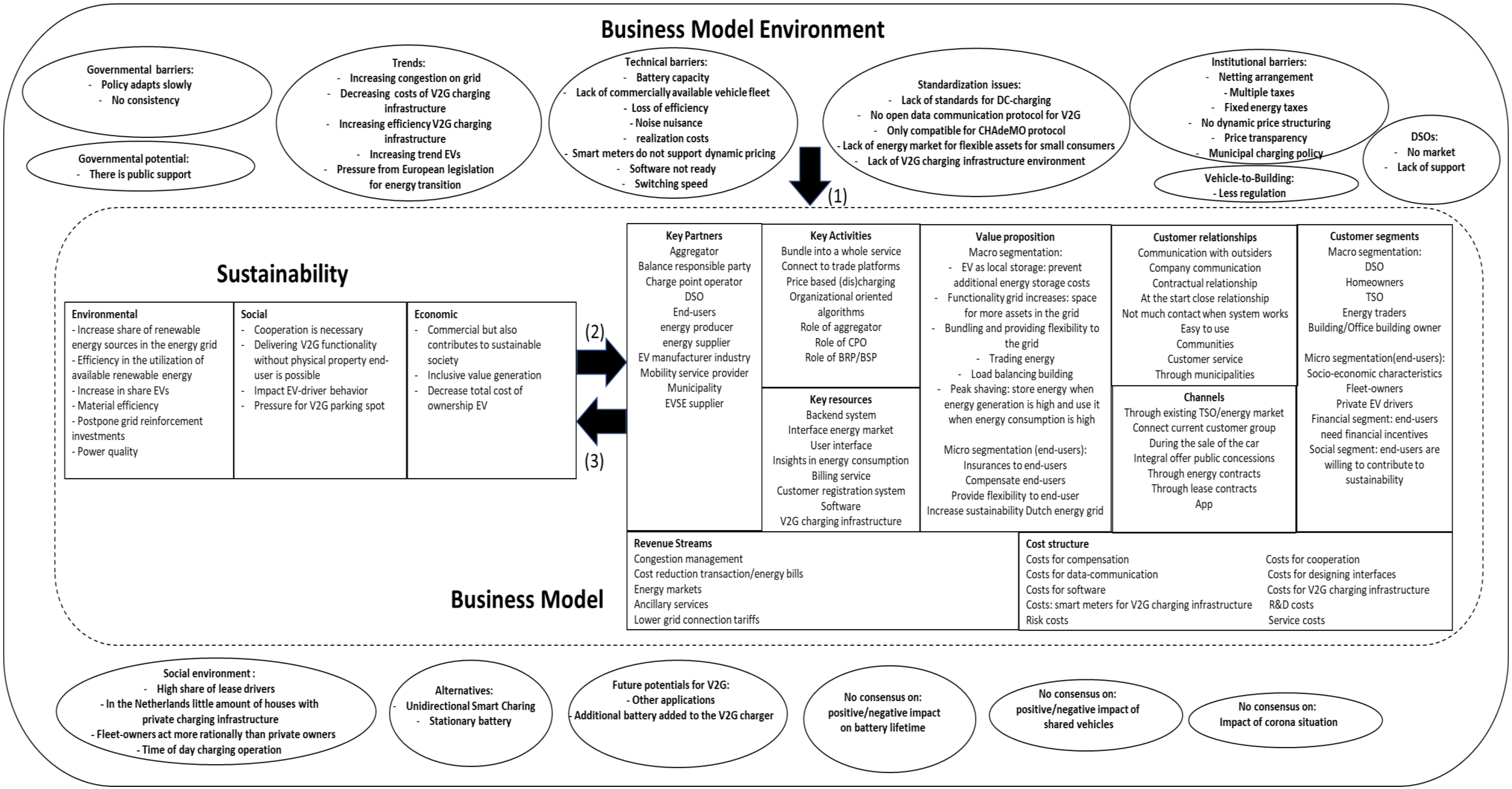

Figure 13: Key components sustainable V2G business models

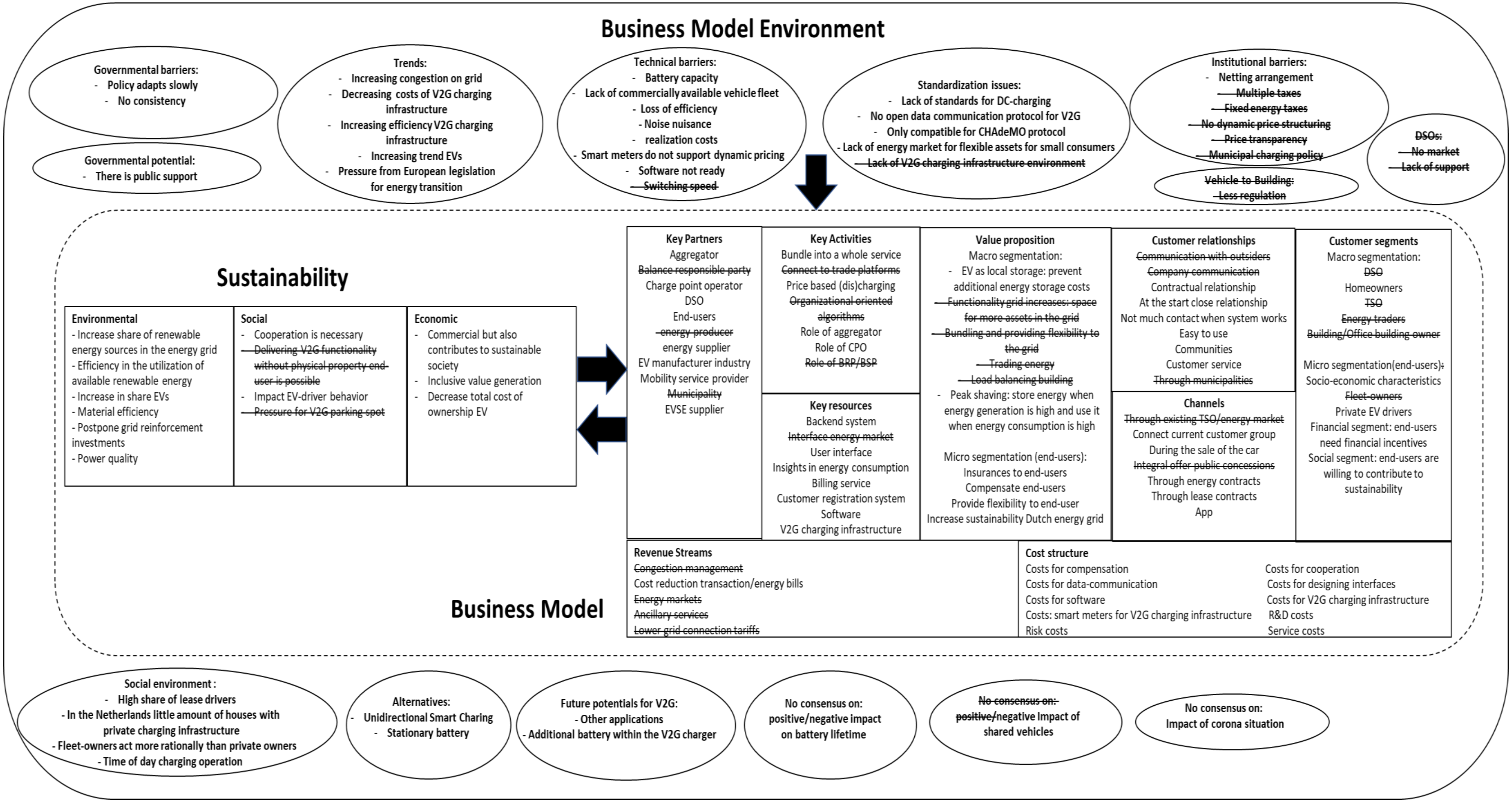

Figure 14: sustainable business model Vehicle-to-Home use case (local)

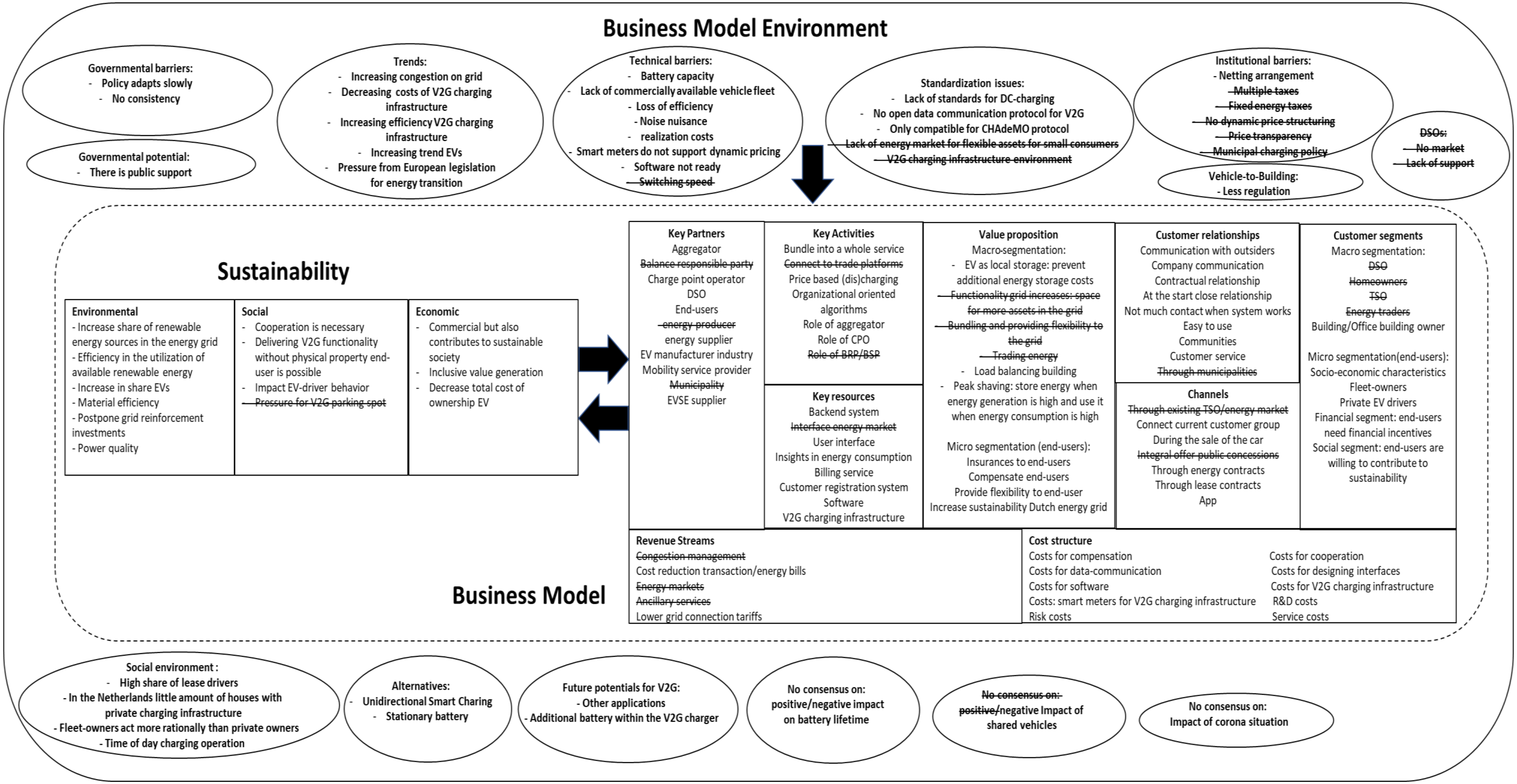

Figure 15: sustainable business model Vehicle-to-Building use case

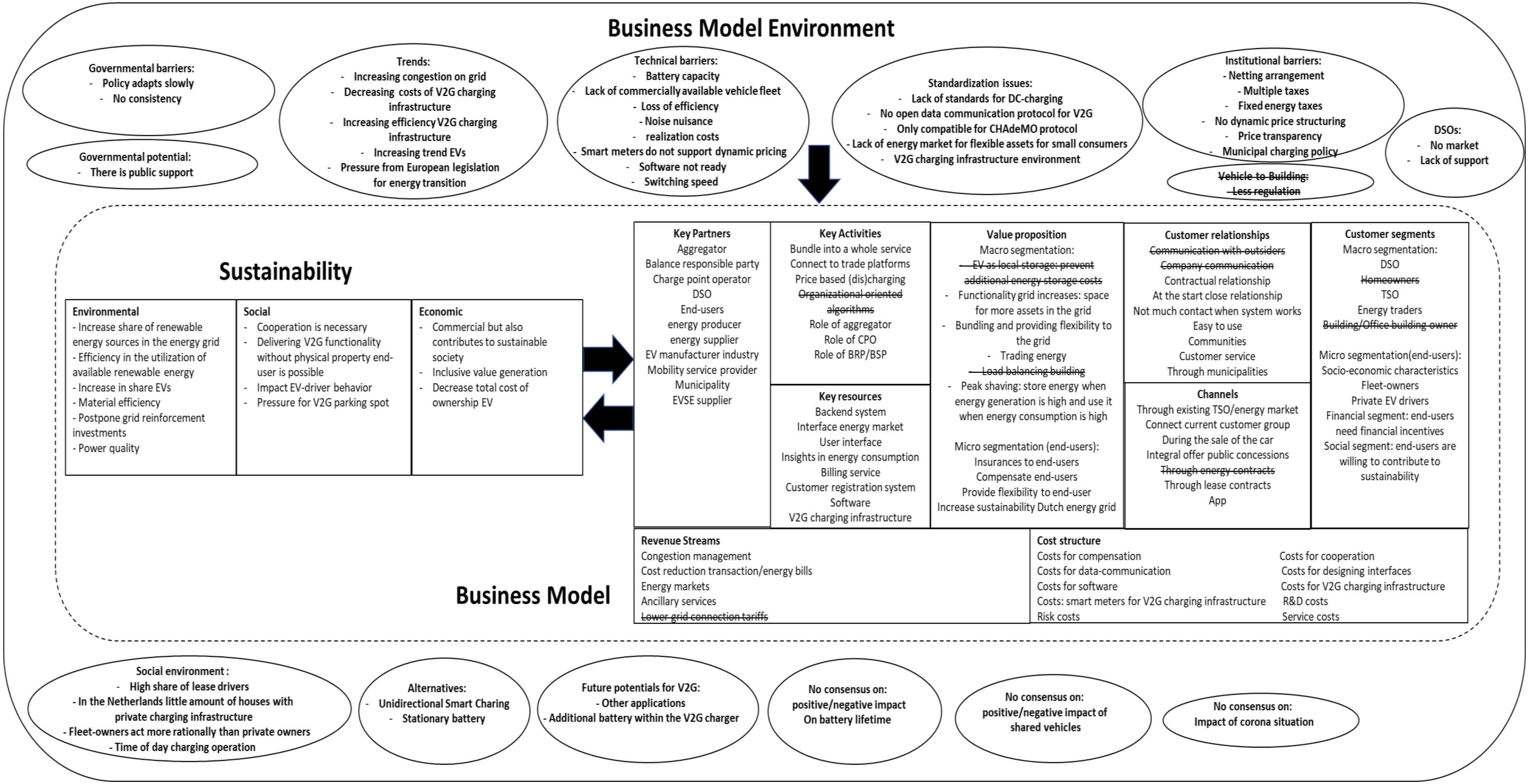

Figure 16: sustainable business model public V2G charging

8. Conclusion and discussion

This research aimed to find the key components for potential sustainable V2G models for the Netherlands. The main research question in this study was phrased as following:

‘’What are the key components for potential sustainable Vehicle-to-Grid business models within the Dutch market conditions?’’

The research was done by a qualitative research in which 11 experts were interviewed. To answer the main research question, five sub-question were asked. The first four sub-questions helped to enrich the theoretical lens of the expert-interviews.

The first sub-questions helped develop a theoretical framework which shows the elements for a sustainable V2G business model. This framework showed that a sustainable V2G business model consists of three themes: business model, sustainability, and business environment.

The second question sub-question was based on the V2G actors environment. The experts were selected from the actor groups that appeared to be important from this actor analysis. Furthermore, the role of V2G service provider and consumers were further detailed. Thereby, the actor analysis showed that there are institutional and standardization issues. The actor analysis contributed therefore to many questions regarding sustainable V2G business models.

The third sub-question aimed to conduct case studies in order to enrich the theoretical framework with insights from current V2G business models. Although no company did determine a V2G business model, the case studies showed insights about how companies would consider developing a business model regarding V2G.The case studies showed that V2G could be used in further applications, which are not directly associated with Vehicle-to-Grid. A possible use case was the vehicle-to-off-grid in which bi-directional chargers has been used for supplying electricity to events without using the energy grid. Furthermore, the case studies contributed to question regarding sustainable V2G business models.

The fourth sub-question aimed to conduct an analysis on how technological developments can impact the potential of a sustainable V2G business model. First, it appeared that the developments of the electric vehicles in itself could matter: BEV which have relatively high battery capacity but a low range, PHEV which have relatively low battery capacity but a high range, and FCEV which have relatively high capacity and range but the fuelling infrastructure is not developed and is relatively more costly per kilometre. Furthermore, the impact of autonomous vehicles, shared vehicles, and wireless charging on a V2G business model needed more clarification. This resulted also in additional questions regarding sustainable V2G business models.

The fifth sub-questions aimed to explore the perceptions of experts regarding the development of sustainable business models for V2G. For this sub-question, the semi-structured interviews were conducted and analysed.

Based on results it must be mentioned the Dutch market is not mature enough to be feasible for a V2G business model. This has to do with 3 main categories, those are the institutional, technical, and standardization issues.

The main technical issues refer to issues with battery capacity, commercially available vehicle fleet, and the V2G infrastructure costs.

The main standardization issues refer to there is no open data communication protocol for V2G that is expected to be enabled by ISO-15118 but which is for now not ready. There is only the CHAdeMO protocol which is compatible for V2G, while the Tesla and CCS protocol are commonly applied in the Netherlands. There is also no V2G charging infrastructure environment which negatively contributes to the standardization of V2G.

The institutional barriers depends one two parameters which is the use case and which is the customer segment a V2G service provider would prefer to focus on.

The customer segments that can be served to gather revenue from are homeowners, office/building owners, the energy market (day-ahead and intraday market) and ancillary services market (FCR and aFRR). A preferable additional market is the local congestion market for serving DSOs in congestion management. However, it appeared that the DSO market is under heavily legislation. They may not use batteries and they cannot apply dynamic price structuring because of legislations. This makes the application of V2G at the DSO market for now too complicated. Multiple taxes, in which for each charging sessions after the car is discharged taxes must be paid, has also a barrier for a V2G business model.

For V2G several use cases are possible: Public V2G charging, V2G for homeowners (Vehicle-to-Home), and V2G for office building/building owners (Vehicle-to-Building).Whereas public V2G charging has to deal with municipal regulation regarding restrictions on the occupation of charge points, Vehicle-to-Home and Vehicle-to-Building cases do not have to face such regulations. What particularly disturbs the Vehicle-to-Home case is the netting arrangement in which energy generation from solar panels can be virtually stored in the energy grid. The Vehicle-to-Building case could be feasible because building owners or businesses could also save money from lower grid connection tariffs, for which the regulatory issues are less a bottleneck.

Although the V2G market is not mature yet, there appeared to be potential for a working V2G business model due to the increasing trend of EVs, increasing grid congestion, and decreasing costs for V2G charging infrastructure. Also the netting arrangement which is expected to be expired in 2023 and the prevention of multiple taxes which is expected to be prevented soon will have a positive impact on the developing of sustainable V2G business models.

From the results of the interview the key components for categories of each of the themes of V2G sustainable business models are determined.

For answering the main research question these key components are synthesised into the theoretical V2G framework. This resulted into a final framework which shows the key components for a sustainable V2G business model (Figure 13). This was further detailed in Vehicle-to-Home (Figure 14), Vehicle-to-Building (Figure 15), and public V2G charging (Figure 16) use cases.

8.1 Generalization to other markets

It has to be mentioned that for a working V2G business model the business environment seems vital. Whereas within the Netherlands for the current institutional environment only the Vehicle-to-Building case seems feasible, for other countries this could be different. Also the developments that the market is undergoing could differ among countries. Whereas the Netherlands has an increasing trend in EVs, in particular for BEVs, other markets does not particularly need to experience the same developments.

Taking the Netherlands as a scope within this thesis has therefore weakened the generalization of the V2G business model to other countries. On the other hand, this is something expectable and if parties would like to operate in multiple countries, different business models are necessary. Each country has its own legislation and own developments that positively or negatively affect the potential of a sustainable V2G business model. In countries where dynamic price structuring is possible for grid connection, the potential for applying V2G services for congestion management is much more accessible. For countries where there are many homes with solar panels and where there is no arrangements as the netting arrangement, a Vehicle-to-Home application could get much more attention. On contrary, these countries could have other legislation that could hamper the realization of a sustainable V2G business model.

Furthermore, the standardization issue could differ for each country. The CHAdeMO protocol is for now the only commercial way to apply V2G, which makes it difficult to create a sustainable V2G business model within the Dutch market conditions. In the Netherlands the CCS and Tesla protocols are widely spread. This creates issues to have a commercially available vehicle fleet. However, countries where the CHAdeMO is widely used do not have to face such big standardization issues.

8.2 Generalization to other applications

To which use case application a V2G service providers would like to focus on does matter as well. This thesis has been limited to determining the key components for developing V2G for public charging, Vehicle-to-Home, and Vehicle-to-Building case applications because of the results that were determined from the expert interviews. However, the application of a Vehicle-to-off-grid use case was also addressed during the cases studies but in the expert-interviews this does not get high attention. The application of Vehicle-to-Appliance and application in which other electrical equipment can be used instead of cars was also addressed but such applications in which bi-directional charging can be applied did not get high attention. This could be because the idea of the V2G technology is established by using EVs for the energy grid. Such applications go a step further. While the V2G in itself is not commercialised yet, the bidirectionality of V2G makes this technology possible to use for other applications. However, the developed sustainable V2G business model is not fully applicable to these applications because such applications could mean other partnerships, value proposition, and customer segments which is not determined in this model yet. Thereby, the impact on sustainability could be different and how the business environment will impact the business model could also be different.

8.3 Comparison to smart charging

In the introduction, it was addressed that V2G is a form of smart charging which operates bidirectional. Although this study focused on V2G, smart charging could also create to a large extent the same benefits what V2G could. Smart charging could deliver energy services by optimizing time of use (price tariffs), managing network constraints, peak demand shaving, and optimizing use of renewables. Value propositions as peak shaving, load balancing, and providing flexibility to the energy grid could also delivered by smart charging.

However, the flexibility which could be offered by smart charging is lower than which could be done with V2G. When the EVs are fully charged, smart charging has no ability to discharge which makes the utilization of this EV no more possible. With V2G, fully charged EVs could also be used for discharging which provides more flexibility. While with smart charging peak shaving apply for charging the EV during high generation of renewable energy, for V2G the EVs can also be utilized during high consumption. The same counts for load balancing of an office building or congestion management. V2G has further also ability to deliver ancillary services to the TSO and to use it for energy trading. These all make the potential of earning money and contributing to sustainability from V2G higher than smart charging.

On the contrary, smart charging does not have to face as much barriers as V2G is undergoing. The technical, standardization, institutional issues addressed for V2G such as the high infrastructure cost, the only compatibility of the CHAdeMO protocol, and the netting arrangement does not create barriers for smart charging. Thereby, battery degradation does not occur with smart charging. Consequently, smart charging has lower costs, risks, and barriers. Thereby, smart charging is already commercially available and is broadly accepted. However, from the Jedlix case it appeared that smart charging is for now commonly consumed by EV drivers who own private charge points. How smart charging will deal with public charging, office/building owners, or fleet owners are possible markets in which smart charging is not commonly applied yet. So, smart charging has more potential as well. The social factor of impacting the behavior of EV-drivers are also more limited in the case of smart charging. During smart charging only the charging rates could be modulated but during V2G services discharging could be applied as well.

Comparing V2G and smart charging, shows that V2G has more benefits in terms of the higher flexibility that it could offer and smart charging has more benefits in terms of less barriers that it faces. Hence, both V2G and smart charging could play important roles.

Smart charging could also be a channel for V2G services in the future. Namely, as described before, connecting current costumers groups could be a channel to reach customers for V2G. Users of smart charging services can therefore in the future be approached to use V2G services as long as they have the appropriate vehicle for it. So, smart charging could also be a stepping stone until V2G is commercially ready.

8.4 Dynamics

Dynamics play an important role in V2G business models. The business environment and also the cost- and revenue structure is changing over time. There is an increasing trend in congestion on the Dutch energy grid due to higher decentralized energy generation and use of renewables in the energy grid. The increasing trend of EVs which is visible in the increasing penetration rates makes the pressure on the grid and the need of V2G even higher.

The institutional issues are not static either. The netting arrangement is valid until 2023 but this will probably be abolished after time. Multiple taxes will probably be prevented and pressure from European legislation for energy transition is increasing which could result in other regulatory incentives. V2G is also getting more attention, which could result in more standardization. The decreasing costs of V2G infrastructure and its increasing efficiency gets the V2G technology closer to being commercially ready as well.

However, the flexibility which from V2G can be gathered is difficult to predict. To what extent the increasing trend of EVs will keep going, whether the EVs will be V2G ready, what the acceptability of EV drivers will be for allowing to discharge their EVs, and to what extent they will limit the SOC of their EVs are factors that are not static. These factors impact the predictability of revenue generation and therefore impact the potential of developing sustainable V2G business models.

While the market for DSOs are not developed yet and until now there was no high support, DSO are also starting to take part in V2G pilot projects. The development of AC or DC charging could change over time as well. Whereas now DC-charging seems to have more potential, the change of attitudes of EV OEMs could make AC-charging more competitive.

Thereby, the development of alternatives as smart charging an stationary batteries are ongoing too. To what manner these technologies will penetrate or dominate the market will have an impact on the development of sustainable V2G business models. If stationary batteries take the lead, this could result in less need for V2G, which makes the business model not work.

All of these factors are variable and hard to predict. This means that it is important to be alert on that those factors are dynamic and to be aware in what direction these factors are moving to. If positive trends stop or negative factors and barriers increase, the potential of sustainable V2G business models will be lost.

8.5 Policy recommendations

For obtaining a sustainable V2G business model, the government could have a significant impact. The recommendations for policy is based on three dimensions: solve institutional issues, contribute to use open data, and incentivize the market until V2G is commercially feasible.

Based on the results, the institutional aspect creates barriers which make the use of V2G not attractive.

Firstly, the netting arrangement makes the Vehicle-to-Home use case unnecessary. This arrangement is valid until 2023. It is recommended to not to expand this arrangement. Thereby, it is recommended to give the market more information regarding the expiration date. If the arrangement will expand to for example 2031, this make the Vehicle-to-Home use case inappropriate. By providing information in a timely manner, the market will at least know what the situation will be.

It is therefore also recommended to develop a roadmap to provide this to market players in which the plans related to the adaption of legislation and arrangements regarding electric mobility and the energy grid are shared.

Another institutional barrier is that no dynamic price structuring is possible for the connection the distribution grid. It is recommended to make this in a way possible to provide DSOs the opportunity to use V2G and compensate end-users for services that are delivered regarding congestion management.

Energy taxes are fixed as well. Applying dynamic pricing for energy taxes could contribute to the use of V2G.

Thereby, the multiple taxes is an institutional barrier too. Although the EU has already provided directives to prevent this, it must still be adapted to the Dutch legislation. It is recommended to solve this because elsewise people will be disadvantaged for using V2G.

The municipal charging policies makes the use of public V2G charging complicated, therefore it is also recommended to adapt this. Currently, some municipalities impose a maximum duration for EVs to stay parked or connected at a charge point. An exception could be made for V2G charge points in which the EVs could stay connected for longer times which make the flexibility of such an EV much higher.

It is also recommended to incentivize the use of open data and enforcing EV OEMs to provide data of their cars. Cars are of the property of the end-users but if they cannot manage the data, the communication of the EV with the V2G infrastructure becomes less optimal. The government could put pressure on EV OEMs to make the use of vehicle data more open. The government could also search for legislation which empowers the right of the EV drivers regarding the data of their vehicles.

Lastly, it is recommended that the government incentivizes the use of V2G until it is commercially ready. The government is already supporting V2G by granting subsidies to pilot projects and investing in charging squares which are capable of V2G. It is recommended to continue with this and support R&D but also by providing subsidies in order to give the impulse that it is needed to make V2G feasible. These incentives will be temporary because the market must be able to operate independently, but for now a business case seems not feasible. Therefore, incentives from the governments are vital.

8.6 Managerial implications

For actors that are relevant for V2G services or regarding potential V2G service providers some notes can be made as well.

Firstly, actors who would enter the V2G market or are working already on it will face many barriers at the moment due to institutional, technical, and standardization issues. It is therefore helpful to keep in mind that this technology will be associated with a lot of R&D, investment costs, risks, and cooperation. However when it is operationally feasible, its realization costs decrease, and it becomes widely applied, then it could be profitable because the costs are mainly those investment costs. This makes the V2G market complicated but also promising due to the ability to generate revenue through V2G services.
To be aware of this and to have a long breath are necessary because there will be no quick solutions.

Secondly, it is helpful, for actors who see themselves as potential V2G service providers that they know to which customer segment they would like to serve and which use case they would like to apply. However, it is not recommended to stick on it too much. The business environment is mainly impacting the feasibility of a use case. How this business environment develops is therefore something important to be alert on and something to be adaptive on.

Thirdly, it is for potential V2G service providers recommended to fulfil as much roles as possible. These roles contain the role of CPO, MSP, energy supplier, aggregator, BRP/BSP and even the role of EV OEM. Such a party, who could satisfy as much roles as possible, will be more competitive because this makes it much easier for the end-user and the revenues will be shared among less parties.

In the end, it is important to make V2G easily accessible and easy to use for the end-user. Therefore, offering the V2G option during the sale of an EV is an important channel to reach the end-users.

Lastly, V2G technology seems to develop beyond its initial intention. It is possible that V2G technology will be applied in other cases then the ones for which business models are intended to be developed for. To keep this mind and searching for such opportunities could make a company which is involved in the V2G market more competitive.

8.7 Scientific contribution

The knowledge gaps showed that the current literature needed more research on determining sustainable V2G business models. Thereby, it showed the need to explore relevant actors and relationships, the most appropriate actor(s) for providing V2G services, the role of consumer groups related to business models, and insights about current V2G business models.

This research helped to understand the actors and relationships that are involved in delivering V2G services and how they interrelate to a V2G business model. The role of V2G service provider, which not get too much attention, has also been made more explicit in this research. It is clear that V2G associates with interrelated partnerships and cooperation in the mobility and energy sector. The roles of MSP, CPO, aggregator, and BRP (for public V2G charging) must all being satisfied. The V2G service provider could be the actor who coordinates this partnership and offers the bundle of activities as one service, or the V2G service provider could satisfy all these roles by itself.

Thereby, the role of EV OEM and government were specified as necessary in creating a business environment that contributes to sustainable V2G business models. The role of EV OEM is important to serve as a channel for delivering V2G services directly to the end-user. On the other hand, the role of EV OEM is essential to obtain a commercially available vehicle fleet and for data communication. The role of government is vital to solve institutional issues and incentivize the use of V2G until it is commercially ready.

The role of consumers during the development of sustainable V2G business models was made more precise as well. The consumers could consist of private EV drivers but also from fleet-owners. The ways to offer them value are made more explicit in this research.

Furthermore, a sustainable V2G business model is developed, which was as far as known not developed yet by applying a qualitative approach and conducting expert-interviews. The use of such an approach was new in this field.

This business model also showed the key themes, categories, and components for a sustainable V2G business model. Although, the components could differ per use case, customer segment to which these services would be offered, and in which country/market the V2G business model is operating. The themes and categories that are constructed could be the basis for each sustainable V2G business model. So, this research contributes to the scientific literature by providing a comprehensive view of the key actors and factors for a sustainable V2G business model as well.

8.8 Link to the programme of ‘’Complex Systems Engineering and Management’’

The ‘’Complex Systems Engineering and Management’’ programme educates to explore innovations in complex socio-technical environments. It is multidisciplinary programme that looks to innovations from technological as well as from social, economic, and institutional perspectives. The current technological developments regarding V2G make it already possible that bidirectional charging occurs. Developments show that technology is in progress, like the increasing efficiency and the decreasing V2G infrastructure costs. However, there are still technical complexities such as the infrastructure that is still significantly expensive, software that is not ready yet, and the protocols that are still an issue. Thereby, the institutional and standardization problems make the development of sustainable V2G business models difficult. There are a lot of actors involved and social acceptance of end-users are still questionable. These problems make clear that V2G technology corresponds to multidisciplinary issues. When developing sustainable V2G business models, these issues were all accounted for, which makes this research fit into the ‘’Complex Systems Engineering and Management’’ programme.

8.9 Limitations research

Although expert from each relevant actors group was intended to be used for the interviews and was contacted, for some actor groups, there were no experts founded, the request was forwarded, or they did not react. This could be a limitation of this research because each expert could provide insights from its background. The lack of an expert from the TSO, which is a key player for delivering ancillary services, could therefore limit the findings. The lack of an expert from a municipality could also be a limitation because they could play an important role in public V2G charging.

Furthermore, a limitation of this research is the perspective that has been used. The perspective that has been used was to develop a sustainable V2G business model for a V2G service provider. However, emphasizing on one actor group and their perspectives on V2G could provide more insights into the business environment of a V2G business model.

For instance, the EV OEMs play a key role in the production of V2G compatible cars, whether this will be AC/DC, and to what extent they will give the data of the vehicles free. Also, questions, whether EV OEMs see their selves satisfying the role of V2G service provider, are interesting topics to research on. Although an expert who formerly worked for an automotive company had participated, the interview was conducted by semi-structured question which followed the same perspective for each expert-interview.

A more specific example is the attitude of Tesla. Tesla was in the expert-interviews seen as a company that could satisfy the role of the V2G service provider, but their perspectives with regards to V2G are not clear. Nevertheless, Tesla could have a significant impact on the business environment for V2G if they make their vehicles capable of V2G.

So, gathering insights from EV OEMs is important but this research did not explicitly focus on them. This also counts for actors as DSOs and the government from who the attitude towards V2G is not very well-known.

Another limitation was that the research was limited to the Netherlands. This was necessary because the market conditions in which a V2G business model will operate is vital. So, the market conditions must be determined. The available timeframe for this research did not allow to widen the scope to multiple countries and therefore the choice was made to focus on one specific country.

The research has also the limitation that each interview was done online because of the current corona situation. This resulted in that the audio-recording was not totally optimal due to the connection which was sometimes hampering. This could have been resulted in loss of information. However, the transcriptions of the interviews were sent to the experts for approval. Furthermore, the interviews and transcriptions were conducted in Dutch, while the coding and citations were applied in English. This could also result in loss of information.

8.10 Future research recommendations

Based on the limitations addressed before, future research can be conducted towards specific actor groups. In particular for the actors EV OEM, government, and DSO. Qualitative research to different automotive companies, governmental agencies, and DSOs could shed light on what their perceptions, attitudes, and expectations are towards V2G and to what extent they are willing to support V2G.

A limitation which is addressed before is that this research limited itself to the Netherlands. Similar researches for other countries could give the opportunity to see how key components for sustainable V2G business models differ for other countries. What differences and similarities contribute to the potential of sustainable V2G business models can be used as lessons. Thereafter, it can be researched whether this opportunities can be adapted to the Netherlands. Similarly, qualitative research and expert-interviews can be used as methods for the research of these countries.

Another recommendation for future research is to look into what the results will be if the netting arrangement will be expired. Most of the experts see this as a barrier and expects that if this arrangement expires, the V2G gets more potential because of the need for energy storage. However, people can also use stationary storages, or just apply unidirectional smart charging, or maybe remove their solar panels. What the behaviour of people with solar panels will be among these and other options is an issue that needs research in order to explore what the potential of the expiration of the netting arrangement will be for V2G. Thereby, experts addressed that V2G could contribute to the adoption of EVs. Maybe it could also contribute to the adoption of solar panels among people who has already an EV. Research to whether V2G can contribute to the adoption of EVs and/or solar panels can therefore be helpful. This can be researched by conducting surveys or stated choice experiments.

Also quantitative research is recommended for future researches. Studies calculating the business case for a sustainable V2G business model for different use cases could provide a better view on which use cases are more recommended, how much revenue can be gathered from the different customer segments and under which conditions the business model is economically viable. Modelling studies could be used for this.

This research showed that V2G is open for new use cases. Whereas the use cases which are used in this research are the common cases where the literature gives attention to, the feasibility of other use cases and application could get more attentions. Vehicle-to-off-Grid was already shown in the case studies and other use cases where addressed as well. This and other uses case could get more attention.

Lastly, this research showed that there is between experts no consensus about the impact of three categories on sustainable V2G business models. These categories were battery degradation, shared vehicles, and the corona situation. Regarding battery degradation there is no consensus on whether it will impact the lifetime of a battery. Although there are quite research towards this issue, there is in the literature neither consensus about it. It is recommended to do more research on this aspect and also determine whether battery degradation must be considered in a V2G business model. Because if battery degradation is the case, this will negatively impact the environment and compensation should be provided to the EV owner. Research on the integration of shared vehicles for V2G is also recommended because as appeared from the case studies a lot of pilot projects use shared vehicles. However, the experts have no consensus on whether this shared vehicle concept is useful for a V2G business model. Therefore, future research is recommended.

References

ACM. (2020). Energieleveranciers. Retrieved from https://www.acm.nl/nl/onderwerpen/energie/energiebedrijven/vergunningen/het-leveren-van-elektriciteit-en-gas

Ahmad, A., Alam, M. S., & Chabaan, R. (2017). A comprehensive review of wireless charging technologies for electric vehicles. *IEEE Transactions on Transportation Electrification, 4*(1), 38-63.

AirQon. (2020). AirQon. Retrieved from https://www.airqon.eu/

Atieno, O. P. (2009). An Analysis of the Strengths and Limitation of Qualitative and Quantitative Research Paradigms. *Problems of Education in the 21st Century, 13*, 13-18. Retrieved from <Go to ISI>://WOS:000453469800002

Bailey, J., & Axsen, J. (2015). Anticipating PEV buyers' acceptance of utility controlled charging. *Transportation Research Part A: Policy and Practice, 82*, 29-46.

Bocken, N. M., Short, S. W., Rana, P., & Evans, S. (2014). A literature and practice review to develop sustainable business model archetypes. *Journal of Cleaner Production, 65*, 42-56.

Bohnsack, R., Van den Hoed, R., & Oude Reimer, H. (2015). Deriving vehicle-to-grid business models from consumer preferences. *World Electric Vehicle Journal, 7*(4), 621-630.

Boons, F., & Lüdeke-Freund, F. (2013). Business models for sustainable innovation: state-of-the-art and steps towards a research agenda. *Journal of Cleaner Production, 45*, 9-19.

Brandt, T., Wagner, S., & Neumann, D. (2017). Evaluating a business model for vehicle-grid integration: Evidence from Germany. *Transportation Research Part D: Transport and Environment, 50*, 488-504.

Briones, A., Francfort, J., Heitmann, P., Schey, M., Schey, S., & Smart, J. (2012). Vehicle-to-grid (V2G) power flow regulations and building codes review by the AVTA. *Idaho National Lab., Idaho Falls, ID, USA.*

Broneske, G., & Wozabal, D. (2017). How do contract parameters influence the economics of vehicle-to-grid? *Manufacturing & Service Operations Management, 19*(1), 150-164.

CBS. (2019). Share of renewable energy up to 7.4 percent. Retrieved from https://www.cbs.nl/en-gb/news/2019/22/share-of-renewable-energy-up-to-7-4-percentShare

Chan, C. C. (2007). The state of the art of electric, hybrid, and fuel cell vehicles. *Proceedings of the IEEE, 95*(4), 704-718.

de Rubens, G. Z. (2019). Who will buy electric vehicles after early adopters? Using machine learning to identify the electric vehicle mainstream market. *Energy, 172*, 243-254.

DeeldeZon. (2020). Deelauto's als wijkaccu met zonne-energie in Vlaanderen en Zuid-Nederland. Retrieved from https://www.deeldezon.eu/

Drude, L., Pereira, L. C., & Ruther, R. (2014). Photovoltaics (PV) and electric vehicle-to-grid (V2G) strategies for peak demand reduction in urban regions in Brazil in a smart grid environment. *Renewable Energy, 68*, 443-451. doi:10.1016/j.renenE.EC1014.01.049

Energieleveranciers. (2020). Overzicht Netbeheerders stroom en gas in Nederland. Retrieved from https://www.energieleveranciers.nl/netbeheerders/overzicht-netbeheerders

EUR. (2019). Directive (EU) 2019/944 of the European Parliament and of the Council of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU. Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1587821027300&uri=CELEX:32019L0944

Evans, S., Vladimirova, D., Holgado, M., Van Fossen, K., Yang, M., Silva, E. A., & Barlow, C. Y. (2017). Business model innovation for sustainability: Towards a unified perspective for creation of sustainable business models. *Business Strategy and the Environment, 26*(5), 597-608.

evRoaming4EU. (2020). The next e-mobility architecture. Retrieved from https://www.evroaming4.eu/news/the-next-e-mobility-architecture/

Flath, C. M., Gottwalt, S., & Ilg, J. P. (2012). *A revenue management approach for efficient electric vehicle charging coordination.* Paper presented at the 2012 45th Hawaii International Conference on System Sciences.

García-Villalobos, J., Zamora, I., San Martín, J. I., Asensio, F. J., & Aperribay, V. (2014). Plug-in electric vehicles in electric distribution networks: A review of smart charging approaches. *Renewable and Sustainable Energy Reviews, 38*, 717-731.
Gatzert, N., & Osterrieder, K. (2020). The future of mobility and its impact on the automobile insurance industry. *Risk Management and Insurance Review, 23*(1), 31-51.
Geels, F. W. (2012). A socio-technical analysis of low-carbon transitions: introducing the multi-level perspective into transport studies. *Journal of Transport Geography, 24*, 471-482. doi:10.1016/j.jtrangeo.2012.01.021
Geissdoerfer, M., Vladimirova, D., & Evans, S. (2018). Sustainable business model innovation: A review. *Journal of Cleaner Production, 198*, 401-416.
Gerring, J. (2004). What is a case study and what is it good for? *American political science review, 98*(2), 341-354.
Geske, J., & Schumann, D. (2018). Willing to participate in vehicle-to-grid (V2G)? Why not! *Energy Policy, 120*, 392-401.
Ghotge, R., van Wijk, A., & Lukszo, Z. (2019). *Challenges for the design of a Vehicle-to-Grid Living Lab.* Paper presented at the 2019 IEEE PES Innovative Smart Grid Technologies Europe (ISGT-Europe).
H2Platform. (2020). tanklocaties. Retrieved from https://opwegmetwaterstof.nl/tanklocaties/
Habib, S., Kamran, M., & Rashid, U. (2015). Impact analysis of vehicle-to-grid technology and charging strategies of electric vehicles on distribution networks–a review. *Journal of Power Sources, 277*, 205-214.
Han, S., & Han, S. (2012). *Economics of V2G frequency regulation in consideration of the battery wear.* Paper presented at the 2012 3rd IEEE PES Innovative Smart Grid Technologies Europe (ISGT Europe).
Hermans, L. M., & Thissen, W. A. (2009). Actor analysis methods and their use for public policy analysts. *European Journal of Operational Research, 196*(2), 808-818.
Iacobucci, R., McLellan, B., & Tezuka, T. (2018). Modeling shared autonomous electric vehicles: Potential for transport and power grid integration. *Energy, 158*, 148-163.
Iacobucci, R., McLellan, B., & Tezuka, T. (2019). Optimization of shared autonomous electric vehicles operations with charge scheduling and vehicle-to-grid. *Transportation Research Part C: Emerging Technologies, 100*, 34-52.
Jang, Y. J. (2018). Survey of the operation and system study on wireless charging electric vehicle systems. *Transportation Research Part C: Emerging Technologies, 95*, 844-866.
Jayadharashini, N. Driving the Future-Electric Mobility a Paradigm Shift & Its Challenges.
Jayadharashini, N. V. (2019). Driving the future - electric mobility a paradigm shift & its challenges. *IEEE Transportation Electrification Conference (ITEC-India)*. doi:10.1109/itec-india48457.2019.itecindia2019-146
Ke, W. W., Zhang, S. J., Wu, Y., Zhao, B., Wang, S. X., & Hao, J. M. (2017). Assessing the Future Vehicle Fleet Electrification: The Impacts on Regional and Urban Air Quality. *Environmental Science & Technology, 51*(2), 1007-1016. doi:10.1021/acs.est.6b04253
Kempton, W., & Letendre, S. E. (1997). Electric vehicles as a new power source for electric utilities. *Transportation Research Part D: Transport and Environment, 2*(3), 157-175.
Kempton, W., & Tomic, J. (2005). Vehicle-to-grid power implementation: From stabilizing the grid to supporting large-scale renewable energy. *Journal of Power Sources, 144*(1), 280-294. doi:10.1016/j.jpowsour.2004.12.022
Khan, S. A., & Bohnsack, R. (2020). Influencing the disruptive potential of sustainable technologies through value proposition design: The case of vehicle-to-grid technology. *Journal of Cleaner Production, 254*, 120018.
Kiaee, M., Cruden, A., & Sharkh, S. (2015). Estimation of cost savings from participation of electric vehicles in vehicle to grid (V2G) schemes. *Journal of Modern Power Systems and Clean Energy, 3*(2), 249-258.
Klapwijk, P. (2018). *EV RELATED PROTOCOLS*. Retrieved from https://ocw.tudelft.nl/wp-content/uploads/I0wfMo-EV_Related_Protocols_v05.pdf
Krueger, R., Rashidi, T. H., & Rose, J. M. (2016). Preferences for shared autonomous vehicles. *Transportation Research Part C: Emerging Technologies, 69*, 343-355.

Kubli, M., Loock, M., & Wüstenhagen, R. (2018). The flexible prosumer: Measuring the willingness to co-create distributed flexibility. *Energy Policy, 114*, 540-548.
Laurischkat, K., Viertelhausen, A., & Jandt, D. (2016). Business models for electric mobility. *Procedia CIRP, 47*(2016), 483-488.
Liu, C., Chau, K., Wu, D., & Gao, S. (2013). Opportunities and challenges of vehicle-to-home, vehicle-to-vehicle, and vehicle-to-grid technologies. *Proceedings of the IEEE, 101*(11), 2409-2427.
Liu, H., Ning, H., Zhang, Y., & Guizani, M. (2013). Battery status-aware authentication scheme for V2G networks in smart grid. *IEEE Transactions on Smart Grid, 4*(1), 99-110.
MacLeod, M., & Cox, C. (2018). V2G market study–Answering the preliminary questions for V2G: What, where and how much? *CENEX, July*.
Madawala, U. K., & Thrimawithana, D. J. (2011). A bidirectional inductive power interface for electric vehicles in V2G systems. *IEEE Transactions on Industrial Electronics, 58*(10), 4789-4796.
Magretta, J. (2002). Why business models matter. In: Harvard Business School Boston, MA.
Meijssen, A. (2019). Dutch electric vehicle drivers' preferences regarding vehicle-to-grid contracts: Examining the willingness to participate in vehicle-to-grid contracts by conducting a context-dependent stated choice experiment taking into account the EV recharging speed.
Milakis, D., Snelder, M., van Arem, B., van Wee, B., & de Almeida Correia, G. H. (2017). Development and transport implications of automated vehicles in the Netherlands: scenarios for 2030 and 2050. *European Journal of Transport and Infrastructure Research, 17*(1).
Niesten, E., & Alkemade, F. (2016). How is value created and captured in smart grids? A review of the literature and an analysis of pilot projects. *Renewable and Sustainable Energy Reviews, 53*, 629-638.
Nieuwenhuizen, C. v. (2020). *Selectie pilotprojecten klimaatadaptatie*. Rijksoverheid
Noel, L., Zarazua de Rubens, G., Kester, J., & Sovacool, B. K. (2019). Consumers, Society and V2G. In *Vehicle-to-Grid: A Sociotechnical Transition Beyond Electric Mobility* (pp. 141-165). Cham: Springer International Publishing.
Noori, M., Zhao, Y., Onat, N. C., Gardner, S., & Tatari, O. (2016). Light-duty electric vehicles to improve the integrity of the electricity grid through Vehicle-to-Grid technology: Analysis of regional net revenue and emissions savings. *Applied energy, 168*, 146-158.
Nosratabadi, S., Mosavi, A., Shamshirband, S., Kazimieras Zavadskas, E., Rakotonirainy, A., & Chau, K. W. (2019). Sustainable business models: A review. *Sustainability, 11*(6), 1663.
Osterwalder, A., & Pigneur, Y. (2010). *Business model generation: a handbook for visionaries, game changers, and challengers*: John Wiley & Sons.
Osterwalder, A., Pigneur, Y., & Tucci, C. L. (2005). Clarifying business models: Origins, present, and future of the concept. *Communications of the association for Information Systems, 16*(1), 1.
PBL. (2014). *Energiecoöperaties: ambities, handelingsperspectief en interactie met gemeenten*. Retrieved from https://www.pbl.nl/en/publicaties/energieco%C3%B6peraties-ambities-handelingsperspectief-en-interactie-met-gemeenten
Pillai, J. R., & Bak-Jensen, B. (2010). *Impacts of electric vehicle loads on power distribution systems.* Paper presented at the 2010 IEEE Vehicle Power and Propulsion Conference.
Plenter, F. (2017). *Eliciting value propositions and services in the market for electric vehicle charging.* Paper presented at the 2017 IEEE 19th Conference on Business Informatics (CBI).
Pollet, B. G., Staffell, I., & Shang, J. L. (2012). Current status of hybrid, battery and fuel cell electric vehicles: From electrochemistry to market prospects. *Electrochimica Acta, 84*, 235-249.
PWC. (2017). *Smart Charging van elektrische voertuigen - Institutionele knelpunten en mogelijke oplossingen*. Retrieved from https://www.elaad.nl/uploads/files/PWC_rapport_met_appendix.pdf
Reinhardt, R., Christodoulou, I., García, B. A., & Gassó-Domingo, S. (2020). Sustainable business model archetypes for the electric vehicle battery second use industry: towards a conceptual framework. *Journal of Cleaner Production*, 119994.
Rijksoverheid. (2019). 5 miljoen voor laadpalen van de toekomst. Retrieved from https://www.rijksoverheid.nl/actueel/nieuws/2019/09/02/5-miljoen-voor-laadpalen-van-de-toekomst

Rijksoverheid. (2020). Duurzaam bouwen. Retrieved from https://www.rijksoverheid.nl/onderwerpen/duurzaam-bouwen-en-verbouwen/duurzaam-bouwen
Robledo, C., Poorte, M., Mathijssen, H., van der Veen, R., & van Wijk, A. (2019). Fuel Cell Electric Vehicle-to-Grid Feasibility: A Technical Analysis of Aggregated Units Offering Frequency Reserves. In *Intelligent Integrated Energy Systems* (pp. 167-194): Springer.
Rotering, N., & Ilic, M. (2010

). Optimal charge control of plug-in hybrid electric vehicles in deregulated electricity markets. *IEEE Transactions on Power Systems, 26*(3), 1021-1029.
RVO. (2019a). *Laden van elektrische voertuigen - Definities en toelichting*. Retrieved from https://www.rvo.nl/sites/default/files/2019/06/Laden%20van%20Elektrische%20Voertuigen%20-%20Definities%20en%20Toelichting%20april%202019.pdf
RVO. (2019b). Nationale agenda laadinfrastructuur. Retrieved from https://www.rvo.nl/onderwerpen/duurzaam-ondernemen/energie-en-milieu-innovaties/elektrisch-rijden/beleid/nationale-agenda-laadinfrastructuur-nal
RVO. (2020a). Statistics Electric Vehicles in the Netherlands. Retrieved from https://www.rvo.nl/onderwerpen/duurzaam-ondernemen/energie-en-milieu-innovaties/elektrisch-rijden/stand-van-zaken/cijfers
RVO. (2020b). Stimulering Duurzame Energieproductie (SDE+). Retrieved from https://www.rvo.nl/subsidie-en-financieringswijzer/stimulering-duurzame-energieproductie-sde
SAE. (2016). Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles. Retrieved from https://www.sae.org/standards/content/j3016_201609/
Salpakari, J., Rasku, T., Lindgren, J., & Lund, P. D. (2017). Flexibility of electric vehicles and space heating in net zero energy houses: an optimal control model with thermal dynamics and battery degradation. *Applied energy, 190*, 800-812.
San Román, T. G., Momber, I., Abbad, M. R., & Miralles, A. S. (2011). Regulatory framework and business models for charging plug-in electric vehicles: Infrastructure, agents, and commercial relationships. *Energy Policy, 39*(10), 6360-6375.
Schaltegger, S., Hansen, E. G., & Lüdeke-Freund, F. (2016). Business models for sustainability: Origins, present research, and future avenues. In: Sage Publications Sage CA: Los Angeles, CA.
Schuller, A., Dietz, B., Flath, C. M., & Weinhardt, C. (2014). Charging strategies for battery electric vehicles: Economic benchmark and V2G potential. *IEEE Transactions on Power Systems, 29*(5).
Slootweg, J. (2010). Smart Grids-fundament voor de toekomstige energievoorziening. *Eindhoven: Technische Universiteit Eindhoven*.
SmartSolarCharging. (2020). Vijf proeftijnen Retrieved from https://smartsolarcharging.eu/vijf-proeftuinen/
Sortomme, E., & El-Sharkawi, M. A. (2011). Optimal Charging Strategies for Unidirectional Vehicle-to-Grid. *IEEE Transactions on Smart Grid, 2*(1), 131-138. doi:10.1109/Tsg.2010.2090910
Sovacool, B. K., Axsen, J., & Kempton, W. (2017). The future promise of vehicle-to-grid (V2G) integration: a sociotechnical review and research agenda. *Annual Review of Environment and Resources, 42*, 377-406.
Sovacool, B. K., & Hirsh, R. F. (2009). Beyond batteries: An examination of the benefits and barriers to plug-in hybrid electric vehicles (PHEVs) and a vehicle-to-grid (V2G) transition. *Energy Policy, 37*(3), 1095-1103.
Sovacool, B. K., Noel, L., Axsen, J., & Kempton, W. (2018). The neglected social dimensions to a vehicle-to-grid (V2G) transition: a critical and systematic review. *Environmental Research Letters, 13*(1), 013001.
Stuckey, H. L. (2013). Three types of interviews: Qualitative research methods in social health. *Journal of Social Health and Diabetes, 1*(02), 056-059.
Sundén. (2019). Fuel cell systems and applications. Hydrogen, Batteries And Fuel Cells 203-216. *Academic Press*. doi:doi: 10.1016/b978-0-12-816950-6.00011-7

Tachikawa, K., Kesler, M., & Atasoy, O. (2018). *Feasibility study of bi-directional wireless charging for vehicle-to-grid* (0148-7191). Retrieved from
Taiebat, M., & Xu, M. (2019). Synergies of four emerging technologies for accelerated adoption of electric vehicles: Shared mobility, wireless charging, vehicle-to-grid, and vehicle automation. *Journal of Cleaner Production, 230*, 794-797.
Tarroja, B., Zhang, L., Wifvat, V., Shaffer, B., & Samuelsen, S. (2016). Assessing the stationary energy storage equivalency of vehicle-to-grid charging battery electric vehicles. *Energy, 106*, 673-690. doi:10.1016/j.energy.2016.03.094
TenneT. (2020a). Balancing responsibility. Retrieved from https://www.tennet.eu/electricity-market/dutch-market/balancing-responsibility/
TenneT. (2020b). Grid operators. Retrieved from https://www.tennet.eu/our-key-tasks/energy-industry/grid-operators/
Thomas, C. (2009). Fuel cell and battery electric vehicles compared. *international journal of hydrogen energy, 34*(15), 6005-6020.
Toquica, D., De Oliveira-De Jesus, P. M., & Cadena, A. I. (2020). Power market equilibrium considering an EV storage aggregator exposed to marginal prices-A bilevel optimization approach. *Journal of Energy Storage, 28*, 101267.
Turton, H., & Moura, F. (2008). Vehicle-to-grid systems for sustainable development: An integrated energy analysis. *Technological Forecasting and Social Change, 75*(8), 1091-1108. doi:10.1016/j.techforE.EC1007.11.013
Un-Noor, F., Padmanaban, S., Mihet-Popa, L., Mollah, M. N., & Hossain, E. (2017). A comprehensive study of key electric vehicle (EV) components, technologies, challenges, impacts, and future direction of development. *Energies, 10*(8), 1217.
V2G-hub. (2020). Insight. Retrieved from https://www.v2g-hub.com/insights
Wagner, I. (2019). Electric vehicle registrations as a share of total in selected countries worldwide in 2018. Retrieved from statista.com/statistics/267162/world-plug-in-hybrid-vehicle-sales-by-region/
Wang, D., Coignard, J., Zeng, T., Zhang, C., & Saxena, S. (2016). Quantifying electric vehicle battery degradation from driving vs. vehicle-to-grid services. *Journal of Power Sources, 332*, 193-203.
Wang, L., Sharkh, S., & Chipperfield, A. (2016). Optimal coordination of vehicle-to-grid batteries and renewable generators in a distribution system. *Energy, 113*, 1250-1264.
Wang, X., & Liang, Q. (2015). Energy management strategy for plug-in hybrid electric vehicles via bidirectional vehicle-to-grid. *Ieee Systems Journal, 11*(3), 1789-1798.
Wang, Y., Zhang, Y., Wang, J., Wang, K., Zheng, W., & Sun, K. (2017). *Evaluation on business model of smart grid value-added service.* Paper presented at the 2017 2nd International Conference on Power and Renewable Energy (ICPRE).
Wiebes, E. (2019). *Draft Climate Agreement*. Retrieved from https://www.government.nl/documents/parliamentary-documents/2019/06/28/letter-to-the-house-of-representatives-about-the-proposal-for-a-national-climate-agreement
Wilson, C. (2013). *Interview techniques for UX practitioners: A user-centered design method*: Newnes.
Wolsink, M. (2012). The research agenda on social acceptance of distributed generation in smart grids: Renewable as common pool resources. *Renewable and Sustainable Energy Reviews, 16*(1), 822-835.
Yilmaz, M., & Krein, P. T. (2012). Review of Benefits and Challenges of Vehicle-to-Grid Technology. *2012 Ieee Energy Conversion Congress and Exposition (Ecce)*, 3082-3089. Retrieved from <Go to ISI>://WOS:000312901703043
Yunus, M., Moingeon, B., & Lehmann-Ortega, L. (2010). Building social business models: Lessons from the Grameen experience. *Long range planning, 43*(2-3), 308-325.
Zonneveld, J. (2019). Increasing participation in V2G through contract elements: Examining the preferences of Dutch EV users regarding V2G contracts using a stated choice experiment.

Appendix A

Table 24 shows a number of V2G projects that is going on around the world. With the support of this table and some additional projects Table 24 is built which shows a list of V2G projects in the Netherlands. Companies (or employees from these companies) that have participated in these projects are contacted to conduct the case studies in Section 5.

Table 24: V2G projects worldwide (adapted from (V2G-hub, 2020))

V2G project name	Country	Time Span
AirQon	NL	2019 - ongoing
Amsterdam Vehicle2Grid	NL	2014 - 2017
BlueBird School Bus V2G	US	2017 - 2020
Bus2Grid	GB	2018 - ongoing
Cenex EFES	GB	2013 - 2013
City-Zen Smart City	NL	2014 - 2019
Clinton Global Iniative School Bus Demo	US	2014 - ongoing
Denmark V2G	DK	2016 - ongoing
Distribution System V2G for Improved Grid Stability for Reliability	US	2015 - 2018
E-FLEX -Real-world Energy Flexibility through Electric Vehicle Energy Trading	GB	2018 - ongoing
e4Future	GB	2018 - ongoing
Electric Nation	GB	2016 - 2019
Elia V2G	BE	2018 - 2019
EV-elocity	GB	2018 - ongoing
Fiat-Chrysler V2G	US	2009 - 2014
Fiat-Chrysler V2G (Italy)	IT	2019 - 2021
Genoa pilot	IT	2017 - unknown
Grid Motion	FR	2017 - 2019
Grid on wheels (University of Delaware)	US	2012 - 2014
GrowSmarter	ES	2015 - unknown
Hitachi Isle of Scilly Smart Islands - No V2G yet	GB	2017 - unknown
Hitachi, Mitsubishi and Engie	NL	2018 - unknown
Honda, The Mobility House, Offenbach	DE	2017 - unknown
INEES Volkswagen, SMA, Lichtblick, Fraunhofer	DE	2012 - 2015
Intelligent Transport, Heating and Control Agent (ITHECA), UK	GB	2015 - 2017
INVENT - UCSD / Nissan / Nuvve	US	2017 - 2020
IREQ	CA	2012 - 2014
iZEus (Toyota)	DE	2012 - 2014
KEPCO, Hyundai	KR	2012 - ongoing
KIA Motors, Hyundai Technical Center Inc., UCI	US	2016 - unknown
Leaf to home	JP	2012 - ongoing
M-tech Labo	JP	2010 - 2013
Massachusetts Electric School Bus Pilot	US	2015 - 2018
NewMotion V2G	NL	2016 - 2018
Northern Power Grid, The Network Impact of Grid-Integrated Vehicles	GB	2018 - 2021
NREL Integrate / living lab	US	unknown - unknown

NRG Evgo, UCSD	US	2015 - 2018
NYSERDA	US	2016 - ongoing
Osaka business park	JP	unknown - unknown
Parker	DK	2016 - 2018
PG&E disaster hybrid truck	US	2014 - 2014
Powerloop: Domestic V2G Demonstrator Project	GB	2018 - ongoing
Powerstream pilot	CA	2013 - 2015
Redispatch V2G	DE	2018 - 2021
Renault, the mobility house - V1G at present	PT	2018 - 2020
Scirius	GB	2018 - ongoing
SEEV4City	GB	2016 - 2020
SHAR-Q	GR	2016 - 2019
Smart Solar Charging	NL	2015 - ongoing
SMARTHUBS Demonstrator	GB	2018 - ongoing
SmartMAUI, Hawaii	US	2012 - 2015
Solar-powered bidirectional EV charging station	NL	2015 - 2017
Suvilahti pilot	FI	2017 - unknown
Torrance V2G School Bus	US	2014 - 2017
Toyota Tsuho / Chubu Electric / Nuvve	JP	2018 - 2019
UCLA WinSmartEV	US	unknown - unknown
UK Vehicle-2-Grid (V2G)	GB	2016 - ongoing
UNDP Windhoek (Namibia) V2G	NA	2019 - ongoing
US Air Force	US	2012 - ongoing
US DoD, Smith trucks,	US	2013 - 2014
Utrecht V2G charge hubs (We Drive Solar)	NL	2018 - ongoing
V2G Aggregator project - Mitsubishi	JP	2018 - unknown
V2GO	GB	2018 - ongoing
Vehicle-to-coffee - The Mobility House	DE	2015 - ongoing
Vehicle-to-Grid (V2G) Pilot Project	HK	2011 - 2012
Vehicle-to-Metal	DE	2019 - 2019
Zem2All	ES	2012 - 2016

Table 25: V2G projects Netherlands

V2G projects Netherlands	Time span
AirQon	2019 - ongoing
Amsterdam Vehicle2Grid	2014 - 2017
City-Zen Smart City	2014 - 2019
DeeldeZon	2018 - ongoing
Hitachi, Mitsubishi and Engie	2018 - unknown
NewMotion V2G	2016 - 2018
Smart Solar Charging	2015 - ongoing
Solar-powered bidirectional EV charging station	2015 - 2017
Utrecht V2G charge hubs (We Drive Solar)	2018 - ongoing

Appendix B

Table 26: overview experts

Expert codes	**Sector**	**Relation with V2G**
E.ES	Electric vehicle supply equipment	Business developer at a company which supplies EV charging and V2G equipment.
E.EC1	Energy company	Operational in the sector of electric transport and formerly employed by an energy company in which the expert has participated in V2G projects.
E.AC	Automotive company	Formerly employed by an automotive company in which the expert has participated in V2G projects.
E.KI	Knowledge institution	Project manager and an expert in V2G at a knowledge and innovation center in which they do research on smart charging infrastructure.
E.U	University	Researcher at an university of applied sciences in which the expert has conducted user research for various V2G research projects.
E.EC2	Energy company	Project manager at an energy company which operates as a charge point operator but also as an energy supplier and balance responsible party. They are working on V2G pilots.
E.BRP	Balance responsible party	Employee at a company which is a balance responsible party and a balancing service provider. They are working on V2G projects and searching how to serve the Dutch TSO.
E.EC3	Energy company	Product developer at a sustainable energy supplier company in which the expert is involved electrical mobility and providing flexibility to the grid.
E.GA	Governmental agency	Employee at a governmental agency in which the expert is involved in electrical mobility. The expert has also done research on how legislation and policy hampers V2G.
E.DSO	Distribution system operator	Employee at distribution system operator in which they are proponents of smart charging and also thinking about the possibilities of V2G.
E.M	Mobility	Employee at a company which operates as charge point operator and mobility service provider. They have participated in many V2G pilots and developed their own V2G charging infrastructure which is in pre-commercial stage.

Appendix C

Table 27 shows how the questions, that has been used for the interviews, are derived from the analysis of each section and are corresponded to which theme and category of the theoretical V2G framework. These questions of Table 27 were the basis of the semi-structured interview set-up. The final set-up of the interview is showed in the interview guide.

Table 27: overview interview questions

#	Questions (Dutch)	Questions (English)	Derived from:	Category	Theme
1.1	Wie zijn volgens u de potentiele klanten aan wie de Vehicle-to-Grid service wordt geleverd?	Who are the potential customers to whom the Vehicle-to-Grid service will be delivered?	Section 3	Customer segments	Business model
1.2	In hoeverre denkt u dat er bepaalde segmenten van klantengroepen zijn waar meer belang gehecht aan moet worden (Indien ja, welke segmenten zijn er)?	To what extent do you think there are certain segments of customer groups to which importance should be attached (If so, which segments are there)?	Section 3	Customer segments	Business model
1.3	Er kunnen ook persoonlijk onderscheidingen zijn binnen de segmenten, zoals groepen die meer belang geven aan financiële, functionele, of sociale aspecten. In hoeverre denkt u dat hier onderscheid in gemaakt moet worden?	There may also be personal differences within the segments, such as groups that give more importance to financial, functional or social aspects. To what extent do you think this should be distinguished?	Section 4	Customer segments	Business model
2.1	Wat is de meerwaarde die Vehicle-to-Grid biedt aan zijn klanten?	What is the value that Vehicle-to-Grid offers to its customers?	Section 3	Value proposition	Business model
2.2	Welke bundels aan services/producten moet een Vehicle-to-Grid serviceprovider leveren aan verschillende klantensegmenten?	Which bundles of services/products should a Vehicle-to-Grid service operator deliver to different customer segments?	Section 3, Section 5	Value proposition	Business model
3	Via welke kanalen zal deze service aan verschillende klantsegmenten aangeboden moeten worden?	What are channels to offer this service to different customer segments?	Section 3	Channels	Business model
4	Hoe zal de relatie met (verschillende) klanten(segmenten) moeten verlopen?	How should the relationship with (different) customers (segments) be structured?	Section 3	Customers relationship	Business model
5	Welke activiteiten zou een Vehicle-to-Grid serviceprovider moeten uitvoeren?	What activities should a Vehicle-to-Grid service provider perform?	Section 3	Activities	Business model
6	Wat zijn de middelen/resources die nodig zijn om de Vehicle-to-Grid service goed te laten verlopen?	What are the key resources that must be acquired to run the Vehicle-to-Grid service properly?	Section 3	Resources	Business model
7	Welke partij denkt u dat het meest geschikt is voor deze rol?	Which party do you think can satisfy this role?	Section 4	Role of V2G service provider	Business model
8.1	Met welke partijen zou een V2G serviceprovider een samenwerking moeten aangaan?	Which parties are the key partners of a V2G service provider?	Section 3	Partnerships	Business model

8.2	Welke resources zouden verwerven moeten worden van deze samenwerkingspartners?	Which resources should be acquired from these partners?	Section 3	Partnerships	Business model
8.3	Welke activiteiten moeten deze partijen uitvoeren?	What activities should these parties perform?	Section 3	Partnerships	Business model
9.1	Welke omzetstromen kan Vehicle-to-Grid opleveren?	What revenue streams can Vehicle-to-Grid generate?	Section 3	Revenue streams	Business model
9.2	Met name in congestiemanagement lijkt het verwerven van inkomsten onduidelijk, denkt u dat er via congestiemanagement omzet behaald kan worden?	Regarding congestion management the generation of revenue seems unclear, do you think that revenue can be acquired through congestion management?	Section 5	Revenue streams	Business model
9.3	Hoe zouden deze omzet verdeeld moeten worden tussen de verschillende partijen?	How should this revenue be shared between the different parties?	Section 5	Revenue streams	Business model
9.4	Welke inkomstenstromen verwacht u uiteindelijk dat er zal overblijven voor de Vehicle-to-Grid serviceprovider?	What revenue streams do you think will be left for the Vehicle-to-Grid service operator?	Section 3, Section 5	Revenue streams	Business model
10.1	Wat zijn de kostenposten voor Vehicle-to-Grid?	What are the cost that must be made for Vehicle-to-Grid?	Section 3	Cost structure	Business model
10.2	Hoe zouden deze kosten verdeeld moeten worden tussen de verschillende partijen?	How should these costs be shared between the different parties?	Section 5	Cost structure	Business model
10.3	Welke kosten zouden onder de verantwoordelijk moeten liggen van een Vehicle-to-Grid serviceprovider?	For which costs should the Vehicle-to-Grid service operator be responsible of?	Section 3, Section 5	Cost structure	Business model
11.1	In hoeverre en op welke manier denkt u dat V2G het aandeel van hernieuwbare energiebronnen kan verhogen?	To what extent and in what manner do you think V2G can increase the share of renewable energy sources?	Section 3	Environmental	Sustainability
11.2	In hoeverre en op welke manier denkt u dat V2G de efficiëntie omtrent het benutten van aanwezige duurzame energie kan verhogen?	To what extent and in what manner do you think V2G can increase the efficiency in the utilization of available renewable energy?	Section 3	Environmental	Sustainability
11.3	Aan welke environmental aspecten zou u nog meer denken bij het leveren van V2G services?	What other environmental aspects would you consider when providing V2G services?	Section 3	Environmental	Sustainability
12.1	In hoeverre en op welke manier denkt u dat een V2G serviceprovider behoeftes van V2G gebruikers kan voorzien zonder dat deze gebruikers fysiek een laadpaal bezitten?	To what extent and in what manner do you think a V2G service provider can satisfy the needs of V2G users without these users physically owning a charging station?	Section 3	Social	Sustainability

12.2	In hoeverre en op welke manier denkt u dat een V2G serviceprovider proactief in gesprek moet gaan met alle belanghebbenden om hun welzijn op lange termijn te waarborgen?	To what extent and in what manner do you think a V2G service provider should engage proactively with all stakeholders to ensure their long-term well-being?	Section 3	Social	Sustainability
12.3	Aan welke sociale aspecten zou u nog meer denken bij het leveren van V2G services?	What other social aspects would you consider when providing V2G services?	Section 3	Social	Sustainability
13.1	In hoeverre denkt u dat een V2G serviceprovider, naast zijn eigen economische waarde, ook moet proberen om positieve waarde te creëren voor alle belanghebbenden met in het bijzonder de samenleving en het milieu?	To what extent do you think that a V2G service provider, besides its own economic value, should try to create positive value for all stakeholders with in particular the society and environment?	Section 3	Economic	Sustainability
13.2	In hoeverre en op welke manier denkt u dat alleen met een goede samenwerking tussen partijen en het delen van resources waarde met V2G gecreëerd kan worden?	To what extent and in what manner do you think that only with good cooperation and sharing of resources between parties value can be created with V2G?	Section 3	Economic	Sustainability
13.3	In hoeverre en op welke manier denkt u dat de overheid of andere non-profitorganisaties economische steun moeten leveren aan een V2G serviceprovider?	To what extent and in what manner do you think that the government or other non-profit agencies should provide economic support to a V2G service provider?	Section 3, Section 5	Economic	Sustainability
13.4	Aan welke economische aspecten zou u nog meer denken bij het leveren van V2G services?	What other economic aspects would you consider when providing V2G services?	Section 3	Economic	Sustainability
14	Wat zijn de technologische beperkingen voor V2G?	What are the technological limitations for V2G?	Section 5	Technical	Business environment
15	V2G kan plaatsvinden via een off-board charger die de wisselstroom omzet of met AC-charging waarbij de auto zelf de wisselstroom omzet. Welke van de twee denkt u dat zich verder gaat ontwikkelen in het gebruik van V2G?	V2G can take place via an off-board charger that converts the alternating current or with AC-charging where the car converts the alternating current itself. Which of the two do you think will develop further in the use of V2G?	Section 5	AC/DC-Charging	Business environment
16	Wat zijn de institutionele en wetmatige beperkingen voor V2G?	What are the institutional and legal restrictions for V2G?	Section 4, Section 5	Institutional	Business environment

17	Welke problemen zijn er rondom de standaardisatie van V2G?	What problems are there around the standardization of V2G?	Section 4, Section 5	Standardization	Business environment
18	Hoe denkt u dat deze genoemde problemen zich gaan ontwikkelen door de tijd heen?	How do you think these problems mentioned will develop over time?	Section 4	Technical, institutional, standardization	Business environment
19.1	Wat verwacht u wat betreft het belang van overheidssteun bij het oplossen van de hiervoor genoemde problemen en het stimuleren van V2G?	What do you think about the importance of governmental support hereby?	Section 4	Government	Business environment
19.2	Waarom denkt u dat de overheid hier nog geen oplossing aan biedt?	Why do you think that the government does not yet offer a solution?	Section 5	Government	Business environment
20	Er zijn drie typen voertuigen die gebruikt kunnen worden voor V2G en verschillende kenmerken hebben: PHEV, BEV en FCEV. Wat verwacht u van de ontwikkelingsloop van deze types binnen de Nederlands markt en hoe denkt u het de potentie van V2G gaat beïnvloeden?	There are three types of vehicles that can be used for V2G and have different characteristics: PHEV, BEV and FCEV. 4.7 What do you expect from the development of these types within the Dutch market and how do you think it will affect the potential of V2G?	Section 6	Types of EV	Business environment
21	Naast de V2G-technologie zijn er ook andere technologieën die in ontwikkeling zijn. Hierbij kan gedacht worden aan autonome voertuigen, deelauto’s en wireless charging. 4.8 Wat verwacht u van de ontwikkeling van deze technologieën en de invloed ervan op de potentie van V2G?	In addition to V2G technology, there are also other technologies under development. Hereby you can think to autonomous vehicles, shared cars and wireless charging. 4.8 What do you expect from the development of these technologies and their impact on the potential of V2G?	Section 6	Impact other technological developments	Business environment
22	Wat verwacht u van de invloed van de Coronasituatie op V2G?	What do you expect from the impact of the Corona situation on V2G?	Adapted from the interviews	Impact Corona situation	Business environment

Interview Guide

Dutch version:
Het doel van dit interview is om een potentieel duurzaam businessmodel voor Vehicle-to-Grid op te stellen. Dit vanuit het perspectief van een partij die V2G service zou willen leveren in Nederland. Het interview zal bestaan uit drie delen. Eerst zullen de vragen gebaseerd zijn op de elementen van hoe een businessmodel voor V2G eruit moet zien. Het tweede deel gaat over de duurzaamheidsaspecten die een V2G businessmodel zal moeten bevatten. Het derde deel zal zich richten op het business environment. Dat wil zeggen de huidige bottlenecks, benodigdheden en market trends die de potentie van V2G positief/negatief kan beïnvloeden.

Uw naam zal binnen het rapport anoniem gehouden worden en zal alleen eventueel gedeeld worden met mijn supervisors. Binnen het rapport zal alleen uw functieomschrijving vermeld worden. Het interview zal getranscribeerd worden en naar uw verzonden worden ter goedkeuring. Indien er binnen een week geen reactie op wordt gegeven zal er uitgegaan worden dat het goedgekeurd is. De getranscribeerde versie zal verder gebruikt in de analyse van de resultaten.

1. Introductievragen
Om van start te gaan zal er allereerst een aantal introductievragen gesteld worden.

1.1 Mag het gesprek worden opgenomen?
1.2 Relatie met Vehicle-to-Grid
   1.2.1 Welke bedrijf werkt u voor?
   1.2.2 Welke rol vervult uw bedrijf in de energiemarkt?
   1.2.3 Wat is uw functie binnen het bedrijf met betrekking tot Vehicle-to-Grid?

2. Businessmodel
Focussend op het businessmodel zal het businessmodel canvas als basis genomen worden en de belangrijkste elementen hiervan zullen aan bod komen. Als begin:

V2G services kunnen aan verschillende segmenten worden aangeboden, zoals gebruikers van individuele laadpalen, publieke laadpalen, fleetowners en commerciële gebruikers.
2.1 Customer segmenten
   2.1.1 Wie zijn volgens u de potentiele klanten aan wie de Vehicle-to-Grid service wordt geleverd?
   2.1.2 In hoeverre denkt u dat er bepaalde segmenten van klantengroepen zijn waar meer belang gehecht aan moet worden (Indien ja, welke segmenten zijn er)?
   2.1.3 Er kunnen ook persoonlijk onderscheidingen zijn binnen de segmenten, zoals groepen die meer belang geven aan financiële, functionele, of sociale aspecten. In hoeverre denkt u dat hier onderscheid in gemaakt moet worden?

De waardenproposities voor Vehicle-to-Grid kunnen verschillen zoals het bieden van betaalbaarheid en financiële compensatie of het bieden van flexibiliteit en een andere type vergoeding of mogelijk een andere manier.
2.2 Waardenproposities
   2.2.1 Wat is de meerwaarde die Vehicle-to-Grid biedt aan zijn klanten?
   2.2.2 Welke bundels aan services/producten moet een Vehicle-to-Grid serviceprovider leveren aan verschillende klantensegmenten?
   Beste propositie?

2.3 Via welke kanalen zal deze service aan verschillende klantsegmenten aangeboden moeten worden?
Hoe kan de marketing ervan verlopen?

2.4 Hoe zal de relatie met (verschillende) klanten(segmenten) moeten verlopen?

Wie de rol van Vehicle-to-Grid serviceprovider kan vervullen is voor nu nog niet bevestigd. Er zijn verschillende partijen die deze rol kunnen vervullen zoals, energy suppliers, charge point operators, autofabrikanten, mobility serviceproviders, aggregators, of wellicht een nieuwe partij binnen de energiemarkt etc.

2.5.1 Welke activiteiten zou een Vehicle-to-Grid serviceprovider moeten uitvoeren?
2.5.2 Wat zijn de middelen/resources die nodig zijn om de Vehicle-to-Grid service goed te laten verlopen?
2.5.3 Welke partij denkt u dat het meest geschikt is voor deze rol?

2.6 Partnerships

- 2.6.1 Met welke partijen zou een V2G serviceprovider een samenwerking moeten aangaan?
- 2.6.2 Welke resources zouden verwerven moeten worden van deze samenwerkingspartners?
- 2.6.2 Welke activiteiten moeten deze partijen uitvoeren?

2.7 Omzet

- 2.7.1 Welke omzetstromen kan Vehicle-to-Grid opleveren?
  - 2.7.1.1 Met name in congestiemanagement lijkt het verwerven van inkomsten onduidelijk, denkt u dat er via congestiemanagement omzet behaald kan worden?
- 2.7.2 Hoe zouden deze omzet verdeeld moeten worden tussen de verschillende partijen?
- 2.7.3 Welke inkomstenstromen verwacht u uiteindelijk dat er zal overblijven voor de Vehicle-to-Grid serviceprovider?

2.8 Kosten

- 2.8.1 Wat zijn de kostenposten voor Vehicle-to-Grid?
- 2.8.2 Hoe zouden deze kosten verdeeld moeten worden tussen de verschillende partijen?
- 2.8.3 Welke kosten zouden onder de verantwoordelijk moeten liggen van een Vehicle-to-Grid serviceprovider?

3. Sustainability

Belangrijk voor de opkomst van V2G is de impact op duurzaamheid, omdat verwacht wordt dat V2G een stimulans zal zijn wat betreft duurzaamheid, zoals groene-energie, zelfvoorziening en de support aan het elektriciteitsnet. Er zijn ook veel belanghebbenden voor wie waarde moet worden gecreëerd of van wie middelen nodig zijn om waarde te creëren. Om deze duurzame technologie in de markt te brengen zal er daarvoor gekeken moeten worden aan welke duurzaamheidsarchetypen het V2G businessmodel zal voldoen. Deze duurzaamheidarchetypen zal beoordeeld worden aan de hand van 3 categorieën: Environment, sociaal en economisch.

3.1 Wat betreft environment

- 3.1.1 In hoeverre en op welke manier denkt u dat V2G het aandeel van hernieuwbare energiebronnen kan verhogen?
- 3.1.2 In hoeverre en op welke manier denkt u dat V2G de efficiëntie omtrent het benutten van aanwezige duurzame energie kan verhogen?
- 3.1.3 Aan welke environmental aspecten zou u nog meer denken bij het leveren van V2G services?

3.2 Wat betreft sociaal

- 3.2.1 In hoeverre en op welke manier denkt u dat een V2G serviceprovider behoeftes van V2G gebruikers kan voorzien zonder dat deze gebruikers fysiek een laadpaal bezitten?
- 3.2.2 In hoeverre en op welke manier denkt u dat een V2G serviceprovider proactief in gesprek moet gaan met alle belanghebbenden om hun welzijn op lange termijn te waarborgen?
- 3.2.3 Aan welke sociale aspecten zou u nog meer denken bij het leveren van V2G services?

3.3 Wat betreft economisch

3.3.1 In hoeverre denkt u dat een V2G serviceprovider, naast zijn eigen economische waarde, ook moet proberen om positieve waarde te creëren voor alle belanghebbenden met in het bijzonder de samenleving en het milieu?
3.3.2 In hoeverre en op welke manier denkt u dat alleen met een goede samenwerking tussen partijen en het delen van resources waarde met V2G gecreëerd kan worden?
3.3.3 In hoeverre en op welke manier denkt u dat de overheid of andere non-profitorganisaties economische steun moeten leveren aan een V2G serviceprovider?
3.3.4 Aan welke economische aspecten zou u nog meer denken bij het leveren van V2G services?

4. Business environment
4.1 Wat zijn de technologische beperkingen voor V2G?

V2G kan plaatsvinden via een off-board charger die de wisselstroom omzet of met AC-charging waarbij de auto zelf de wisselstroom omzet.
4.2 Welke van de twee denkt u dat zich verder gaat ontwikkelen in het gebruik van V2G?

4.3 Wat zijn de institutionele en wetmatige beperkingen voor V2G?

4.4 Welke problemen zijn er rondom de standaardisatie van V2G?

4.5 Hoe denkt u dat deze genoemde problemen zich gaan ontwikkelen door de tijd heen?

Overheid heeft met wet- & regelgeving en stimuleringsbeleid belangrijke tools in handen om problemen voor V2G op te lossen en het gebruik ervan te stimuleren.
4.6 Wat verwacht u wat betreft het belang van overheidssteun bij het oplossen van de hiervoor genoemde problemen en het stimuleren van V2G?
4.7 Waarom denkt u dat de overheid hier nog geen oplossing aan biedt?

Er zijn ook verschillende technologieën in opkomst die het succes van V2G kan belemmeren of kan aanmoedigen.

In eerste instantie kunnen we hierbij denk aan de elektrische voertuigen zelf. Er zijn drie typen voertuigen die gebruikt kunnen worden voor V2G en verschillende kenmerken hebben: PHEV, BEV en FCEV.
4.7 Wat verwacht u van de ontwikkelingsloop van deze types binnen de Nederlands markt en hoe denkt u het de potentie van V2G gaat beïnvloeden?

Naast de V2G-technologie zijn er ook andere technologieën die in ontwikkeling zijn. Hierbij kan gedacht worden aan autonome voertuigen, deelauto's en wireless charging.
4.8 Wat verwacht u van de ontwikkeling van deze technologieën en de invloed ervan op de potentie van V2G?

4.9 Wat verwacht u van de invloed van de coronasituatie op V2G?

4.10 Heeft u wat betreft de business environment nog wat toe te voegen?

5. Afsluiten
5.1 Heeft u nog iets aan uw antwoorden op toe te voegen?
5.2 Heeft u nog iets op te merken met betrekking tot het ontwerpen van een duurzaam V2G businessmodel dat niet aan bod is gekomen?
5.3 Heeft u iets ander toe te voegen aan dit interview?

5.4 Bent u geïnteresseerd om het eindrapport te ontvangen?
5.5 Zou ik u later mogen contacteren om indien nodig vragen te stellen voor additionele informatie?

Bedanken en afronden.

English version
This interview aims to gather insight in order to develop a potential sustainable business model for Vehicle-to-Grid from the perspective of a party that would intend to provide V2G services in the Netherlands. The interview will consist of three parts. First, the questions will be based on the elements of what a business model for V2G should look like. The second part is about the sustainability archetypes that a V2G business model must satisfy. The third part will focus on the business environment. This means the current bottlenecks, requirements, and market trends that can positively / negatively influence the potential of V2G.

Your identity will be kept anonymous within the report and will only be shared with my supervisors if necessary. Only your function description will be included in the report. The interview will be transcribed and sent to you for approval. If there is no response within a week, it will be assumed that it has been approved. The transcribed version will be further used in the analysis of the results.

1. Introduction
To get started, a few introduction questions will be asked.

1.1 May this conversation be recorded?
1.2 Relationship with Vehicle-to-Grid
- 1.2.1 Which company do you work for?
- 1.2.2 What role does your company fulfil in the energy market?
- 1.2.3 What is your function within the company with regards to Vehicle-to-Grid?

2. Business model
To focus on the business model, the business model canvas will be taken as the basis and the main elements of this canvas will be discussed. To start:

V2G services can be offered to different segments, such as users of private charge points, users of public charge points, fleet owners and commercial users.
2.1 Customer segments
- 2.1.1 Who are the potential customers to whom the Vehicle-to-Grid service will be delivered?
- 2.1.2 To what extent do you think there are certain segments of customer groups to which importance should be attached (If so, which segments are there)?
- 2.1.3 There may also be personal differences within the segments, such as groups that give more importance to financial, functional or social aspects. To what extent do you think this should be distinguished?

The Vehicle-to-Grid value propositions may vary per segment, such as offering affordability and financial compensation or offering flexibility and a different type of compensation or maybe another way.
2.2 Value proposition
- 2.2.1 What is the value that Vehicle-to-Grid offers to its customers?
- 2.2.2 Which bundles of services / products should a Vehicle-to-Grid service operator deliver to different customer segments?

2.3 What are the distribution channels to offer this service to different customer segments?

2.4 How should the relationship with (different) customers (segments) be structured?

Who will fulfill the role of V2G service operator has not yet been determined. There are various parties that can fulfill this role, such as energy suppliers, charge point operators, car manufacturers, mobility service providers, aggregators, perhaps a new party in the energy market, etc.
2.5.1 What activities should a Vehicle-to-Grid service provider perform?
2.5.2 What are the key resources that must be acquired to run the Vehicle-to-Grid service properly?
2.5.3 Which party do you think can satisfy this role?

2.6 Key partnerships

2.6.1 Which parties are the key partners of a V2G service provider?
2.6.2 Which resources should be acquired from these partners?
2.6.2 What activities should these parties perform?

2.7 Revenue streams

2.7.1 What revenue streams can Vehicle-to-Grid generate?
2.7.1.1 Regarding congestion management the generation of revenue seems unclear, do you think that revenue can be acquired through congestion management?
2.7.2 How should this revenue be shared between the different parties?
2.7.3 What revenue streams do you think will be left for the Vehicle-to-Grid service operator?

2.8 Cost structure

2.8.1 What are the cost that must be made for Vehicle-to-Grid?
2.8.2 How should these costs be shared between the different parties?
2.8.3 For which costs should the Vehicle-to-Grid service operator be responsible of?

3. Sustainability

The impact on sustainability is important for the rise of V2G since it is expected that V2G will stimulate renewable energy, self-sufficiency and the support to the electricity grid. There are also many stakeholders involved for who value must be created or from who resources are needed. Therefore, it will be necessary to consider which sustainability archetypes the V2G business model will satisfy when bringing this sustainable technology to the market. These sustainability archetypes will be assessed based on 3 categories: Environment, social and economic.

3.1 Related to environment

3.1.1 To what extent and in what manner do you think V2G can increase the share of renewable energy sources?
3.1.2 To what extent and in what manner do you think V2G can increase the efficiency in the utilization of available renewable energy?
3.1.3 What other environmental aspects would you consider when providing V2G services?

3.2 Related to social

3.2.1 To what extent and in what manner do you think a V2G service provider can satisfy the needs of V2G users without these users physically owning a charging station?
3.2.2 To what extent and in what manner do you think a V2G service provider should engage proactively with all stakeholders to ensure their long-term well-being?
3.2.3 What other social aspects would you consider when providing V2G services?

3.3 Related to economic

3.3.1 To what extent do you think that a V2G service provider, besides its own economic value, should try to create positive value for all stakeholders with in particular the society and environment?
3.2.2 To what extent and in what manner do you think that only with good cooperation and sharing of resources between parties value can be created with V2G?

3.2.3 To what extent and in what manner do you think that the government or other non-profit agencies should provide economic support to a V2G service provider?
3.2.4 What other economic aspects would you consider when providing V2G services?

4. Business environment
4.1 What are the technological limitations for V2G?

V2G can take place via an off-board charger that converts the alternating current or with AC charging where the car itself converts the alternating current.
4.2 Which of the two do you think will develop further in the use of V2G?

4.3 What are the institutional and legal restrictions for V2G?

4.4 What problems are there around the standardization of V2G?

4.5 How do you think these problems mentioned will develop over time?

4.6 What do you think about the importance of governmental support hereby?
4.7 Why do you think that the government does not yet offer a solution?

There are also several technologies that emerges and can hinder or encourage the success of V2G.
In the first instance we can think about the electric vehicle types. There are three types of vehicles that can be used for V2G and have different characteristics: PHEV, BEV and FCEV.
4.7 What do you expect from the development of these types within the Dutch market and how do you think it will affect the potential of V2G?

In addition to V2G technology, there are also other technologies under development. Hereby you can think of technologies as autonomous vehicles, shared cars and wireless charging.
4.8 What do you expect from the development of these technologies and their impact on the potential of V2G?

4.9 What do you expect from the impact of the corona situation on V2G?

4.10 Do you have something to add regarding the business environment?

5. Closure questions
5.1 Do you have any remaining remarks to add to your answers?
5.2 Do you have any remarks about the design of a sustainable V2G business model that has not been discussed?
5.3 Do you have any remaining remarks to this interview?

5.4 Are you interested to receive the final report?
5.5 Could I contact you later to ask questions for additional information if needed?

Thank and finish.