The market potential for V2G in Belgium

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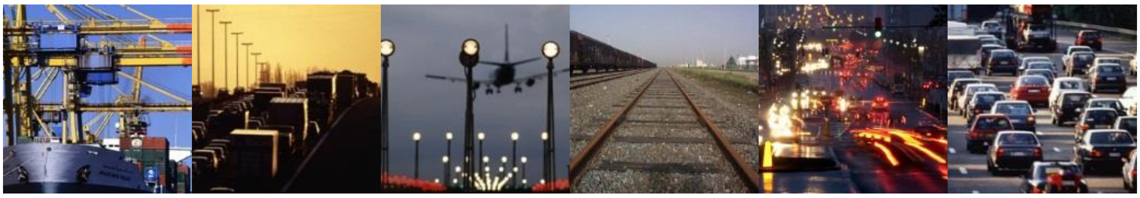

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Contents

List of tables

List of figures

Abbreviations, symbols and units

CO_2e	CO_2 equivalent
DSO	Distribution system operator
EV	Electric vehicle
FCEV	Fuel cell electric vehicle
GMR	Guaranteed minimum driving range
km	kilometre
PHEV	Plug-in hybrid electric vehicle
RPT	Required plug-in time
TSO	Transmission system operator
V2G	Vehicle-to-grid
WTP	Willingness-to-pay

Executive summary

The importance of decarbonizing the Belgian vehicle fleet for the energy transition and climate change mitigation efforts cannot be ignored.

Transport is one of the main greenhouse gas emitting sectors. In 2019, it accounted for 21.5 percent of greenhouse gas emissions in Belgium (EEA, 2019). Greenhouse gas emissions by car transport accounted for more than 54 percent of the transport emissions. They increased by 10.3 percent between 1990 and 2019. In spite of an increase in energy efficiency during this period, emissions rose due to higher car transport activity. The Federal government of Belgium is taking steps to accelerate the decarbonization of the vehicle fleet. The market segment of company cars will be used as leverage in this effort. As of 2026, only fully electric company cars will still be able to benefit from a tax advantage. This government intervention is expected to result in a swift electrification of the company car segment. In addition, the Flemish government recently proposed a phasing out of the sales of new fossil fuelled vehicles as from 2029. In the Brussels Capital Region only electric vehicles will be allowed to enter from 2035 onwards.

The electrification of the car fleet comes with several challenges. One of these challenges is to balance electricity demand. At the same time, important opportunities may arise. Most cars drive only a very limited part of the day, and are parked during the majority of the day. While parked, the car's battery is not used and may serve as an energy source for other purposes. Making use of this potentially large source of energy stored in the batteries of electric cars, requires dedicated (smart) charging techniques.

One of these smart charging techniques is Vehicle-to-Grid (V2G). V2G is a smart, bidirectional charging system. V2G-enabled cars will charge their batteries when demand for electricity and electricity prices are low. During periods of high electricity demand and high prices, the car's battery provides energy to the grid. The car can be discharged up to a predetermined minimum level such that the driver can rely on his/her car when needed. A V2G charging systems allows for a more efficient use of renewable energy because the cars will be predominantly charged when green energy is available (or even in oversupply).

The potential advantages of V2G are promising, but there are still several implementation barriers. A precondition for V2G to be successful and economically viable is a wide consumer adoption of electric cars and participation to the V2G system.

This study investigates the potential for V2G for the Belgian market. In a nationwide survey 2 500 respondents were asked about their vehicle purchase intentions, their familiarity with electric cars and recharging techniques, their driving behaviour and their preferences with respect to vehicle types and charging systems. The survey respondents participated in a discrete choice experiment in which they made a choice between two electric vehicles with V2G capability. The survey was designed by TML and was carried out by Bpact in May-June 2021.

The main takeaways from this study are the following:

- The **purchase intention for electric vehicles is relatively low**. In the private car segment, only 28 percent of the respondents who consider to buy a new car in the coming five years state that this may be a 100 % electric car. About 43 percent of these respondents consider to buy a plug-in hybrid in the coming five years. For company cars, 44 percent of the respondents believe to drive a new plugin hybrid and 39 percent of them expect to drive fully electric vehicle in the coming five years. This indicates **that a strong stimulus from the government and/or the industry is needed** to guarantee a quick and strong electrification of the car fleet in Belgium.
- The main **barriers** for a transition to electric vehicles are their **high purchase price** and the **limited driving range**. The likelihood of choosing an electric vehicle increases with the level of education and the number of private parking spots at home. Men are more likely to choose an electric vehicle compared to women.
- **Opportunities for charging locations are regionally different**. In Brussels, 36 to 41 percent of the respondents park their car on the streets, which implies that public charging stations with bidirectional charging capability would be important in this region. This is less the case in Flanders and Wallonia, where only 14 to 20 percent of the respondents' car fleet is parked on the street. In these regions, about 80 percent of the car fleet is parked at a private location, at home or at work.
- Although a large majority of the Belgian population is familiar with electric vehicles, the concept of **V2G is generally unknown in Belgium**. 79 percent of the survey respondents have never heard of V2G. As a result of the poor knowledge about V2G, there is a **strong public resistance** to accept the technology. Listed disadvantages are given a much higher weight in the evaluation of the technology than the advantages. Therefore, **more effort should be placed in educating consumers and in translating the potential benefits of V2G into economic benefits**.
- With respect to the adoption of V2G, people experience a **strong range anxiety**. High mileage drivers are less likely to participate to V2G because they may be worried that the scheme would not be able to guarantee their required mileage. The idea that **long trips should be planned in advance** also significantly reduces the willingness to participate in a V2G scheme.
- The willingness-to-pay for V2G contract specifications are different for private car drivers and company car drivers. C**ompany car drivers are less price sensitive with respect to the purchase price of the V2G enabled vehicle than private car drivers.** Private car drivers are willing to pay € 2700 extra for increasing an EV's driving range by 100 km. Company car drivers are only willing to pay € 760 extra in this case.
- Survey respondents are insensitive to the proposed financial compensation in the V2G contract. The **guaranteed minimum range is the only V2G contract specification that is considered to be relevant**. Private car drivers are willing to pay € 27 for an extra km of guaranteed minimum range. For company car drivers, this is only € 3.4. This means that company car drivers are willing to accept a much lower financial compensation to participate in a V2G scheme. For private car drivers, the average required financial compensation is higher than the financial revenue that can be achieved with a V2G contract.

To conclude, the study shows that consumer appetite for V2G in Belgium is currently fairly low. This is mainly caused by two factors. On the one hand, the technology is largely unknown, which makes it hard for consumers to assess its full potential. The low level of familiarity with V2G results in a public reluctance to adopt the technology. On the other hand, Belgian drivers express a strong feeling of range anxiety. This is especially the case for high mileage drivers.

A successful implementation of V2G in Belgium requires important efforts to educate consumers. Also, V2G contract must be set up such that the drivers' required mileage can always be guaranteed. A high guaranteed minimum range is more important than financial compensations (unless the latter are very large).

1 Introduction

The European Climate Law (Regulation ((EU) 2021/1119) sets the objective of a climate-neutral EU by 2050 and a collective, net, GHG emission reduction target (emissions after deduction of removals) of at least 55 % in 2030 compared to 1990 (EU, 2021). For transport, there is no corresponding legally enshrined sector specific reduction target. However, the European Green Deal states as an ambition that in 2050 the GHG emissions from transport should be 90 % lower than in 1990 in order to achieve climate neutrality for the economy as a whole (EC, 2019).

Both at the EU level and in Belgium a range of policy instruments are in place in order to decarbonise road transport (see EC (2020) and the National Energy and Climate Plan that was submitted by of Belgium in 2019 (Belgium, 2019)). Despite a continuously ameliorating fuel efficiency of new cars, in 2019 the total emissions of greenhouse gases from car transport in Belgium were 10.3 % higher than in 1990. The reason is the ever increasing demand for car transport. In 2019 car transport emissions amounted to 14 063 ktonnes of CO_2e, which corresponds with 54.2 % of transport emissions in Belgium. The transport sector as a whole emitted about 26 000 ktonnes CO_2e in 2019, or 21.5 % of the total greenhouse gas emissions in Belgium (EEA[1]). Together with the commercial sector, transport is the only sector in which emissions increased compared to 1990. In 2019 transport emissions were 25 % higher than in 1990.

Mandatory EU fleet-wide targets apply for new cars, which have been tightened gradually over time. Providing electric vehicles (EVs) to the market is one of the strategies that car manufacturers can take to comply with these targets. Over the last years, an increase in the uptake of these cars is observed. According to EAFO (2022), at EU level the share of battery EVs and plug-in hybrid EVs in new car sales increased from 3 % in 2019 to 17.8 % in 2021. This corresponds to a growing though still modest share in the vehicle stock of 0.46 % in 2019 and 1.61 % in 2021.

In Belgium, the share of EVs in new car sales grew from 3.2 % in 2019 to 18.3 % in 2021 (5.6 % battery EVs + 12.7 % plug-in hybrid EVs). The share of EVs in the Belgian car stock was 3.0 % in 2021, compared to 1 % in 2019. Up to now sales in Europe are concentrated in high income countries (ACEA, 2021). Also there is a strong correlation between the market share of EVs and the policy incentives that are provided (Wappelhorst, 2021; ACEA, 2021).

In the near future, EVs are expected to play a growing role in the decarbonisation of road transport, given the further strengthening of the CO_2 performance standards. Regulation (EU) 2019/631, which covers both new passenger cars and vans, sets the following targets compared to 2021: a 15 % reduction from 2025 onwards and a 37.5 % reduction from 2030 onwards for cars and 31 % for vans. Moreover, in view of the ambitious climate neutrality target set in the Climate Law, the Fit-for-55 package of the European Commission includes a proposal for even more stringent CO_2 emission performance standards. The proposal sets the 2030 CO_2 emission limits for new passenger cars and vans registered in the EU respectively 55 % and 50 % lower compared to the emission limits applicable in 2021. In addition, if the proposal is accepted, all new passenger cars and vans should have zero emissions by 2035 (EC, 2021).

[1] https://www.eea.europa.eu/data-and-maps/data/data-viewers/greenhouse-gases-viewer

The energy transition in the vehicle fleet will result in a higher demand for electricity. Although the energy-efficiency of EVs is high, there might be a capacity problem if EVs are massively charged during peak hours of electricity demand. To allow for a well-balanced powered grid, smart charging is necessary. Smart charging allows for communication between the EV and the charging operator and intelligently manages how the EV charges by connecting it to the grid. A step beyond smart charging is vehicle-to-grid (V2G) or bidirectional smart charging.

Vehicle-to-grid (V2G) is a technology that allows energy stored in the battery of EVs to be pushed back to the power grid. The vehicle's battery can be charged and discharged based on specific signals such as the fluctuation of the electricity price. The point of V2G is to balance the electricity grid and lower the risk of blackouts. In addition, V2G allows for a more efficient use of renewable electricity because the vehicle fleet will be charged when renewable energy is available and discharged when there is a shortage of renewable energy. This saves money for the vehicle owner and the electricity provider.

V2G requires the use of smart charging technologies. This includes the use of smart meters, a smart network and smart charging stations. The system must be adapted to the needs of the vehicle drivers such that it is able to guarantee sufficient battery autonomy. The driver must communicate when the vehicle is needed for a trip and the state of charge of the battery at that time. The V2G technology should also respond in a flexible way to peaks in electricity demand and electricity prices.

Electric cars with V2G capabilities are now brought to market at an accelerating pace. For example, the Nissan Leaf is a popular EV whose battery can be discharged with V2G stations.[2] Yet, the successful implementation of V2G is conditional on a widespread adoption by vehicle users. EV drivers need to take part and enable their vehicle batteries to be used for V2G.

This study investigates the potential market uptake for V2G in Belgium using a nationwide survey among a representative sample of the Belgian population. Because the adoption of EVs is a prerequisite for the participation to V2G, the potential for EVs is assessed first, followed by the potential for V2G. A distinction is made between people with privately-owned cars and those with company cars, in order to investigate the market potential for EVs and V2G in each segment. This distinction is important, considering the high share of company cars in Belgium and the fact that the Belgian government recently decided to use the company car segment as leverage to accelerate the electrification of the Belgian car fleet.

Statbel (2020) estimates that 10.7 % to 13.4 % of the total car stock are cars registered under a corporate number that can be used for private purposes, with as beneficiary either employees (salary cars) or company directors.[3] The law of 25 November 2021 on the fiscal and social greening of mobility recently changed the tax deductibility rules of company cars in favour of zero carbon emission cars.[4] As of 2023, the tax deductibility of company cars using fossil fuels will be reduced gradually, reaching zero in 2026. As of 2026, tax deductibility will only apply for cars with zero CO_2 emissions. This intervention by the federal government is expected to boost the electrification of

[2] https://www.virta.global/vehicle-to-grid-v2g

[3] Statbel (2020) estimates that a minimum of 613 603 of the 994 624 vehicles registered in the DIV under an enterprise number can be attributed to households, but mentions that experts indicate that this could be an underestimate of 150 000 vehicles. The total car stock in 2019 was 5 691 869. May (2017) confirms the difficulty of determining the number of company cars that can be used for private purposes.

[4] http://www.ejustice.just.fgov.be/eli/wet/2021/11/25/2021033910/staatsblad

the company car segment. Because salary cars are typically replaced after four years and subsequently sold on the passenger car market, the electrification of the company car segment may create a significant second hand EV market in Europe. In addition to this measure by the Federal government, the Brussels Capital Region will allow only electric vehicles to drive on its territory from 2035 onwards.[5] The government of the Flemish Region also recently proposed a phasing out of the sales of new fossil fuelled vehicles as from 2029, depending on a number of conditions.[6]

The central part of this study consists of a discrete choice experiment in which respondents are asked to choose between two electric vehicles with a range of V2G contract specifications. Drivers of company cars and privately-owned cars take part in a separate choice experiment. The choice experiment aims to estimate the willingness-to-pay for specific EV and V2G attributes. This allows for a critical evaluation of the market potential for V2G in Belgium.

The remainder of this report is structured as follows. Chapter 2 provides an overview of the literature on V2G. The survey design is explained in Chapter 3. The analysis of the V2G survey is presented in Chapter 4. The results of the discrete choice experiment are in a separate dedicated chapter, Chapter 5. The Chapter 6 concludes this report.

[5] https://lez.brussels/mytax/fr/practical?tab=Agenda

[6] https://energiesparen.be/sites/default/files/atoms/files/VR%202021%200511%20DOC.1237-1%20Visienota%20VEKP%20Bijkomende%20maatregelen.pdf

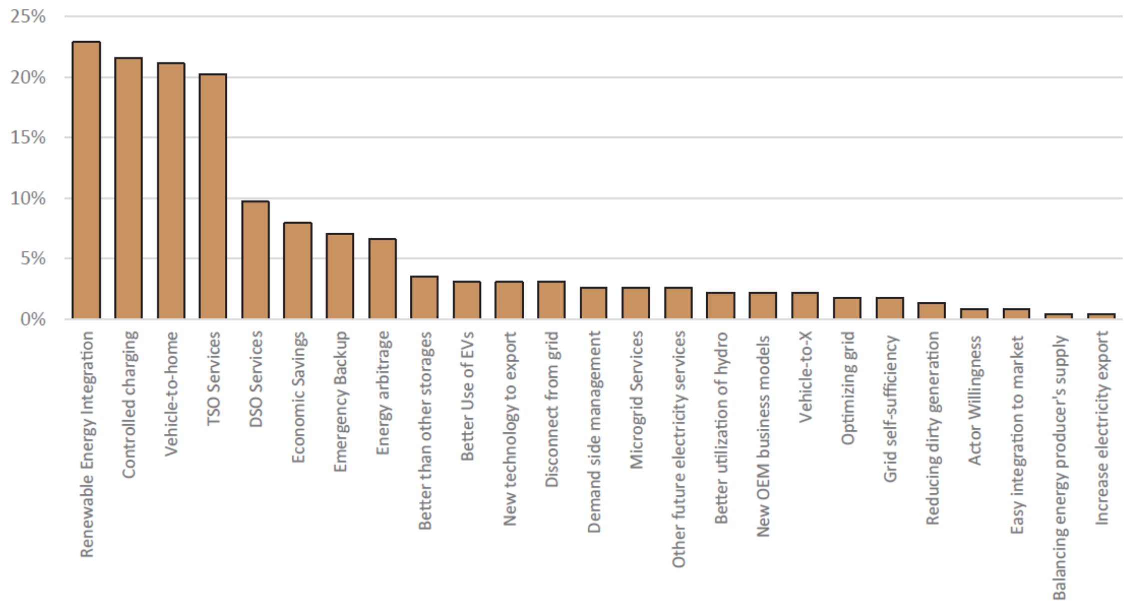
2 Overview of the literature

The growing market share of EVs has encouraged research on innovations of these vehicles. One such innovation is the design of EVs with vehicle-to-grid (V2G) capability. V2G refers to the possibility of EVs to deliver electricity to the power grid based on the remaining capacity of the car's battery. Most cars are parked the majority of the day. During that time, spare battery capacity can be used as a resource to the grid. V2G helps to balance the electricity supply and demand, by delivering electric power to the grid during demand peaks and charging the EVs' battery when energy demand is low.

This section discusses the advantages of V2G as stated in previous studies, the barriers to V2G implementation and the market potential for V2G.

2.1 Advantages of V2G

By interviewing 227 experts from the transport and electricity sector, Noel et al. (2018) analyse and review the co-benefits of EVs and V2G. They find that the advantages of V2G are versatile. An overview of the advantages is shown in Figure 1.



Source: Noel et al. (2018)

Figure 1 Benefits of V2G

Noel et al. (2018) identify no less than 25 benefits associated with V2G, of which eight are mentioned most. The most mentioned benefit of V2G is its capacity to **integrate intermittent sources of renewable energy**. The second and third benefits, **controlled charging** and **vehicle-to-home**, are related. A V2G participant can decide when to charge and can use the energy stored in the vehicle's battery to power his home.

Other important advantages of V2G are the benefits it can provide to the electricity grid, notably **Transmission System Operator (TSO) services** and **Distribution System Operator (DSO)**

services. Examples of TSO services are ancillary services and peak shaving. DSO services include the capacity for V2G-enabled EVs to delay investments in upgrading local transformers and addressing local congestion on the electricity network.

Economic savings for individual consumers and energy providers are also considered as a potential benefit of V2G. However, experts consider economic savings more of an advantage related to EVs and less to V2G. The interviewed experts estimated V2G revenues for consumers and energy providers combined to be around € 120 per month. It is important to note that this is an estimate for the Danish market. Estimated revenues are likely to be country and time specific.

Next to economic savings, V2G may provide non-economic services. It can serve as an **emergency backup for power**. This may be especially relevant for regions that are prone to disaster risk. The emergency backup service may play an important role in case of a blackout.

Beyond the eight advantages discussed above, several other benefits of V2G were mentioned, but less frequently or were considered less important. For conciseness they are not discussed further.

2.2 Barriers to V2G

Noel et al. (2019) follow-up on their investigation of the benefits of V2G by studying the barriers that may prevent a successful implementation of V2G in the Nordic countries. Based on structured interviews conducted among a wide panel of experts, the authors identify 35 barriers of which the top nine can be classified into four clusters:

- scepticism of the benefits of V2G,
- consumer resistance and battery degradation,
- lack of economic viability, and
- insufficient EV volume and electricity market structure.

The first barrier is a general **scepticism of the benefits of V2G**. Many experts believe that V2G can be outperformed by other technologies such as hydropower reservoirs. In addition, experts who appreciate the benefits of V2G doubt whether V2G is necessary for the Nordic power grid.

A second important barrier for V2G may be **consumer resistance**. Consumers may be very reluctant to accept third party access to their car's battery, especially because they worry that the frequent discharging might degrade the battery more quickly. Some experts state that the concept of V2G is too complicated for consumers to understand.

A third barrier to V2G may be the **lack of a clear business model** caused by the absence of substantial economic benefits and/or the lack of a scalable business model. Many experts are worried about the increased costs to make EVs V2G capable. They wonder whether these costs are sufficiently compensated by the potential economic revenues V2G might generate. Given these additional costs, some experts are sceptical whether V2G contracts that include some type of financial compensation for the customer can be economically viable.

The fourth cluster of barriers to V2G considers the number of EVs that are needed for V2G participation. Experts state that there are **currently not sufficient EVs** to implement V2G and some even question whether the threshold for V2G participation will ever be reached. Related to the capacity problem of EVs, **the structure of the electricity market** may pose a barrier to V2G. Take for example taxation. With a V2G model, energy that moves in and out of the battery may be double taxed. Besides taxation, other issues such as the absence of a smart power grid may be an obstacle to V2G implementation.

2.3 Market potential for V2G

Given the relative young age of the technology, the literature on the potential consumer uptake of V2G is relatively scarce. The following paragraphs provide an overview of the studies that investigate the consumer appetite and willingness-to-pay (WTP) for V2G-enabled EVs and the V2G contract specifications.

Based on a discrete choice experiment conducted on U.S. households, Parsons et al. (2014) were one of the first to investigate the potential for V2G and the WTP for its contract specifications. They designed a discrete choice experiment in which respondents are asked to choose between three vehicles: two V2G-enabled EVs and their "preferred fossil fuel vehicle" that was obtained from the preceding questions. The V2G-enabled EVs are described by five car-specific attributes, three V2G contract terms, and the purchase price. To reduce the cognitive burden for the respondents, the five EV attributes are kept constant across all alternatives in the choice sets. A downside of this approach is that it prevents the researchers from determining the trade-offs (interactions) between V2G contract terms and car attributes. For example, one may expect an interaction between the charging time of the vehicle and the guaranteed minimum driving range in the V2G contract.

Parsons et al. (2014) preceded their V2G choice experiment by another choice experiment to determine the preferences for electric vehicles in general. They find that the probability of purchasing an EV decreases with age and is higher for men compared to women. People who

- think gasoline prices will rise,
- have a green life style,
- have a hybrid car as a preferred gasoline vehicle,
- have a residence that will accommodate an EV outlet for charging, and
- are interested in new products,

are more likely to buy an EV. Based on respondent characteristics, the sample is then split into gasoline-oriented and EV-oriented drivers.

With respect to the V2G contract specifications, Parsons et al (2014) considered the following attributes: guaranteed minimum driving range (GMR), required plug-in time (RPT) per day and annual cashback payment. The authors find that drivers are very reluctant to accept V2G contracts. Respondents express a high inconvenience with guaranteed minimum driving range and required plug-in time per day. Per extra hour required plug-in time, respondents require a financial compensation ranging between $282 (for RPT between 5 to 10h/day) to $810 (for RPT between 15 to 20h/day). At a 1.15 EUR/USD exchange rate, this corresponds to a compensation of €245 to €704 per hour required plug-in time.

Parsons et al (2014) conclude that consumers require a high financial benefit to sign V2G contracts, which reduces the competitiveness of V2G-EV power in the power market. As a consequence, the authors recommend to structure V2G contracts such that consumers may provide the service at their convenience on a pay-as-you-go basis. They also conclude that an upfront cash payment in exchange for signing a V2G contract is more effective to convince consumers than a recurrent cashback payment.

Hidrue and Parsons (2015) estimate the willingness-to-pay for different attributes of V2G-enabled electric passenger cars in the U.S.. They run a discrete choice experiment to assess the preferences for the following car attributes:

- availability or a range extender,
- vehicle model,
- purchase price,
- maximum driving range,
- recharging time for 50 miles of driving range,
- acceleration,
- pollution,
- fuel cost.

With respect to the V2G contract specifications, Hidrue and Parsons (2015) consider the guaranteed minimum driving range (GMR), the required plug-in time per day, and an annual cash payment received by the customer.

The authors conclude that the WTP for V2G-enabled vehicles is lower than the projected cost of producing V2G–EVs under different battery cost scenarios. They attribute this finding predominantly to a high range anxiety of the customers. For example, the WTP for an EV with similar configuration but 150 miles smaller driving range than another EV is $ 10 000 lower. This corresponds to a WTP of about € 36 per km.

The low WTP for V2G-enabled vehicles also results from a high implicit discount rate respondents' use to value future earnings from V2G contracts. This means that future benefits are considered significantly less important than current benefits and cost savings. Therefore, to convince people to participate in V2G, the authors conclude that the contract should offer consumers an upfront financial benefit instead of a monthly renumeration.

Geske and Schumann (2018) analyse the market potential for V2G on the German market based on a discrete choice experiment with a sample of 611 respondents. They consider the following V2G attributes:

- guaranteed minimum driving range (GMR)
- the availability of an onboard computer
- minimum required plug-in time per day
- minimum number of plug-in days per week
- a monthly renumeration
- an upfront one-time renumeration

Table 1 shows the willingness-to-pay for the attributes GMR and onboard computer. The WTP for one kilometre of GMR ranges from €3.88 to € 6.45 per month. Given that the average monthly compensation for the V2G contract in the experiment was equal to €30 per month, the WTP for the attributes GMR and onboard computer are fairly high. The high WTP for an extra kilometre of guaranteed range is in line with the findings of Parsons et al (2014) and is consistent with a strong range anxiety of drivers.

Table 1 Willingness-to-pay for V2G attributes in Geske and Schumann (2018)

Attribute	Unit	Min	Max
Guaranteed minimum range	€/km per month	3.88	6.45
Onboard computer	€ per month	11.78	44.21

Source: Geske and Schumann (2018)

With respect to the other V2G attributes, Geske and Schumann (2018) find that one-time payments are strongly preferred over a monthly renumeration. In addition, a minimum number of plug-in days per week does not affect the choice for a V2G contract. They conclude that high participation rates to V2G can be obtained, even without remuneration, provided that the contract provides an attractive design in which guaranteed minimum range is very important.

In a study of the Nordic market covering Denmark, Finland, Iceland, Norway and Sweden, Noel, Carrone et al. (2019) investigate the WTP for electric cars and V2G. This study is more recent than Parsons et al. (2014) and is performed in a multi-country setting. A downside is that it does not allow for an evaluation of the different attributes of V2G. The authors merely inform the participants of the benefits and costs of V2G capability, and include it as a zero-one dummy (V2G-enabled or not) in the general EV choice set.

Noel, Carrone et al. (2019) find that the WTP for V2G capability of an electric vehicle is only significant in two out of the five countries under study, notably Norway and Finland. Consumers in Denmark, Iceland and Sweden show no willingness to pay for V2G capability. The authors state that this may be explained by the low level of familiarity of consumers with V2G. Less than 10 % of the respondents had heard of V2G before taking the survey. This means that energy providers and policy makers should make more effort in educating consumers and explaining the potential economic benefits of V2G.

The lack of attention given to the general knowledge about V2G is also mentioned by Sovacool et al. (2018), who conducted a meta-analysis of 197 studies on V2G. They show that most of these studies focus primarily on the technical aspects of V2G such as renewable energy storage, batteries and load balancing. The climate and environmental aspects and the role of consumer acceptance are generally overlooked in most studies. The latter is a genuine problem because the success of V2G depends crucially on a wide adoption rate by EV drivers.

To summarize, the general consensus in the literature is that the WTP for V2G contract specifications is fairly high. Stated differently, the willingness-to-pay extra for an V2G-enabled vehicle is low. This means that consumers expect a high financial compensation to participate in such a system and to give up the freedom inherent to uncontrolled charging. This may threaten the economic viability of the V2G system. The reluctance of consumers to participate in a V2G system can be explained by two factors. On the one hand, consumers reveal strong range anxiety, which is a fear that the car's battery has insufficient energy to cover the road distance needed to reach its destination. On the other hand, the concept of V2G is largely unknown. As a consequence, people may find it hard to properly assess their likelihood of participating.

3 Survey design

This study conducts a web-based survey including a discrete choice experiment covering the choice of electric vehicle and V2G attributes in Belgium. The survey was designed by TML and carried out by Bpact from May 28, 2021 to June 18 2021.[7]

The purpose of the survey is to assess consumer preference for V2G in Belgium. To guarantee a successful implementation of a V2G system, a large number of EVs must participate to the system such that a sufficient number of EVs is plugged to the grid at any point in time. A pre-condition for V2G participation is the adoption of EVs. Therefore, the survey is developed such that it can investigate the EV adoption rate and the preferences for a V2G system simultaneously. This approach is in line with Hidrue and Parsons (2015) who estimate the willingness to pay for V2G-enabled EVs in the U.S.

The survey contains five sections. The first section asks respondents about their current car ownership and parking habits. In the second section, respondents are asked about their awareness of different car types and charging techniques, their car preferences and purchase intention. The third section contains the V2G choice experiment. Before starting the experiment, respondents are informed about the concept of V2G and other charging systems and are asked about their willingness to participate to different systems. In section four respondents provide information about their driving habits. Finally, section five contains questions about the socio-demographic characteristics of the respondents.

The choice experiment is designed to assess the market potential for V2G-enabled EVs in the near future. Respondents are asked to make a choice between two electric vehicles, that have two sets of attributes: attributes related to the vehicle and attributes related to the V2G contract. Respondents can also select a “none of these” alternative. Each of the respondents is confronted with six decision tasks. Table 2 shows the attributes and their levels used in the different choice cards.

Each choice set contains two electric vehicles, each with six attributes. The three attributes that relate to the EV are (1) Driving range, (2) Recharging time, (3) Purchase price (or catalogue price for the company cars). The remaining three attributes relate to the V2G characteristics: (4) Guaranteed minimum range, (5) Yearly savings on the electricity bill, (6) Single payment.

The choice cards were designed in Alchemer using a balanced design.[8] This means that each level occurs equally often within each factor and the intercept is orthogonal to each attribute effect.

The survey was distributed in a randomized sample, representative of the Belgian population with respect to age, gender, region and education. The survey was also distributed to a small non-random convenience sample, containing 70 respondents. More details about the sample statistics are presented in Chapter 5.

The full text of the survey is available in Annex 1.

[7] The responses might be influenced by the COVID-19 situation. At the time the survey was held, no lockdown was effective in Belgium, but safety measures such as a recommendation to work from home were in place. Where relevant, we asked the respondents to answer questions as if there were no COVID-19 restrictions.

[8] https://www.alchemer.com/

Table 2 Attributes and their levels used in the V2G discrete choice experiment

Attributes	**Levels**
Attributes of the electric vehicle	
1. Driving range	200km, 300km, 400km, 600km
2. Recharging time (fast charging)	20min, 45min, 60min, 90min
3. Purchase price/catalogue price	€ 20 000, € 30 000, € 40 000, € 55 000, € 80 000
Attributes of the V2G contract	
4. Guaranteed minimum range	15 % of the driving range 25 % of the driving range 50 % of the driving range 75 % of the driving range
5. Savings on electricity bill	€25/year, €50/year, €70/year, €120/year
6. Upfront premium	€0, €250, €500, €1000

4 Survey analysis

4.1 Demographics and car fleet

4.1.1 Demographics

The survey data were collected by Bpact.[9] 2 570 respondents completed the survey and the discrete choice experiment. We also collected non-random survey data for a convenience sample of 70 participants. Given the small sample size of the convenience sample, these observations are not used in the analysis. After cleaning the data for inconsistencies and incompleteness, we retained 2499 completed surveys from the random sample. The gender and regional distribution of the sample is shown in Table 3.

Table 3 Characteristics of the respondents – gender and regional split

	Number of respondents			Share per region			Regional share
	Male	Female	Other	Male	Female	Other	
Brussels	120	84	0	58.82%	41.18%	0.00%	8.16%
Flanders	819	770	2	51.48%	48.40%	0.13%	63.67%
Wallonia	386	318	0	54.83%	45.17%	0.00%	28.17%
Total	1325	1172	2	53.02%	46.90%	0.08%	100.00%

The average respondent in the sample is 54 years old and lives in a family that has a size of two persons, on average. Family size is quite comparable across regions, with a somewhat higher spread in Brussels.

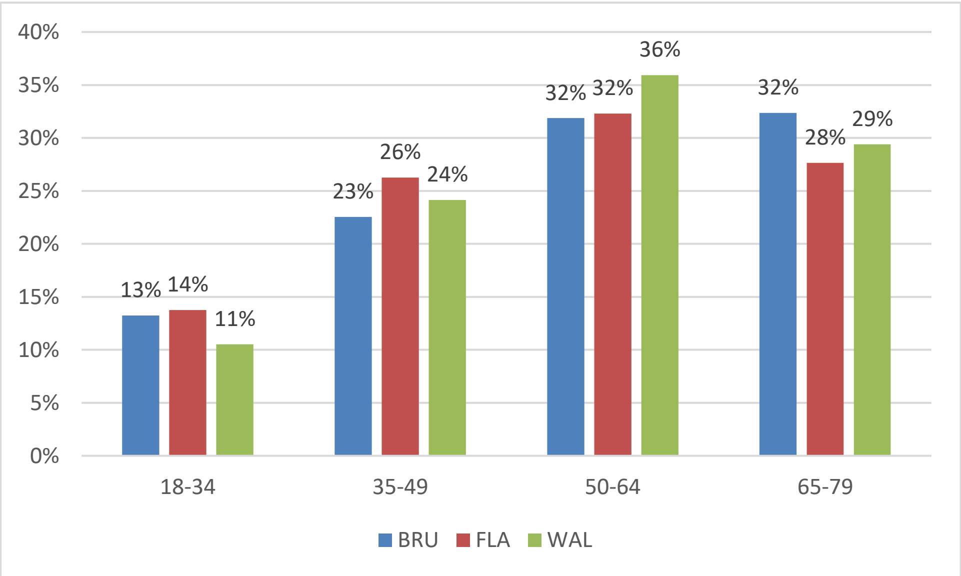


Figure 2 Characteristics of the respondents - age distribution

[9] https://bpact.be/

Table 4 Characteristics of the respondents - Family size

	BRU	FLA	WAL
Average	2.11	1.87	2.04
Median	2	2	2
Std Deviation	1.05	0.70	0.97
Minimum	1	1	1
Maximum	8	6	6

Table 5 shows the distribution of the educational level across regions in our sample. Brussels is an outlier here with a noticeable higher proportion of respondents with a university degree.

Table 5 Characteristics of the respondents - Highest achieved level of education

	BRU	FLA	WAL	TOTAL BE
None	0.0%	0.4%	0.4%	0.4%
Primary school	1.5%	2.3%	2.6%	2.3%
Secondary school - not completed	13.7%	11.2%	12.2%	11.7%
Secondary school - completed	23.0%	38.4%	42.9%	38.4%
Higher education (professional)	24.5%	28.3%	25.7%	27.3%
University education	37.3%	19.4%	16.2%	19.9%

To the question on the household's monthly net income, 51 respondents ticked the box "I prefer not to answer this question". For these observations, the household income range was imputed based on a linear regression model in which the income range is explained by respondent specific and regional characteristics. A full explanation of the handling of missing observations is provided in Annex 2. The distribution of household income including the imputed missing observations is shown in Figure 3.

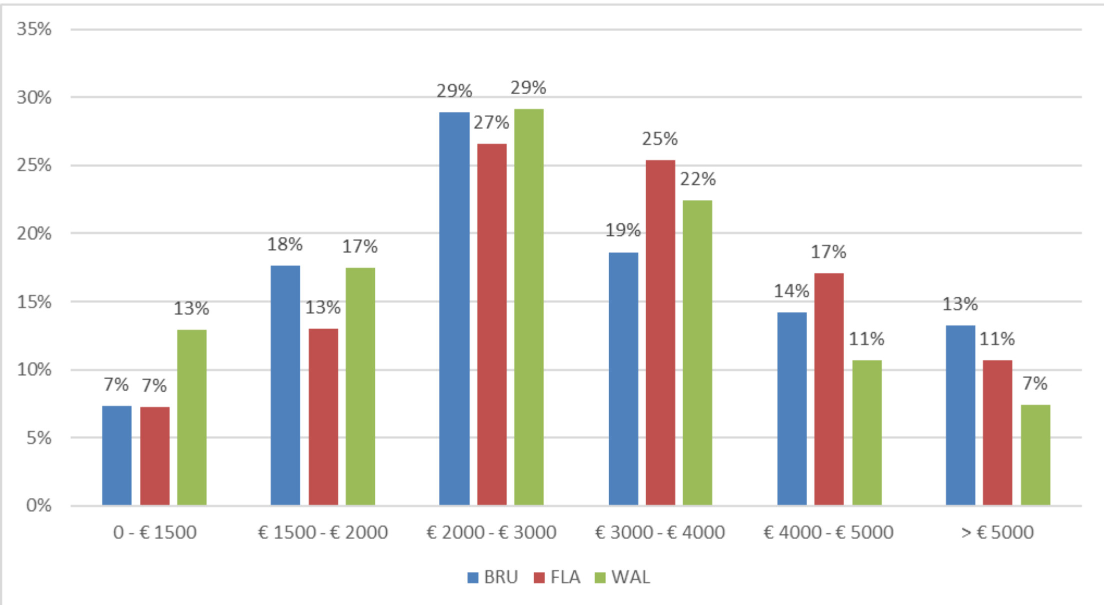


Figure 3 Characteristics of the respondents - Household net income distribution

The distribution of household income per region confirms the earlier remark about Brussels. The sample is not fully representative of the population in Brussels because it contains a disproportionately large share of high income and highly educated respondents.

4.1.2 Car fleet

The total car fleet of the survey consists of 3035 privately-owned (pcar) and 467 company cars (ccar). On average, a household owns 1.3 cars in Wallonia, 1.21 in Flanders and 0.94 in Brussels. Company cars are most common in Flanders with an average of 0.22 cars per household. In Brussels and Wallonia, households have access to respectively 0.16 and 0.12 company cars on average.

Table 6 Characteristics of respondents' household - Car fleet per region

	# pcar	# ccar	average no. of pcar per household	Average no. of ccar per household
BRU	192	32	0.94	0.16
FLA	1931	353	1.21	0.22
WAL	912	82	1.30	0.12
TOTAL BE	**3035**	**467**	**1.21**	**0.19**

Figure 4 shows the proportional car availability per region. Private car ownership is the highest in Wallonia (85.2 % of the respondents) and the lowest in Brussels (70.9 % of the respondents). With 16.6 % of the respondents, Flanders has the highest number company car users, compared to 9.6 % in Wallonia and 14 % in Brussels. Brussels has the highest proportion of respondents making use of car sharing (4.9 %) or households in which no car is available (10.3 %). This is not surprising, given the high degree of urbanization in the region.

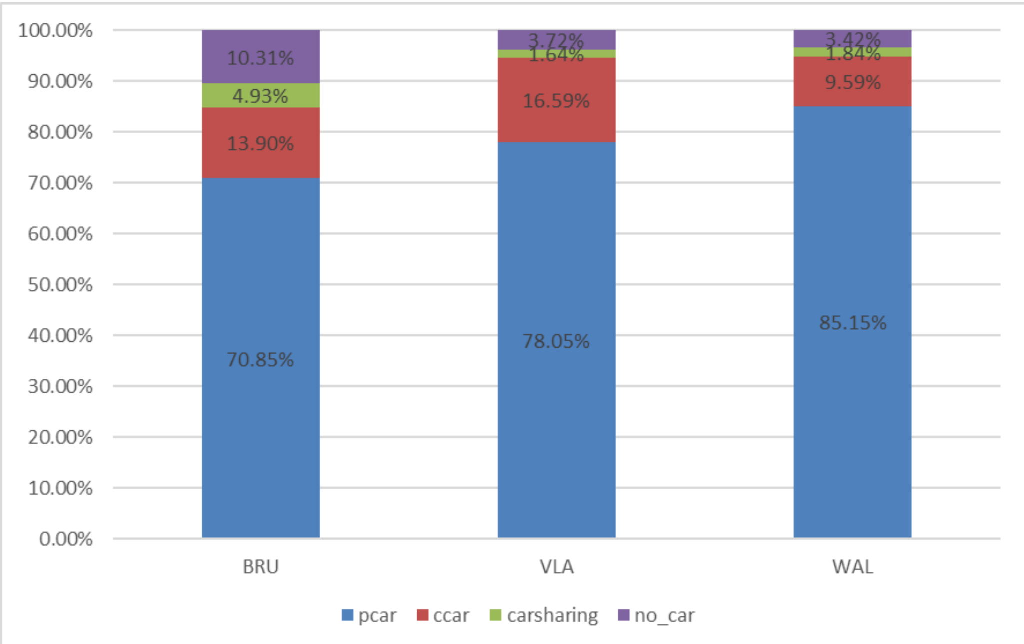
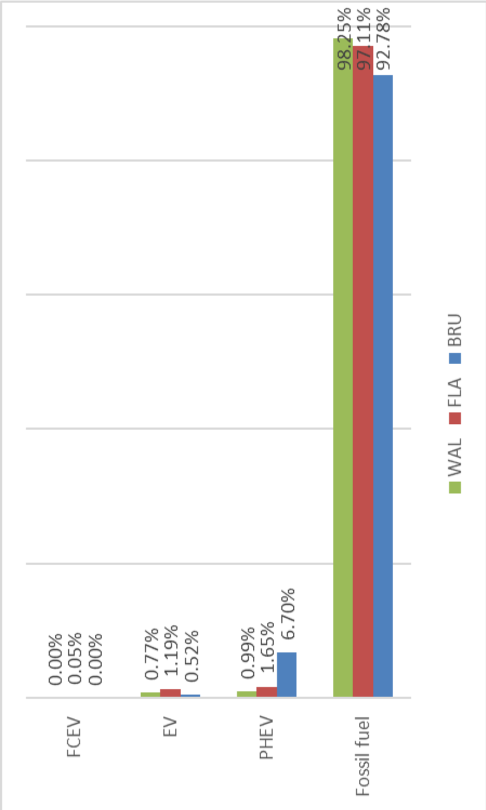


Figure 4 Share of respondents according to availability of a car in the household



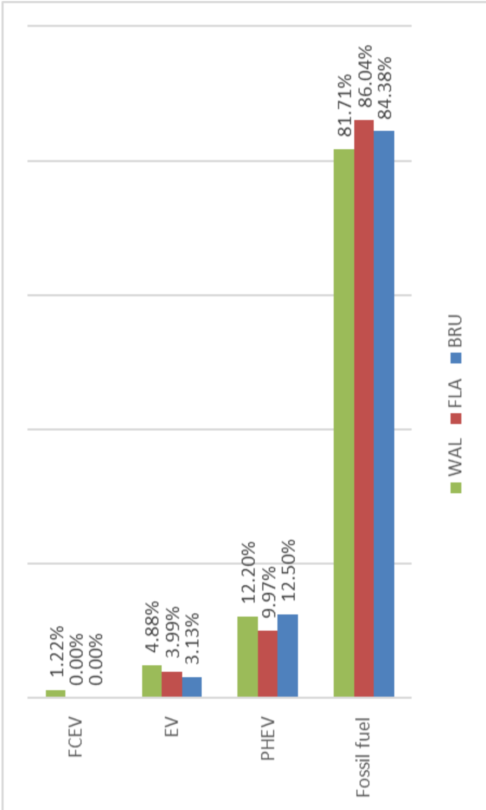


Figure 5 Characteristics of the cars in the respondents' household - Fuel type privately-owned (left) and company (right) cars

Figure 5 shows that the large majority of private and company cars are fossil fuel cars. The share of fully electric cars in the company car segment is much more pronounced than in the private car segment. 10 to 12.5 % of all company cars are plugin hybrids (PHEV), while 3.1 to 4.9 % are fully electric vehicles (EV). For privately-owned cars these percentages are much lower. The sample contains two hydrogen cars (FCEV), one privately owned in Flanders, and one company car in Wallonia.

When not driving, the majority of the respondents' car fleet is parked at a private parking spot at home (garage, private driveway). This is true for all time slots during the day, but especially during the evening and night, when about 80 % of all privately-owned cars are parked at home. During working hours (10-16h), only half of the privately owned cars are parked at home. At this time, 24 % of the privately-owned vehicles is located at a parking spot provided by the employer. The proportion of the car fleet that is parked on the street is relatively stable during the day, ranging between 17 and 19 % of all privately-owned cars.

The whereabouts of company cars during the day is a bit different. When not driving, most company cars are parked at a space provided by the employer. In the early morning 7-10h, this is the case for 41 % of the company cars, while 62 % of the company cars are parked at work in the 10-16h time block.

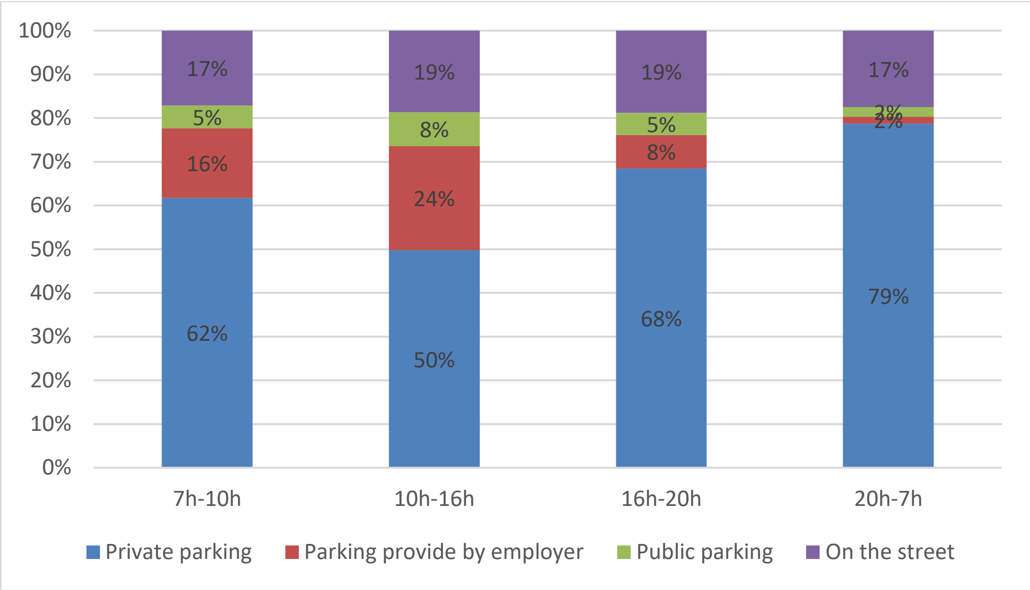


Figure 6 Location of privately-owned cars of the respondents during the day

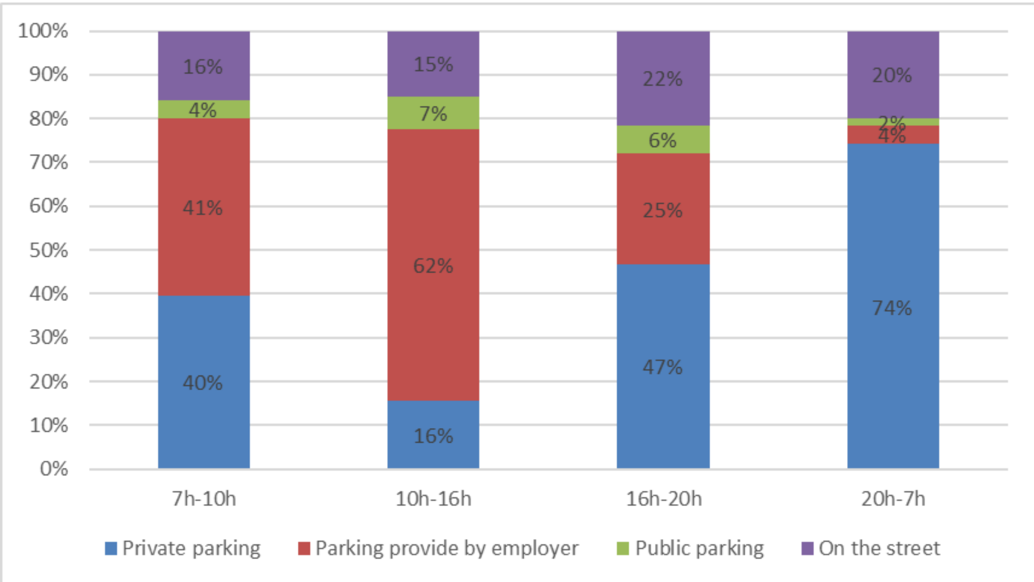


Figure 7 Location of company cars of the respondents during the day

As illustrated by Figure 8 to Figure 10, there are some noticeable differences among the regions. Especially for Brussels, the proportion of private cars parked on the street is significantly higher than in the other regions, ranging between 36 to 39 % during the day. This may have important implications for the installation of a V2G system in this region. The installation of public chargers with V2G capabilities will be more important in Brussels than in the other regions, where energy providers may concentrate on privately-owned bidirectional chargers.

Figure 8 shows that 58 % of the private cars can be parked at home in Brussels. This seems to be a high rate, which can be partly due to the characteristics of our Brussels subsample. Another explanation is the lower car ownership in Brussels. Note that the figure does not imply that 58 % of the houses in Brussels have a private parking space.

The proportion of private cars parked on the streets is the lowest in Flanders, where only 14 to 16 % of the cars are parked on the street during the day. The proportion of cars parked at a public parking is stable at around 5 % of the fleet. This means that about 80 % of the total car fleet in Flanders is parked at a private place during the day, at home or at work.

The location of parked cars in Wallonia is shown in Figure 10. Overall, 20 % of the private car fleet is parked on the street. During the night, 77 percent of the private cars are parked at home at a private parking spot. During day time (10-16h) this proportion drops to 45 %, with 24 % of the cars parked at a parking spot provided by the employer and 10 % at a public parking.

For conciseness, no figures are shown for company cars, but the regional differences are similar to those for private cars. A significantly larger proportion of company cars are parked on the streets in Brussels, ranging from 28 % (10-16h) to 41 % (16-20h). In Flanders, the proportion of company cars parked on the streets during the day ranges between 15 % (7-16h) to 20 % (16-20h). In Wallonia, this proportion is even lower with only 11 % of the company cars parked on the streets during the day (10-16h), rising to 22 % during evening and night time (16-7h).

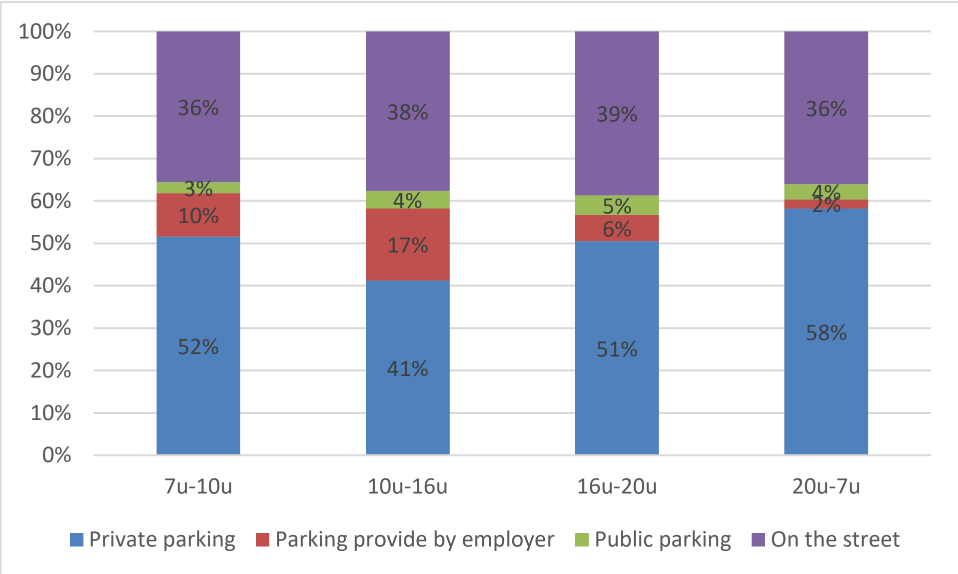


Figure 8 Location of private cars of the respondents during the day – Brussels

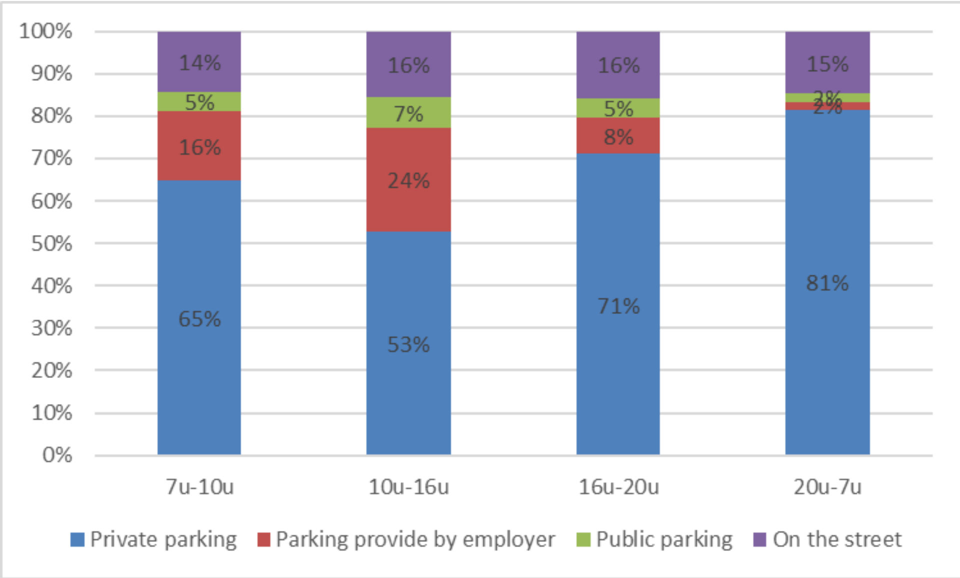


Figure 9 Location of private cars of the respondents during the day – Flanders

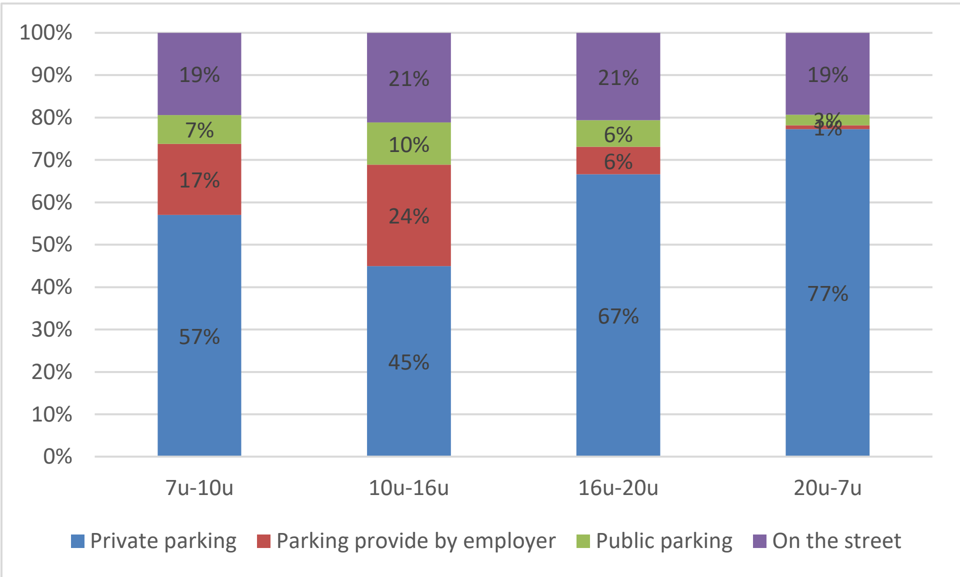


Figure 10 Location of private cars of the respondents during the day – Wallonia

4.2 Awareness of vehicle types and charging systems

A first necessary condition for a potential implementation of V2G is public awareness and use of electric vehicles, and the awareness about the concept of V2G. To get an idea of the general awareness about EVs and V2G, the respondents are asked about their knowledge of these concepts, before providing them with an explanation of the different vehicle types and charging methods.

A large majority of the respondents is familiar with EVs (80.5 %) or plugin hybrids (PHEVs, 71.9 %). The awareness about FCEVs is significantly lower (57.3 %). Awareness about electric vehicles is comparable across regions, with slightly lower familiarity levels in Wallonia and slightly higher familiarity levels in Flanders.

Table 7 Electric vehicle awareness in Belgium

	EV	PHEV	FCEV
Unknown	3.2%	4.4%	16.0%
Heard of it, but unfamiliar	8.3%	14.6%	26.2%
Familiar, but never driven	80.5%	71.9%	57.3%
I drive one (or have driven)	8.0%	9.2%	0.6%

Table 8 Electric vehicle awareness by region

Answers to the question "How familiar are you with the vehicle type below?" Scale from 1 (1=Unknown) to 4 (4 = I drive one (or have driven)). The higher the mean, the higher the awareness about the vehicle type.

	EV		PHEV		FCEV	
	Mean	Std dev	Mean	Std dev	Mean	Std dev
BRU	2.90	0.63	2.91	0.64	2.35	0.85
FLA	2.98	0.48	2.87	0.61	2.49	0.71
WAL	2.83	0.61	2.81	0.67	2.29	0.82
TOTAL BE	**2.93**	**0.54**	**2.86**	**0.63**	**2.42**	**0.76**

In contrast to the vehicle types, the survey respondents are much less familiar with different charging systems. Especially bidirectional charging and V2G are largely unknown, with only 5 % of the respondents claiming to know what these charging methods are. Conventional charging systems such as fast and slow charging are more familiar to the respondents, but still one fifth of the sample has never heard of these charging methods.

The concept of V2G is largely unknown in Belgium. 78.8 % of the respondents do not know V2G, 16.1 % have heard of it, but do not know what it is and only 5.1 % of the respondents report to know the concept well. These numbers are comparable to the study of Geske and Schuman (2018) who conducted a similar survey for the German market. They report even higher levels of unfamiliarity with V2G in Germany: 87.7 % of the respondents who never heard of V2G. A probable reason for this difference is that the German survey was conducted in 2013. At that time, electric vehicles and their charging systems were even less common than today. A similar level of unfamiliarity with V2G is also found for the Nordics. Noel, Carrone et al (2019) report that less than 10 % of their sample had ever heard of V2G before taking the survey.

The difference in awareness about charging systems across regions is small. Overall, familiarity with charging systems is the lowest in Wallonia.

Table 9 Familiarity with different charging systems

	Smart charging	Bidirectional charging	V2G	Fast charging	Slow charging
Unknown	57.9%	76.4%	78.8%	17.2%	21.6%
Heard of it, but don't know it well	32.5%	18.2%	16.1%	47.6%	41.5%
I know it well	9.6%	5.4%	5.1%	35.2%	36.8%

Table 10 Awareness about charging systems by region

Answers to the question "How familiar are you with the following charging techniques?" Scale from 1 (1 = I don't know it) to 3 (3 = I know it well).

	Smart charging		Bidirectional charging		V2G		Fast charging		Slow charging	
	Mean	Std dev	Mean	Std dev	Mean	Std dev	Mean	Std dev	Mean	Std dev
BRU	1.45	0.65	1.33	0.58	1.31	0.59	2.16	0.74	2.17	0.75
FLA	1.55	0.67	1.28	0.56	1.27	0.55	2.23	0.68	2.18	0.75
WAL	1.46	0.66	1.31	0.56	1.23	0.51	2.07	0.73	2.07	0.74
TOTAL BE	**1.52**	**0.67**	**1.29**	**0.56**	**1.26**	**0.54**	**2.18**	**0.70**	**2.15**	**0.75**

4.3 Purchase intention electric vehicle

4.3.1 Evaluation of car attributes

Because the current car fleet in Belgium is predominantly composed of fossil fuel cars, an important prerequisite for V2G introduction is a significant adoption of electric vehicles. At the time of the survey, a second hand market for electric vehicles was non-existent in Belgium. Therefore, the respondents were asked about the likelihood of buying a new car (or having a new company car) in the coming five years. In addition a number of questions were included to assess the importance assigned to different car attributes.

Table 11 shows the frequency of the answers to the question "*How important to you are each of the following car attributes when buying a new car*?". Importance is measured with a five point Likert scale ranging from 1 (1=Unimportant) to 5 (5= Very important). The car's purchase price is by far the most important factor when buying a car. 90.9 % of the respondents indicate that this characteristic is important or very important in the decision. This is not surprising, because cars are large budgetary items of which the purchase typically requires upfront planning and accumulated savings. In terms of importance, the purchase price is closely followed by safety, an attribute noted by 89.6 % of the respondents to be important or very important. The least important characteristic is horse power, and the second least important characteristic is the car's brand.

Table 11 Relative importance of car attributes when buying a new car

	Purchase price	**Horse power**	**Safety**	**Fuel type**	**Fuel cost**	**CO2 emission**	**Brand**	**Type**
Unimportant	0.4%	7.1%	0.6%	3.6%	1.5%	6.5%	10.2%	6.2%
Slightly important	2.4%	14.2%	2.2%	6.0%	4.3%	8.3%	11.4%	6.1%
Neutral	6.2%	36.3%	7.6%	24.1%	14.9%	23.7%	31.3%	21.9%
Important	39.5%	34.5%	39.1%	48.5%	50.1%	41.9%	35.8%	45.3%
Very important	51.4%	7.9%	50.6%	17.7%	29.3%	19.6%	11.2%	20.5%

The respondents were presented with the commonly perceived advantages (environmentally friendly, low noise, low maintenance costs, low fuel costs, innovative, tax benefit) and disadvantages (high purchase price, long charging time, low availability of charging points, costs of private charging system, low driving range, and low differentiation in models) of electric cars and were asked how important they consider each of these advantages and disadvantages to be.

With respect to the advantages (Table 12), the low fuel costs, low maintenance costs and tax benefit are considered to be most important. In the same line, the high purchase price is stated as the most important disadvantage, closely followed by the low availability of charging points, low driving range and high charging time (Table 13). The evaluation of the advantages and disadvantages of electric cars is consistent with the earlier stated relative importance of new car attributes in general. Price aspects turn out to be the respondents' main concern. This is not different when evaluating electric cars. Note that overall, the disadvantages of electric cars are considered to be more important than the advantages.

Table 12 Relative importance of advantages of electric cars

	Environmentally friendly	Low noise	Low maintenance costs	Low fuel costs	Innovative	Tax benefit
Unimportant	7.5%	19.6%	2.6%	2.8%	16.5%	7.6%
Slightly important	7.2%	11.9%	4.2%	3.8%	8.6%	5.8%
Neutral	20.0%	35.4%	14.1%	14.2%	38.7%	22.0%
Important	38.9%	26.0%	47.7%	47.2%	28.7%	42.4%
Very important	26.3%	7.1%	31.3%	32.1%	7.5%	22.2%

Table 13 Relative importance of disadvantages of electric cars

	Purchase price	Charge time	Charger availability	Charger cost	Low range	Few models
Unimportant	1.4%	2.2%	1.9%	2.4%	1.9%	10.0%
Slightly important	2.5%	4.6%	3.2%	4.3%	4.4%	10.8%
Neutral	9.6%	14.9%	12.1%	14.7%	15.7%	33.1%
Important	27.3%	33.5%	30.8%	33.5%	30.9%	27.1%
Very important	59.1%	44.9%	52.1%	45.1%	47.2%	19.0%

Table 14 shows the average importance score for the advantages and disadvantages of electric cars per region. Importance is measured with a five point Likert scale ranging from 1 (1=Unimportant) to 5 (5= Very important). Hence, the higher the average score, the more important the advantage or disadvantage is considered to be. The highest average score per region is shown in bold.

Table 14 Average importance score of the advantages (left) and disadvantages (right) of EVs by region

Advantages	**BRU**	**FLA**	**WAL**	**Disadvantages**	**BRU**	**FLA**	**WAL**
Environmental friendly	3.49	3.81	3.50	Purchase price	4.42	**4.40**	**4.40**
Low noise	3.00	2.80	3.07	Charge time	4.26	4.06	4.29
Low maintenance costs	**3.91**	4.04	**3.96**	Charger availability	**4.56**	4.19	4.39
Low fuel costs	3.84	**4.08**	3.94	Charger cost	4.30	4.08	4.25
Innovative	2.92	3.04	3.02	Low range	4.37	4.06	4.36
Tax benefit	3.53	3.68	3.64	Few models	3.53	3.24	3.52

4.3.2 *Purchase intention*

Descriptive statistics

Nearly half of the respondents intends to buy a new privately-owned car in the coming five years. 17 % of the respondents consider the new purchase to be very likely, while 32 % says they would likely buy a new car in the near future. These percentages are comparable across regions, with a slightly higher likelihood of new car purchase in Wallonia.

A much smaller proportion of the survey respondents thinks to use a new company car in the coming five years. In Flanders, 18 % of the respondents considers a new company car to be likely to very likely, while in Wallonia this is only 9.5 %. The lower percentages for new company cars are intuitive, given that most survey respondents currently do not drive a company car. Among the current users of company cars the picture is totally different, as shown in Figure 11: 72 % of them expects to drive a new company car in the coming five years.

Table 15 Likelihood of a new privately owned car or a new company car in the next five years

	new private car				new company car			
	BRU	FLA	WAL	BE	BRU	FLA	WAL	BE
Very unlikely	20.6%	21.6%	17.3%	20.3%	67.2%	66.2%	74.4%	68.6%
Unlikely	20.1%	19.5%	17.2%	18.9%	11.8%	8.4%	9.9%	9.1%
No opinion	11.8%	11.4%	12.4%	11.7%	5.9%	7.6%	6.1%	7.0%
Likely	28.9%	31.1%	35.7%	32.2%	7.4%	8.0%	4.3%	6.9%
Very likely	18.6%	16.5%	17.5%	16.9%	7.8%	9.8%	5.3%	8.4%

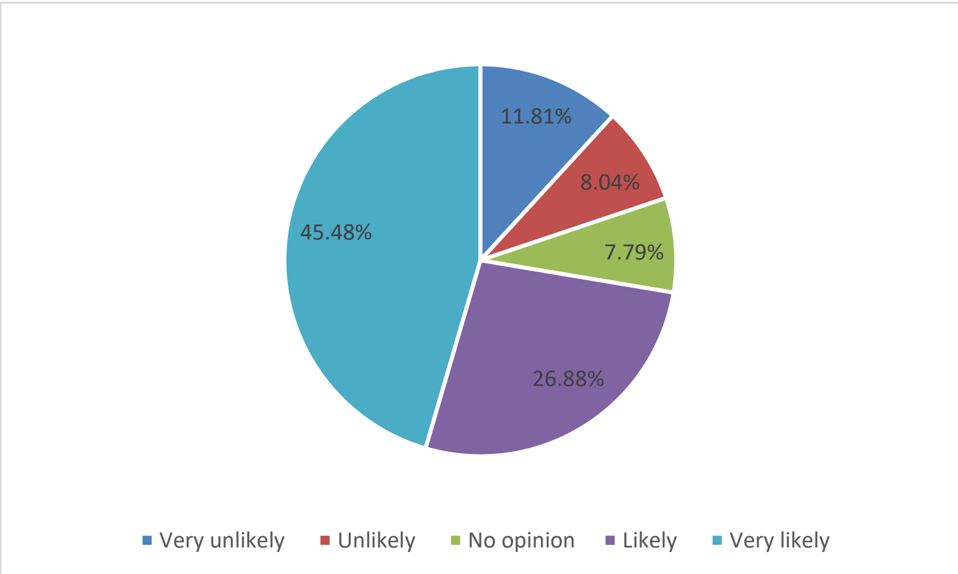


Figure 11 Likelihood of a new company car for the current company car users

The survey participants that respond to the question "How likely is it that you will buy a new car or drive a new company car in the coming five years" with "no opinion", "likely" or "very likely" were subsequently asked about the type of new car they intended to drive. Respondents had to indicate the likelihood that their new car would be a fossil fuel car, a 100 % electric car (EV), a plugin hybrid (PHEV), or a hydrogen car (FCEV). The relative likelihoods for each car type are shown in Table 16.

Looking at the intended new private car purchases, the majority of the respondents plan to buy a new fossil fuel car. Nearly 60 % of the respondents indicate that their new privately-owned car will likely or very likely be a fossil fuel car. Only 28 % of the respondents say they would likely or very likely choose a fully electric vehicle.

For company cars, respondents believe the likelihood to drive a plugin hybrid (44 %) or a fully electric vehicle (39 %) most likely. 37.6 % of the respondents believes that their new company car will likely be a fossil fuel car. This is a remarkably high number because on May 18, 2021, the federal government announced to fiscally stimulate the electrification of the company car fleet. As of 2026, only fully electric vehicles will enjoy tax deductibility.[10] This news was released just before the launch of the survey and got a lot of media attention. Therefore, it is surprising that nearly 38 % of the company car drivers expects their new company car to be a fossil fuel car.

Table 16 Expected car types when driving a new (company) car in the coming five years

	new private car				**new company car**			
	Fossil fuel	EV	PEV	FCEV	Fossil fuel	EV	PEV	FCEV
Very unlikely	9.3%	25.3%	15.1%	33.4%	17.9%	14.0%	9.7%	34.6%
Unlikely	13.0%	25.3%	15.7%	23.0%	15.9%	16.5%	12.2%	16.8%
No opinion	17.8%	21.3%	26.1%	28.8%	28.5%	30.1%	34.4%	37.1%
Likely	37.0%	22.1%	36.3%	12.4%	25.1%	27.1%	31.5%	9.3%
Very likely	22.8%	6.0%	6.8%	2.4%	12.5%	12.4%	12.2%	2.2%

Ordered logit model for privately owned cars

An ordered logit model was estimated to understand the determinants for the likelihood to buy an electric vehicle. The survey answers to the question "How likely is that that your new privately-owned car will be a 100 % electric vehicle?" are decoded to an ordinal variable ranging from 1 (Very unlikely) to 5 (Very likely). The ordered logit is used to explain the likelihood of buying an electric car using the following independent variables:

- Dummy variable indicating whether the respondent already owns a 100 % EV (pcar_EV) or a plugin hybrid (pcar_PHEV).
- The level of familiarity with electric vehicles (EV_familiarity) and V2G (v2g_familiarity)
- The importance given to the listed advantages (adv_EV_climate, adv_EV_noise, adv_EV_maintenance, adv_EV_usecosts, adv_EV_innovative, adv_EC_tax) and disadvantages (disadv_EV_price, disadv_EV_charge, disadv_EV_chargenet, disadv_EV_costcharger, disadv_EV_range, disadv_EV_choice) of an electric car. Due to the high correlation of cost-related advantages (low maintenance costs, low use costs and tax benefit) and disadvantages (high purchase price, cost of a private charging system), two cost variables are considered, one for advantages (adv_EV_costs) and one for disadvantages (disadv_EV_costs), computed as the average value of the respective cost variables.

[10] https://www.tijd.be/politiek-economie/belgie/algemeen/akkoord-over-vergroening-bedrijfswagens/10306532.html

- Dummy variables for the number of trips the respondent drives per week: 1 to 2 trips (pcar_trips1), 3 to 5 trips (pcar_trips3), 6 or more trips (pcar_trips6). The reference level is no trips.
- Dummy variables for the amount of kms driven per week: 11 to 30 km (pcar_11_30km), 31 to 50km (pcar_31_50km), more than 50 km (pcar_50km). The reference level is an average weekly distance of 0 to 10 km.
- A dummy variable equal to unity if the respondent drives 3 or more long trips (>100km) per month and zero otherwise.
- The number of private parking places at home (taking a value of 0, 1, 2 or 3).
- Socio-demographics: age, gender, education, income, regional dummies (VLA, WAL). Brussels is considered the reference region.

The results are presented in Table 16. The current ownership of an electric vehicle is found to be a strong predictor of the future purchase of EVs. This is not true for respondents owning a plugin hybrid. Being familiar with V2G charging significantly increases the likelihood of buying a EV, which is not surprising. The coefficient for EV familiarity is not statistically significant. Note that the familiarity factor may suffer from a problem of endogeneity. People with an interest in EVs will inform themselves about charging methods. The observed effect is therefore a reverse causality.

The advantages of EVs are all important determinants in the decision-making process of buying an EV. For the disadvantages, the low density of the charging network are found not to be a significant driver of the likelihood to purchase an EV.

With respect to driving behaviour, the coefficient estimates of the dummies capturing the number of trips driven per week are all negative, indicating a negative relationship between driving frequency and the likelihood to buy an EV. However, the coefficient is only statistically significant for the dummy variable for 1 to 2 trips per week. All other dummies measuring the driving intensity of the respondent are insignificantly different from zero.

The likelihood to purchase an EV increases with the number of private parking spots available at home. This makes sense because driving an EV requires charging infrastructure. Given the currently low number of public charging stations in Belgium, a private charging point facilitates owning a fully electric vehicle.

Looking at the socio-demographic criteria, women are less likely to purchase a EV and that the likelihood to buy an EV increases with the education level of the respondent. No evidence is found of an income effect. Also, there is no significant regional difference in the purchase intention for electric cars.

Table 17 Determinants for the likelihood to buy a 100 % electric privately-owned car

	Coeff	Std. Error	t value	p value
pcar_EV	1.94***	0.56	3.45	0.001
pcar_PHEV	0.41	0.35	1.16	0.245
EV_familiarity	0.10	0.11	0.92	0.359
V2G_familiarity	0.31***	0.11	2.84	0.004
adv_EV_climate	0.38***	0.06	6.09	0.000
adv_EV_noise	0.26***	0.06	4.73	0.000
adv_EV_costs	0.26***	0.09	2.99	0.003
adv_EV_innovative	0.31***	0.06	5.06	0.000
disadv_EV_costs	-0.24**	0.10	-2.50	0.013
disadv_EV_charge	-0.22***	0.08	-2.82	0.005
disadv_EV_chargenet	0.05	0.08	0.59	0.553
disadv_EV_range	-0.17**	0.08	-2.15	0.032
disadv_EV_choice	-0.11**	0.05	-1.97	0.049
pcar_trips1	-0.42*	0.22	-1.88	0.061
pcar_trips3	-0.38	0.24	-1.54	0.124
pcar_trips6	-0.43	0.28	-1.54	0.124
pcar_11_30km	0.11	0.16	0.68	0.496
pcar_31_50km	0.20	0.18	1.08	0.282
pcar_50km	-0.21	0.20	-1.05	0.294
pcar_long	0.19	0.13	1.41	0.160
number_parking	0.13**	0.06	2.20	0.028
gender	-0.24**	0.11	-2.18	0.029
education	0.14**	0.06	2.41	0.016
age	0.00	0.00	-1.18	0.237
income	0.03	0.04	0.68	0.496
VLA	0.22	0.21	1.04	0.298
WAL	-0.13	0.22	-0.58	0.560
Residual Deviance	3485			
Pseudo R^2	0.12			

Note: Significance at the 90, 95 and 99 percent confidence level is indicated with *, ** and *** respectively

Ordered logit model for company cars

Table 18 contains the estimation results for the ordered logit model to explain the perceived likelihood to drive a 100 % electric company car in the coming five years. The results are more or less in line with the findings for private car owners.

Respondents who currently drive a 100 % EV or a plugin hybrid, or who are more familiar with EVs are more likely to drive a new EV company car in the coming five years.

Among the advantages of EVs, the low maintenance and user costs are found to be the only statistically significant determinant. With respect to the disadvantages, the high purchase cost and the low range are the main hurdles for the likelihood to drive an electric company car.

The number of trips driven per week and the length of the trips have negative coefficient estimates, but none of the coefficients is statistically significant.

For the company car drivers, the only socio-demographic variable that determines the electric car choice is education: the higher the education level the higher the likelihood to adopt an EV.

Table 18 Determinants of the likelihood to choose a 100 % electric company car

	Coeff	Std. Error	t value	p value
ccar_EV	1.44**	0.58	2.50	0.012
ccar_PHEV	0.99**	0.41	2.38	0.017
EV_familiarity	0.55**	0.22	2.53	0.011
v2g_familiarity	0.12	0.18	0.66	0.512
adv_EV_climate	-0.01	0.12	-0.06	0.951
adv_EV_noise	-0.02	0.10	-0.16	0.875
adv_EV_costs	0.35**	0.16	2.10	0.035
adv_EV_innovative	0.15	0.11	1.45	0.148
disadv_EV_costs	-0.26	0.17	-1.60	0.110
disadv_EV_charge	-0.23	0.17	-1.30	0.192
disadv_EV_chargenet	0.01	0.16	0.07	0.941
disadv_EV_range	-0.35**	0.17	-2.12	0.034
disadv_EV_choice	0.08	0.10	0.85	0.398
ccar_trips1	-0.08	0.70	-0.11	0.913
ccar_trips3	-0.23	0.71	-0.32	0.750
ccar_trips6	-0.36	0.73	-0.49	0.626
ccar_11_30km	-0.15	0.61	-0.24	0.808
ccar_31_50km	0.22	0.62	0.36	0.716
ccar_50km	-0.15	0.61	-0.24	0.808
ccar_long	0.15	0.24	0.64	0.519
number_parking	0.07	0.11	0.66	0.510
gender	-0.14	0.23	-0.60	0.551
education	0.28**	0.13	2.23	0.026
age	0.01	0.01	0.63	0.530
income	0.05	0.10	0.52	0.605
VLA	-0.24	0.42	-0.57	0.566
WAL	-0.84*	0.49	-1.70	0.090
Residual Deviance	963			
Pseudo R^2	0.09			

Note: Significance at the 90, 95 and 99 percent confidence level is indicated with *, ** and *** respectively

4.4 Willingness to participate in V2G

The third part of the survey contains the discrete choice experiment to assess people's willingness to buy an EV with V2G contract specifications. Because the concept of V2G is largely unknown, the concept of V2G was first introduced to the respondents. This was done with the help of a short text and an illustration (Figure 12).

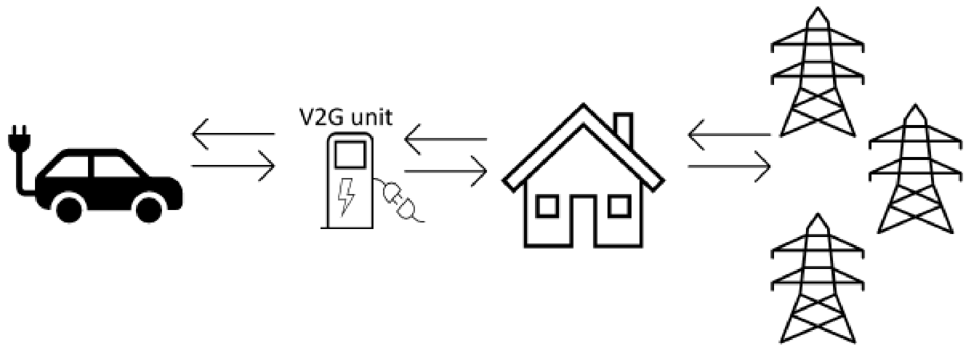


Figure 12 Vehicle-to-Grid (V2G)

The most important advantages and disadvantages of the V2G technology were briefly presented to the respondents and illustrated with an icon for improved comprehension. A full description can be found in Annex 1.

The listed advantages of V2G are

(1) A financial advantage for the consumer. This financial advantage may be twofold. First, consumers enjoy a lower electricity bill. Second, V2G participants may receive an upfront financial premium.
(2) A more efficient use of renewable energy sources.
(3) A lower risk of black-out.

The listed disadvantages are the following:

(1) (Very) long trips that require full battery capacity need to be planned in advance.
(2) Worries that frequent charging and discharging may lower the lifetime of the car's battery, though studies are inconclusive about the impacts.
(3) Additional challenges with respect to data protection and privacy.

The survey respondents were asked about their perceived importance of each of the advantages and disadvantages. Answers are provided on a Likert scale ranging from 1 (1=Unimportant) to 5 (5=Very important).

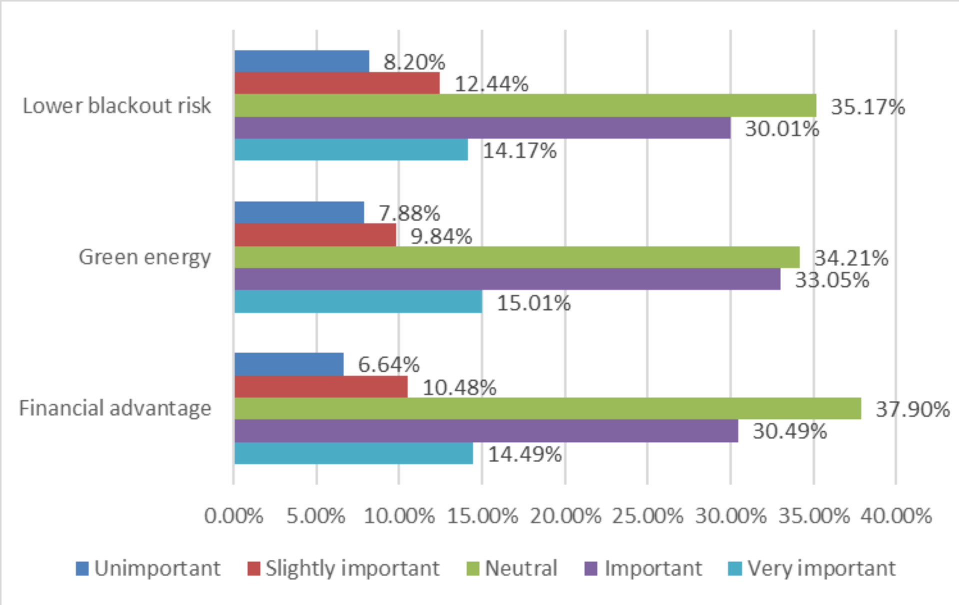


Figure 13 Perceived importance of V2G advantages

Most respondents had a neutral feeling about the V2G advantages. The more efficient use of renewable energy was considered the most important one (mean score of 3.37 out of 5), closely followed by the financial benefit (mean score of 3.36).

Respondents showed a stronger opinion about the disadvantages of V2G. The biggest worry among respondents is the potentially lower battery life of the vehicle (mean score of 4.0). The need to plan long trips is also considered an important disadvantage (mean score of 3.8). The data protection requirement and privacy concerns have a mean importance score of 3.6 out of 5.

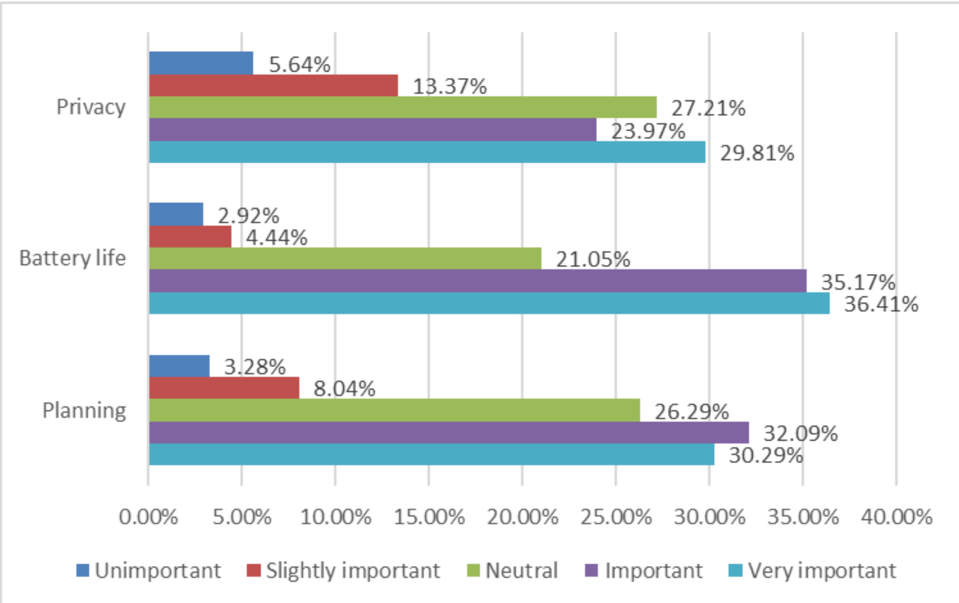


Figure 14 Perceived importance of V2G disadvantages

Overall, it is noted that the disadvantages of V2G are considered more important than the advantages. This finding is consistent with the theory of public resistance against new technologies. The introduction of new technologies often raises public controversy based on socioeconomic considerations. People fear that the benefits of a new technology will only accrue to a small part of society (for example the energy industry or high income households), while the risks and disadvantages are carried by the rest of society (Juma, 2016).

After the explanation of V2G and its advantages and disadvantages, respondents were asked to what extent they would use different charging systems if they could make use of an electric vehicle. Because of the low level of familiarity with different charging systems, each charging method was explained and illustrated. The respondents were presented with the following charging methods and descriptions:

(1) Uncontrolled charging: "charging when and where you prefer."
(2) Uncontrolled charging by default, smart charging during days with a potential risk of a blackout: "Only during about seven days per year in winter, you have to adjust your charging behaviour. During these days, you only recharge your battery during the night or around noon. You receive a small financial benefit in return. The rest of the year, you recharge your vehicle where and when you prefer."
(3) Smart charging: "The energy provider determines the optimal charging process of your vehicle based on the fluctuation of energy prices. Your vehicle only charges when the electricity price is low. This results in a financial benefit for you. You can determine when the battery must be fully charged."
(4) V2G (smart charging and discharging): "The energy provider determines the optimal charging process of your vehicle based on the fluctuation of energy prices. Your vehicle only recharges when the price of electricity is low and your battery is discharged when the price for electricity is high. You realise a financial benefit. The battery of your vehicle is never fully discharged, such that you always can rely on a predetermined minimum driving range. You can determine when the battery has to be fully charged."

Table 19 shows the willingness of the respondents to use each of the different charging systems on a range from 1 (1= I would definitely not use it) to 5 (5=I would definitely use it).

The willingness to use a charging system decreases with the sophistication of the system. In general, respondents are most willing to apply uncontrolled charging, and least willing to apply V2G.

Table 19 Willingness to apply charging systems

	Mean	Std dev
Uncontrolled charging	3.89	1.01
Uncontrolled charging + smart	3.48	1.05
Smart charging	3.33	1.13
V2G	3.08	1.21

Figure 15 shows the relative proportions of the extent to which respondents are willing to apply a specific charging system. There is a clear preference for uncontrolled charging: 70 % of the respondents would probably or definitely use this charging technique. The preference for V2G is much lower, with only 38 % of the respondents stating to probably or definitely use this charging method. Part of the explanation for the low willingness to participate in a V2G system may be caused by the weight people put on the disadvantages of this charging method. Another part of the explanation is that people are sceptical about this technology because it is new and fairly unknown. The low public awareness about different charging systems is also demonstrated by the fairly high proportion of respondents that are neutral about their willingness to participate to a specific charging method. This reveals that they do not know, at this point, which charging system they would choose. For V2G, this consists of one third of the respondents.

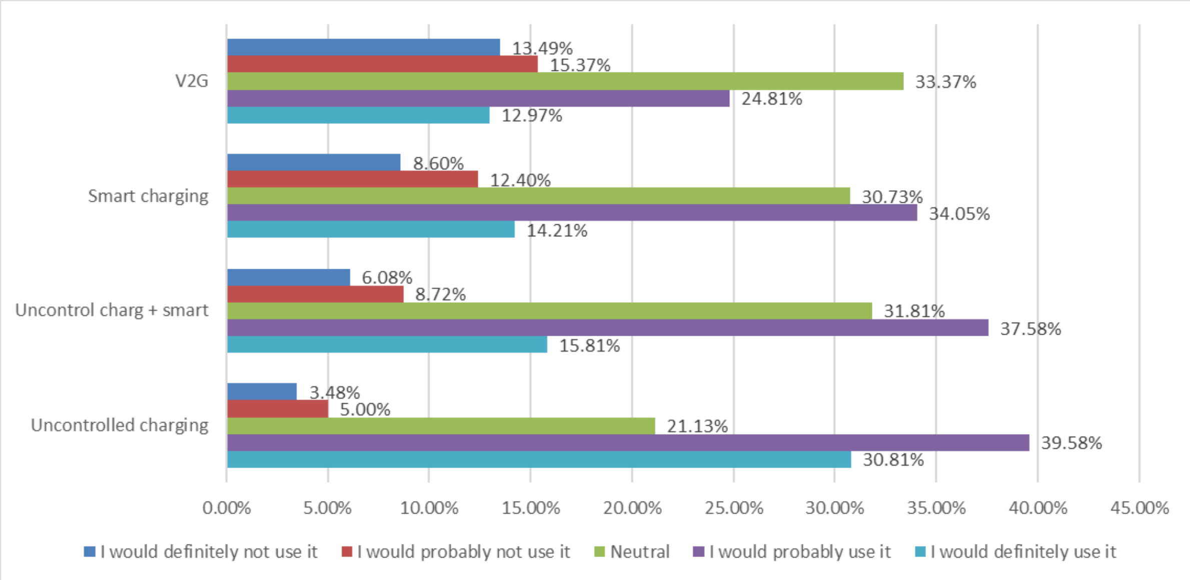


Figure 15 Willingness to apply charging systems

To get a better insight in the determinants of the willingness to participate in V2G, an ordered logit model was estimated. The stated willingness to participate in V2G is decoded as an ordinal dependent variable with possible values from 1 ("I would definitely not use it") to 5 ("I would definitely use it"). Separate models were estimated for private car owners and company car users. The following independent variables are considered:

- Dummy variables indicating whether the respondent currently owns an electric vehicle (pcar_EV) or plugin hybrid (pcar_PEV).
- The respondent's awareness of electric vehicles (EV_familiarity) and V2G (v2g_familiarity)
- The likelihood of buying a new car in the coming five years (pcar_new)
- The relative importance allocated to the advantages (adv_V2G_financial, adv_V2G_climate, adv_V2G_blackout) and the disadvantages (disadv_V2G_planning, disadv_V2G_battery, disadv_V2G_privacy) of V2G.
- Dummy variables indicating the number of trips a respondent drives per week: 1 to 2 trips (pcar_trips1), 3 to 5 trips (pcar_trips3), 6 or more trips (pcar_trips6). The default is no trips.
- Dummy variables to indicate the distance driven per week: 11 to 30 km (pcar_11_30km), 31 to 50 km (pcar_31_50km), more than 50 km (pcar_50km). The default is an average weekly distance of 0 to 10 km.
- Dummy variables to indicate the number of long trips (>100 km) per month: 1 to 2 trips (pcar_long_trips1), 3 to 8 trips (pcar_long_trips3), more than 8 trips (pcar_long_trips8).
- Dummy variables for the number of parking spots available at the respondent's home: 1 (parking_1), 2 (parking_2) or 3 or more (parking_3). The default is no private parking place available at home.
- Socio-demographics: age, gender, education, income, regional dummies (VLA, WAL). Brussels is considered the default region.

Table 20 contains the estimation results of the ordered logit model. Respondents who mentioned earlier in the survey to be familiar with the concept of V2G are more likely to adopt the charging technique. Respondents who valued the advantages of V2G more are more willing to participate. Likewise, respondents who had stronger feelings about the disadvantages are less likely to participate. These results are to be expected, but the comparison of the size and significance of the coefficient estimates gives an indication of the relative importance of these factors. The concern about privacy issues and data protection does not seem to influence the willingness to participate in V2G. The need to plan long trips in advance is considered the main disadvantage. With respect to the advantages, the argument that V2G allows for a more efficient use of renewable energy and a lower overall CO_2 emissions is the strongest influence on the willingness to participate in V2G.

The number of trips driven by the respondent has no influence on the willingness to participate in V2G. This is also the case for long trips. However, people who drive many kilometres per week are less likely to participate in V2G. The coefficient estimates for the dummies for driving between 31 and 50 km per week and more than 50 km per week are significantly negative. This reflects a "range anxiety" among participants. People who drive a lot may be worried that a V2G system is unable to guarantee their mobility needs.

With respect to the socio-demographic indicators, the willingness to participate in V2G slightly increases with the respondents' age. People living in Wallonia are also more willing to participate compared to people living in Brussels.

Table 20 Determinants of the willingness to participate in V2G among private car owners

	Coeff	Std. Error	t value	p value
pcar_EV	0.56	0.44	1.27	0.206
pcar_PEV	-0.48	0.30	-1.62	0.105
EV_familiarity	-0.11	0.08	-1.42	0.156
v2g_familiarity	0.29***	0.08	3.59	0.000
pcar_new	-0.01	0.03	-0.38	0.708
adv_V2G_financial	0.32***	0.05	6.21	0.000
adv_V2G_climate	0.55***	0.05	10.09	0.000
adv_V2G_blackout	0.25***	0.05	4.80	0.000
disadv_V2G_planning	-0.28***	0.05	-5.43	0.000
disadv_V2G_battery	-0.13**	0.05	-2.42	0.015
disadv_V2G_privacy	0.04	0.04	1.05	0.296
pcar_trips1	-0.08	0.16	-0.52	0.605
pcar_trips3	0.08	0.18	0.44	0.660
pcar_trips6	0.10	0.21	0.50	0.620
pcar_11_30km	-0.11	0.12	-0.88	0.376
pcar_31_50km	-0.37***	0.14	-2.60	0.009
pcar_50km	-0.52***	0.15	-3.38	0.001
pcar_long_trips1	-0.13	0.10	-1.38	0.168
pcar_long_trips3	-0.09	0.13	-0.69	0.492
pcar_long_trips8	-0.18	0.21	-0.84	0.401
parking_1	-0.11	0.12	-0.92	0.356
parking_2	-0.16	0.13	-1.25	0.211
parking_3	-0.04	0.15	-0.27	0.786
gender	-0.03	0.09	-0.30	0.768
education	-0.06	0.04	-1.44	0.150
age	0.01**	0.00	1.98	0.048
income	0.05	0.03	1.59	0.112
VLA	-0.08	0.16	-0.49	0.625
WAL	0.35**	0.16	2.10	0.035
Pseudo R^2	0.10			
Residual Deviance	5806			

Note: Significance at the 90, 95 and 99 percent confidence level is indicated with *, ** and *** respectively

In a similar model for company car users (see Annex 3), all three V2G advantages are significant predictors, while only one disadvantage is found to be a significant determinant of V2G participation. The need to plan long trips in advance is the most important hurdle for company car users to participate in V2G.

To summarize, the consumer appetite for V2G in Belgium is relatively low. Survey respondents show a strong preference for uncontrolled charging over more sophisticated charging methods. One reason for this is the low level of familiarity with alternative charging methods. This is normal, because it involves a new technology. An important challenge for the policy makers and the industry is thus to educate consumers and convince them from the potential benefits of smart charging techniques. In this process, a focus on guaranteed driving range will be crucial, because especially high-mileage drivers are found to be reluctant to participate in a V2G system.

5 Discrete choice experiment: stated preferences for electric vehicles with V2G capability

To get further insight in the factors influencing the potential uptake of V2G, a discrete choice experiment has been carried out. In the choice experiment, the respondents are asked to choose between two electric vehicles, or a no choice alternative. An example of a choice card is shown in Figure 16. The choice card is preceded by the following text:

"*Assume that you have decided to buy a fully electric vehicle. You can choose between vehicles with characteristics as shown in the table below. All the other characteristics of the vehicles (total recharging time, horse power, colour, size, design,…) are the same for both cars. Which car do you prefer? You may also decide not to choose any of the cars.*"

	EV 1	EV 2	None of these
Attributes of the electric vehicle			
Driving range	300 km	400 km	
Recharging time 100 km (fast charging)	20 minutes	45 minutes	
Purchase price	30 000 euro	55 000 euro	
V2G contract specifications			
Guaranteed minimum driving range	50 % of the driving range	25 % of the driving range	
Savings electricity bill	50 euro/year	25 euro/year	
Single upfront payment	0 euro	1000 euro	

Figure 16 Example of a choice card

Because V2G is not well known among the majority of the population, the V2G contract specifications are briefly explained below each choice card (see Annex 1).

Each respondent performs six choice tasks. Company car drivers complete the same choice experiment, with the only difference that the attribute "Purchase price" is replaced by "Catalogue price". The introductory text is adapted accordingly.

After removing redundant surveys, incomplete answers, speeders, and straightliners, we retained 1959 completed surveys for owners of private cars and 518 completed surveys from company car drivers.[11] Given that each respondent completed six choice tasks, this results in 11 754 responses for private car users and 3108 responses for company cars users.

A mixed logit model was estimated with alternative specific variables (price, range, recharging time, guaranteed minimum range, yearly savings, single upfront payment) and individual specific variables (income, age, gender, region, education, driving habits,…).

[11] Straightliners are respondents that rush through the survey and give the same answer every time.

Table 21 shows the distribution of the respondents' choices among the alternatives. For private car owners, the tendency to choose for an electric vehicle is fifty-fifty. Company car drivers are more likely to choose an EV; for this group of respondents the average split for EV and no EV is 62.8 % - 37.2 %.

Table 21 Distribution of the choices among the alternatives

	Choices among the alternatives			**Split EV - no EV**	
	EV 1	EV 2	No choice	EV	no EV
Private car owners	19.8	28.0	52.2	47.8	52.2
Company car users	31.7	31.1	37.2	62.8	37.2

The distribution of the characteristics of presented and selected alternatives in the choice experiment is shown in Table 22. The summary statistics of the presented alternatives show that the presented EVs are comparable for private car owners and company car users. Interestingly, the characteristics of the typical EV chosen are different among the two samples. People that are offered a privately-owned car have the tendency to choose a less expensive model. Driving range, recharging time, yearly electricity bill savings and single premium are similar for selected and presented cars, on average. Privately-owned car drivers select EVs with a slightly higher guaranteed driving range than what is offered on average.

Table 22 Distribution of the presented and selected alternatives

		All presented alternatives				**Selected alternatives**			
Privately-owned cars	Unit	Mean	Std dev	Min	Max	Mean	Std dev	Min	Max
Purchase price	€	44 863	20 733	20 000	80 000	37 020	17 547	20 000	80 000
Driving range	km	375	146	200	600	385	145	200	600
Recharging time	minutes	54	25	20	90	51	25	20	90
Guaranteed range	km	159	117	30	450	165	118	30	450
Savings electricity bill	€/year	66	35	25	120	66	35	25	120
Single payment	€	439	370	0	1 000	425	366	0	1 000
		All presented alternatives				**Selected alternatives**			
Company cars	Unit	Mean	Std dev	Min	Max	Mean	Std dev	Min	Max
Catalogue price	€	44 808	20 788	20 000	80 000	42 764	19 653	20 000	80 000
Driving range	km	374	146	200	600	418	148	200	600
Recharging time	minutes	54	25	20	90	52	25	20	90
Guaranteed range	km	158	117	30	450	186	126	30	450
Savings electricity bill	€/year	66	35	25	120	69	35	25	120
Single payment	€	436	370	0	1 000	437	367	0	1 000

A typical company car driver also chooses an EV that is cheaper than what is offered on average. However, the average price is about € 3 500 higher than the typical EV chosen by a private car owner. This is intuitive because the purchase price of a company car is usually paid by the employer, not the driver. For most company cars, the contribution paid by the employee increases with the catalogue price of the car, but still, the employee does not pay the full purchase price. In addition, the purchase price and use costs of the car are tax deductible (for the employer), which is not the case for private car owners.

Also noticeable is that company car drivers have a higher range anxiety than private car owners. They choose EVs with a higher driving range than average and also require a higher minimum guaranteed driving range in a V2G contract.

Model estimation

The parameters of the utility function are estimated using a mixed logit model. Mixed logit is a general statistical model for analysing discrete choices. It offers a solution for three limitations of the standard logit model. It allows for random taste variation across choosers. For example, some persons may attach more importance to a larger driving range than others. It also allows for unrestricted substitution patterns across choices and correlation in unobserved factors over time (Train, 2003).

Because there are only six observations per respondent, the individual specific parameters cannot be estimated directly from the data. Instead, the coefficients are considered as random variables, for which the distributional characteristics are estimated by running simulations.

First an initial hypothesis has to be made about the distribution of the random parameters. It is assumed that the attributes in the choice experiment, price, driving range, recharging time, GMR, yearly savings and upfront payment, are lognormally distributed. This is because it is expected that the coefficients have the same sign for all respondents. Only the magnitude of the coefficients may differ over individuals (Train, 2003). Earlier studies like Noel, Carrone et al. (2019) also found that a lognormal distribution for these attributes leads to a better model fit.

The choice probabilities are approximated through 500 draws generated by Halton sequences.

For a detailed explanation of the mixed logit methodology, we refer to Train (2003) and Hensher et al. (2005).

5.1 Private car drivers

This section discusses the estimation results for the discrete choice model for private car drivers. First the overall results are presented, followed by the interpretation of the model outcomes.

Model results

The parameter estimates of the mixed logit model for private car choices are shown in Table 23. Statistical significance of the parameter estimates at a 99 %, 95 % and 90 % confidence level is denoted with ***, ** and *, respectively. The overall goodness-of-fit of the model is calculated based on the pseudo-R^2, which is equal to 25 %. This is in line with previous studies.

For most of the random parameters, i.e. the parameters associated with the vehicle and V2G contract specifications, the standard deviations of the coefficients are significantly different from zero. This means that the mixed model provides a better representation of the choice situation than a logit model that assumes the same coefficient for each individual.

There is a lot of heterogeneity among respondents with respect to price attributes. In contrast, respondents are more similar in their preference towards driving range and guaranteed minimum range. The variation in these parameters, measured by the standard deviation, is small.

Table 23 Mixed model parameter estimations - private car

Variable	Parameter	Value	Std. Error	z-value
Price	mean of ln(coeff)	-1.765***	0.047	-37.265
	std. dev. of ln (coeff)	0.25***	0.010	24.020
Driving range	mean of ln(coeff)	1.483***	0.337	4.397
	std. dev. of ln (coeff)	0.005	0.088	0.058
Recharging time	mean of ln(coeff)	-0.140***	0.043	-3.256
	std. dev. of ln (coeff)	0.047	0.061	0.770
GMR	mean of ln(coeff)	1.495**	0.437	3.420
	std. dev. of ln (coeff)	0.098*	0.054	1.814
Yearly savings	mean of ln(coeff)	0.009	0.035	0.246
	std. dev. of ln (coeff)	0.258***	0.037	6.879
Single payment	mean of ln(coeff)	-0.001	0.007	-0.098
	std. dev. of ln (coeff)	0.116***	0.013	9.248
Driving range * GMR		-0.120*	0.070	-1.700
Recharging * GMR		-0.140***	0.050	-2.940
ASC_EV		4.540***	2.190	2.080
Income		0.136***	0.030	4.553
Gender		-0.398***	0.075	-5.282
Age		-0.031***	0.002	-12.555
Education		0.122***	0.035	3.514
Number_parking		-0.071*	0.037	-1.916
EV_familiarity		0.642***	0.07	9.113
V2G_familiarity		0.389***	0.072	5.409
Long trips		-0.474***	0.085	-5.614
Weekly mileage > 50 km		-1.089***	0.101	-10.806
Flanders		0.758***	0.135	5.601
Wallonia		0.492***	0.141	3.495
Log likelihood		-8993		
Pseudo R^2		0.248		

Parameter estimates are denoted with ***, ** and * to indicate statistical significance at 99%, 95% and 90% confidence level respectively.

Table 24 Willingness to pay for EV and V2G attributes of private car owners

	median	mean	std dev	conf interval
Driving range	25.74	26.56	6.75	13.3 – 39.8
Recharging time	-5.08	-5.25	1.36	-2.6 - -7.9
GMR	26.05	27.01	7.38	12.5 - 41.5
Yearly savings	5.89	6.29	2.33	1.7 – 10.9
Single upfront payment	5.84	6.06	1.70	2.7 - 9.4

Statistically insignificant values are shown in light grey.

Willingness-to-pay

The coefficient estimates of the attributes are not directly interpretable, especially because the vehicle and V2G contract attribute coefficients are lognormally distributed. However, the willingness-to-pay for each attribute can be computed based on the ratio of the attribute's coefficient estimate and the estimated price parameter.[12] For a detailed description of the calculation of the WTP, we refer to Train (2003) and Hensher et al. (2005).

The mean, median and standard deviation of the estimated WTP of each attribute are shown in Table 24.

For private car owners, the average WTP for an additional km of driving range is €26.6. This means that the accepted price difference between EVs with a range of for example 300 km and 400 km is € 2660. This WTP is at the lower end of what has been reported in the literature. For comparison, the estimated WTP reported by other studies is shown in Table 25. The WTP estimates for driving range are comparable with the more recent studies for the U.S. (Hidrue et al., 2011), Canada (Ferguson et al., 2018) and the Netherlands (Hoen & Koetse, 2014).

Note that the mean value for WTP is just a point estimate. Because the standard deviation of the estimated WTP is also computed, a confidence interval (i.e. the range of values between the true WTP is expected to be at a specific confidence level) can be determined. At a 95 % confidence level, the WTP for driving range is between €13.3/km and €39.8/km.

The WTP for an extra kilometre driving range and an extra kilometre GMR are similar. This indicates that respondents are not myopic with respect to the valuation of an additional kilometre of driving range.

People are willing to pay € 5.25 on average for a reduction of the charging time (fast charging) by one minute. To illustrate this, for a reduction in fast charging time from 1 hour to 30 minutes, consumers are willing to pay a higher purchase price of € 158. This WTP estimate is much lower than what is reported in earlier studies.

Table 25 Willingness-to-pay estimates for EV attributes other studies

Source	Market	WTP for driving range per km	WTP for recharging time per min
Noel, Carrone et al. (2019)	Nordics	€ 150	€ -93.33
Greene et al. (2018)	U.S.	$ 53.9	NA
Ferguson et al. (2018)	Canada	$ 30	$ -32.85
Hackbarth and Madlener (2016)	Germany	€ 95 - € 125	€ -5 - €-194
Hoen & Koetse (2014)	The Netherlands	€ 52	€ -24.00
Jensen et al. (2013)	Denmark	€ 84 - € 134	€ -34.50 - €-89.70
Hidrue et al. (2011)	U.S.	€ 38	€ -5.67 - €-43.33

Of most interest to this study is the WTP for V2G contract attributes. A first observation is that the financial incentives, a yearly reduction of the electricity bill and an upfront financial benefit, play no role in the decision to participate in V2G. A potential reason for this is that consumers consider the proposed financial compensation to be too low compared to the service they provide. Because the parameter estimates for these attributes are not significantly different from zero, the estimated WTP for these attributes is not reliable. This is why the numbers are shown in light grey in Table 24.

[12] The log of the ratio of two terms that are independently lognormally distributed is also lognormally distributed. Therefore, one can calculate the distributional moments (mean, median, standard deviation) for the WTP.

The only V2G attribute that has a significant effect on the respondents' choice is the guaranteed minimum driving range (GMR). The WTP for this attribute is € 27 per kilometre, which is comparable to the valuation of an extra km of driving range of the EV. For a car with a driving range of 300 km, a V2G contract that stipulates a minimum guaranteed range of 50 %, should provide an upfront financial compensation of € 4 050. This is rather high, and well above the average upfront financial premium offered in the experiment. This explains why that attribute is not significant.

Interaction effects

The interaction effect between the EV's attribute "driving range" and the V2G attribute "guaranteed minimum range" is significantly negative. This means that the WTP for an extra kilometre guaranteed range decreases if the driving range of the EV is larger. This makes sense intuitively. Giving up 50 % of the driving range of a car with a 200 km range is much more impactful than giving up half of the driving range of a car with a 500 km autonomy.

The same holds for the interaction between recharging time and GMR. When cars can be recharged faster, people are willing to accept a lower guaranteed minimum driving range.

Socio-demographic factors

Overall, socio-demographic factors play an important role in the choice for a V2G-enabled vehicle.

People who benefit from a higher household income and who have a higher education level are more likely to choose a V2G-enabled electric car. Being familiar with EVs or the V2G technology increases the likelihood of choosing for a V2G-enabled car significantly.

Gender and age play a role as well. Women are less likely to choose a V2G EV, and the willingness to buy such a vehicle decreases with age.

The likelihood of buying a V2G-enabled car is also related to the driving behaviour of the respondent. High mileage drivers and people who frequently drive long trips are less likely to participate in a V2G scheme. The infrastructure at home plays a role to some extent. The number of parking spots is found to be negatively related with the probability to choose for V2G. However, the parameter estimate is only significant at a 90 % confidence level.

Lastly, there are strong regional differences in the willingness to participate in a V2G contract. The market potential for V2G-enabled cars is the highest in Flanders and the lowest in Brussels.

5.2 Company car drivers

Next, this section considers the choices made by the sample of company car drivers, and points out the difference with the estimation results for the private car owners, where relevant.

Model results

Table 26 shows the estimation results for the company car drivers. Although the model obtains a good overall fit (pseudo R^2 is equal to 0.29), there are a smaller number of significant parameter estimates than in the private car model.

The estimation results show that the willingness to choose a V2G-enabled vehicle is negatively related with the vehicle's catalogue price, and positively related with the car's driving range and the guaranteed minimum range specified in the V2G contract. The attributes "recharging time", "yearly savings" and "single payment" are not statistically significant from zero.

Table 26 Mixed model parameter estimations - company car

Variable	Parameter	Value	Std. Error	z-value
Price	mean of ln(coeff)	-1.036***	0.083	-12.435
	std. dev. of ln (coeff)	0.225***	0.023	9.686
Driving range	mean of ln(coeff)	0.972*	0.516	1.884
	std. dev. of ln (coeff)	0.005	0.088	0.058
Recharging time	mean of ln(coeff)	-0.153	0.354	-0.432
	std. dev. of ln (coeff)	0.281***	0.079	3.56
GMR	mean of ln(coeff)	0.127**	0.052	2.426
	std. dev. of ln (coeff)	0.269***	0.047	5.698
Yearly savings	mean of ln(coeff)	0.090	0.062	1.456
	std. dev. of ln (coeff)	0.353***	0.063	5.617
Single payment	mean of ln(coeff)	0.006	0.013	0.446
	std. dev. of ln (coeff)	0.096***	0.027	3.577
Driving range * GMR		0.221*	0.13	1.695
Recharging * GMR		-0.126	0.094	-1.348
ASC_EV		6.648***	4.081	1.629
Income		0.065	0.063	1.028
Gender		-0.238	0.152	-1.566
Age		-0.058***	0.006	-9.428
Education		0.037	0.079	0.462
Number_parking		-0.090	0.078	-1.160
EV_familiarity		0.463***	0.136	3.407
V2G_familiarity		0.248**	0.11	2.248
Long trips		-0.232	0.165	-1.401
Weekly mileage > 50 km		-0.250	0.160	-1.530
Flanders		1.390***	0.261	5.333
Wallonia		0.540*	0.277	1.945
Log likelihood		-2432		
Pseudo R^2		0.287		

Parameter estimates are denoted with ***, ** and * to indicate statistical significance at 99%, 95% and 90% confidence level respectively.

Table 27 Willingness to pay for EV and V2G attributes of company car owners

	median	mean	std dev	conf interval
Driving range	7.45	7.64	1.74	4.23 - 11.05
Recharging time	-2.42	-2.58	0.96	-4.46 - -0.7
GMR	3.20	3.40	1.23	0.99 - 5.81
Yearly savings	3.08	3.37	1.47	0.48 - 6.25
Single payment	2.83	2.92	0.73	1.50 - 4.34

Statistically insignificant values are shown in light grey.

Willingness-to-pay

The WTP for EV attributes and V2G contract specifications is very different between company car drivers and private car owners. Overall, the WTP estimates for company car drivers are much lower than those for private car owners. This finding is in line with the results of Hoen and Koetse (2014) and Koetse and Hoen (2014) who also report higher WTP for private car drivers than for company car drivers.

The finding of lower WTP values for company car drivers is not surprising because these drivers typically are not charged with the actual costs of the vehicle and will therefore be less price sensitive. However, it is remarkable that the attribute "recharging time" is not found to be statistically significant for this driver segment.

Socio-demographics

For company car drivers, socio-demographic factors turn out to be less important as predictors of V2G-capable EV choice. Only age, being familiar with EVs and V2G, and region of domicile are significantly related with the probability of choosing for the EV. Note that there might be a selection bias in this sample. The sample of company car drivers may be expected to be less heterogeneous in terms of socio-demographics than the sample of private car drivers. This may explain the absence of significance of socio-demographic factors in this sample.

6 Conclusion

This study investigated the market potential for V2G-enabled electric vehicles in Belgium. A nation-wide survey was conducted among a representative sample of the Belgian population to get a clear insight in car drivers' perceptions about electric cars and different charging methods. To assess the market potential for different charging methods in Belgium, drivers were asked about their driving habits and purchase intention for the coming five years. The survey also includes a discrete choice experiment, in which respondents were asked to choose between different V2G-enabled electric vehicles. From the willingness-to-pay for different V2G contract specifications is derived. The survey was carried out by Bpact in May-June 2021.

The purchase intention for EVs in the coming five years is found to be relatively low. Half of the Belgian private car drivers and 30 percent of the company car drivers state that when they buy a new car in the coming five years, this will unlikely be a fully electric vehicle. Consumer appetite for plug-in hybrids (PHEV) is higher. 43 percent of the respondents believe that their next new privately-owned or company car may be a PHEV. The main hurdles in the transition to EVs are the high purchase price and the limited driving range.

Turning to the charging methods, there is a strong preference for uncontrolled charging over more sophisticated charging methods. Overall, the willingness to apply a specific charging technique decreases with the sophistication of the technique. The public resistance against more advanced charging techniques such as V2G results mainly from a poor knowledge about this technology. Nearly 80 percent of the people in the sample has never heard of V2G. This number is lower than reported by other studies (for example studies on the German and Nordics markets report ignorance levels of up to 90 percent of the sampled respondents), but it is still very high. Apart from a poor knowledge about the concept, the willingness to participate to a V2G system is lower for high mileage drivers. Drivers are also concerned about the need to plan long trips in advance and they may worry that the EV's battery will be degraded faster when using V2G charging.

The analysis of the driving and parking habits of the respondents reveals differences across the regions. In Brussels, up to 40 percent of the cars are parked on the street. This implies that, for V2G to be implemented successfully, public charging stations with V2G capability are required. This is much less of a concern for Flanders and Wallonia, where 80 percent of the cars are parked at a private location (at home or at work). In these regions, a focus on V2G-capable charging stations at private locations should be the focus.

The results of the discrete choice experiment show that consumers are mostly concerned about the purchase price, driving range and recharging time of their vehicle. The EV specific attributes clearly dominate the V2G contract specifications in the choice of the vehicle. With respect to V2G, consumers are quite insensitive to financial benefits such as a yearly saving on the electricity bill or a single upfront payment. The only V2G attribute that turns out to be important in the experiment is the guaranteed minimum driving range. The willingness-to-pay for an extra kilometre guaranteed driving range is estimated at € 27. More specifically, a V2G contract that allows for the car's battery to be discharged to a level such that the maximum driving range is 100 km lower, would require an upfront payment of € 2700.

Overall, drivers of company cars are less price sensitive than private car owners. The willingness to choose a V2G-enabled car is more likely for company car drivers. In general, they choose for a more expensive car with a higher driving range.

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Annex 1: Survey about the potential for smart charging systems for electric cars in Belgium

Introductory text

The purpose of this survey is to assess the market potential for alternative charging systems of electric cars. A transition to electric vehicles has a significant impact on the overall electricity demand. The way the car's battery is charged will become important. This study aims to investigate the considered importance of different characteristics of charging systems.

Transport & Mobility Leuven conducts this study in the context of the EPOC 2030-2050 project, commissioned by the Energietransitiefonds. EPOC 2030-2050 is the acronym for *Energy modeling framework for POlicy support towards a Cost-effective and Sustainable society in 2030 and 2050*. The project develops energy transition models for Belgium with a time horizon from 2030 to 2050. Fourteen research institutes from Flanders, Wallonia and Brussels join forces to achieve the project's goals.

Completing the survey take about ten to fifteen minutes. Survey answers are recorded anonymously. All collected data will be treated with full respect of the respondent's privacy.

Preselection of respondents

0.0 Do you have a driving license type B (cars)?

Yes => the survey is started

No => "You do not belong to the target audience for this survey. The survey ends here. Many thanks for participating."

Part 1: Current car ownership

1.1. Select the situation that applies to your household (multiple answers allowed):

My household owns at least one car. => if selected, go to 1.1.1
My household can make use of at least one company car. => if selected, go to 1.1.2
My household uses car sharing.
My household does not use a car. . => if selected, go to 2.1

1.1.1. How many cars does your household own (excluding company cars)?
1.1.2. How many company cars does your household have at your disposition?

1.2. Select the type of your car(s):

	Fossil fuel car (diesel, gasoline, gas,…)	Plug-in hybrid	100% Electric car	Fuel cell car (hydrogen)
First car				
Second car				
…				
Company car				
Shared car				

For people with at least one privately-owned car:

1.3. Where is your first private car usually parked during a weekday (Monday-Friday, not during Covid crisis)? Op welke plaats staat uw eigen wagen doorgaans geparkeerd tijdens een weekdag (maandag-vrijdag, niet tijdens een Covid-periode)? Per time block, only one location can be selection. Select the location where your car is parked during the majority of the time.

	7h – 10h	10h -16h	16h-20h	20h-7h
Private parking spot (e.g. garage/driveway)				
Parking spot provided by the employer				
Public parking (parking garage or parking area)				
On the street				

This question is repeated based on the number of privately-owned cars owned by the respondent.

For people with at least one company car :

1.4. Where is your first company car usually parked during a weekday (Monday-Friday, not during Covid crisis)? Op welke plaats staat uw eigen wagen doorgaans geparkeerd tijdens een weekdag (maandag-vrijdag, niet tijdens een Covid-periode)? Per time block, only one location can be selection. Select the location where your car is parked during the majority of the time.

	7h – 10h	10h -16h	16h-20h	20h-7h
Private parking spot (e.g. garage/driveway)				
Parking spot provided by the employer				
Public parking (parking garage or parking area)				
On the street				

This question is repeated based on the number of company cars available to the respondent.

1.5 For how many cars do you have a private parking spot or a garage at your home?

0
1
2
3 or more

Part 2: Familiarity and purchase intention

2.1 How well do you know the following car types?

	Unknown	Heard of it, but I don't know it well.	I'm familiar, but never drove one	I drive one or have driven one
100% Electric car A 100% electric car does not have a combustion engine. The car is powered by a battery that must be charged by plugging it to the electricity grid.				
Plug-in hybrid A plug-in hybrid car has two engines, an electric engine and a combustion engine. The electric motor is charged by the electricity grid (for example with a traditional wall outlet). Short distances are covered with the electric motor. For longer distances, the car relies on the combustion engine.				
Fuel cell electric car A fuel cell electric car uses hydrogen as energy source instead of (or in combination with) an electric battery.				

2.2 For each of the attributes below, select how important you consider them when choosing a new vehicle.

	Unimportant	Low importance	Neutral	Important	Very important
Purchase price					
Horse power					
Safety					
Fuel type					
Fuel costs					
CO_2-emission					
Brand					
Type (e.g. SUV, convertible,…)					

2.3 The following advantages are often associated with electric cars. To what extent are these advantages important to you?

	Unimportant	Low importance	Neutral	Important	Very important
Environmental friendly					
Low noise					
Low maintenance costs					
Low use costs					
Innovative					
Tax benefit					

2.4 The following disadvantages are often associated with electric cars. To what extent are these disadvantages important to you?

	Unimportant	Low importance	Neutral	Important	Very important
High purchase price					
Long recharging time					
Limit availability public charging points					
Cost private charging station					
Limited driving range					
Limit choice in models					

2.5 How well do you know the following charging techniques for electric vehicles?

	I don't know this	Have heard of it, but I don't know it well	I know this well
Smart charging			
Bidirectional charging			
Vehicle-to-grid (V2G)			
Fast charging (charging station)			
Slow charging (wall outlet)			

2.6 How likely is it that you will buy a new car in the coming five years?

Very unlikely
Unlikely
No opinion
Likely
Very likely

⇨ *As of "no opinion", go to 2.8*

2.7 How likely is it that you can drive a new company car in the coming five years?

Very unlikely
Unlikely
No opinion
Likely
Very likely

⇨ *As of "no opinion", go to 2.9*

2.8 How likely will your next new private car be one of the following types?

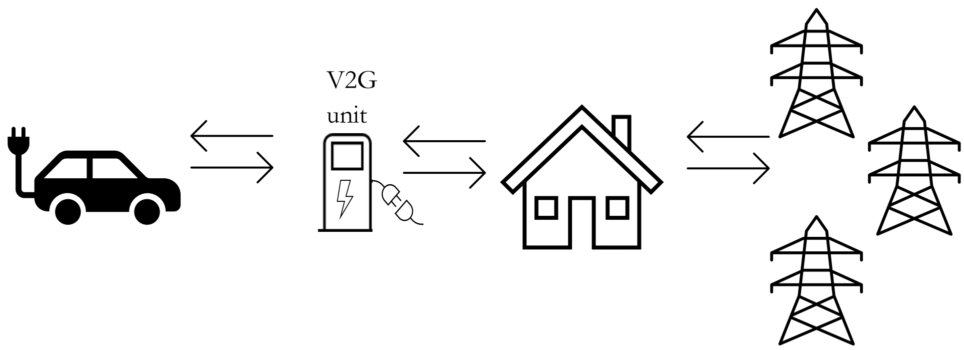
	Very unlikely	Unlikely	No opinion	Likely	Very likely
Fossil fuel car (diesel, gasoline, CNG, LPG,…)					
100% electric car					
Plug-in hybrid					
Fuel cell electric vehicle					

2.9 How likely will your next new company car be one of the following types?

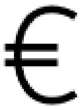
	Very unlikely	Unlikely	No opinion	Likely	Very likely
Fossil fuel car (diesel, gasoline, CNG, LPG,…)					
100% electric car					
Plug-in hybrid					
Fuel cell electric vehicle					

Part 3: V2G and discrete choice experiment

In a Vehicle-to-Grid (V2G) scheme, drivers of electric vehicles put their cars at the disposal of the electricity grid according to the principle of smart charging and discharging. The car's battery recharges when the demand for power and the electricity price are low. When there is a high demand for power and electricity prices are high, the car's battery provides energy to the grid, potentially in return for a financial compensation. When the battery provides energy to the grid, the system always guarantees a minimum driving range, such that the driver can always cover a predetermined distance with the car.

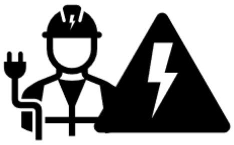


The most important advantages of V2G technology compared to uncontrolled charging of electric cars are the following:



V2G results in a **financial advantage** for the driver. A first source is the reduction of the electricity bill. This is because the car recharges when the electricity price is low, while the car discharges when the electricity price is high. A second source of financial benefit is a single upfront payment that may be offered to V2G participants.

The **total CO_2-emission is reduced** because of the lower demand for energy during the morning and evening peak hours. During these peak hours, there is a low supply of renewable energy (sunlight and wind) and fossil fuels are mostly used to generate energy. V2G results in a more **efficient use of renewable energy** by recharging cars when there is more green energy available.



The batteries of electric cars serve as an emergency source of energy. They also help to balance the demand and supply of electricity. This results in a **smaller risk of a blackout** (a general power outage).

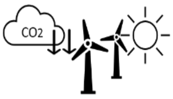
There are also disadvantages associated with the V2G technology.

Recharging of the vehicle before long trips needs to be planned. This is only the case for long trips that require the full capacity of the battery.

Owners of electric vehicles are worried that the frequent charging and discharging of the car's battery may **reduce the battery's lifetime**. However, studies investigating the impact of smart charging and discharging on the lifetime of the battery are inconclusive.

V2G is based on a network of smart meters, smart charging stations and a smart grid. The system registers the driving habits of the driver. This implies additional challenges with respect to **privacy and data protection**.

3.1 How important are the advantages of Vehicle-to-Grid to you?

	Unimportant	Low importance	Neutral	Important	Very important
 Financial advantage					
 More efficient use of renewable energy					
 Lower risk for a black-out					

3.2 How important are the disadvantages of Vehicle-to-Grid to you?

	Unimportant	Low importance	Neutral	Important	Very important
 Recharging for long trips has to be planned in advance					
 Shorter lifetime of the battery					
 Data protection & privacy					

3.3 Which charging technique would you apply in case you would have an electric car at your disposition?

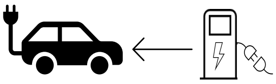
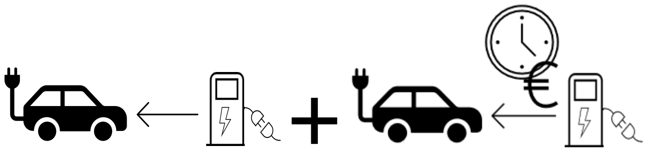
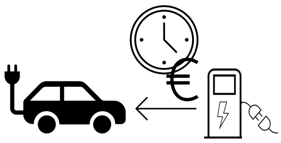
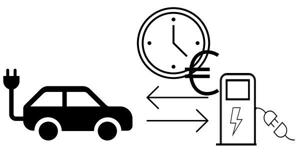
1 = I would definitely not use it

2 = I would probably not use it

3 = Neutral

4 = I would probably use it

5 = I would definitely use it

	1	2	3	4	5
Uncontrolled charging: charging when and where you prefer 					
Uncontrolled charging by default, smart charging during days with a potential risk of a blackout Only during about seven days per year in winter, you have to adjust your charging behaviour. During these days, you only recharge your battery during the night or around noon. You receive a small financial benefit in return. The rest of the year, you recharge your vehicle where and when you prefer. 					
Smart charging: The energy provider determines the optimal charging process of your vehicle based on the fluctuation of energy prices. Your vehicle only charges when the electricity price is low. This results in a financial benefit for the consumer. You can determine when the battery must be fully charged. 					
V2G (smart charging and discharging): The energy provider determines the optimal charging process of your vehicle based on the fluctuation of energy prices. Your vehicle only charges when the electricity price is low and your battery is discharged when the price for electricity is high. You realise a financial benefit. The battery of your vehicle is never fully discharged, such that you can always rely on a predetermined minimum driving range. You can determine when the battery has to be fully charged. 					

3.4 Choice experiment

Assume that you have decided to buy a fully electric vehicle. You can choose between vehicles with characteristics as shown in the table below. All the other characteristics of the vehicles (total recharging time, horse power, colour, size, design,…) are the same for both cars. Which car do you prefer? You may also decide not to choose any of the cars.

(Example of a choice set. Each respondent is presented with six choice sets)

	Electric car 1	**Electric car 2**	**None of these**
Attributes of the electric vehicle			
Driving range	300 km	400 km	
Recharging time 100 km (fast charging)	20 minutes	45 minutes	
Purchase price	30 000 euro	55 000 euro	
V2G contract specifications			
Guaranteed minimum driving range	50 % of the driving range	25 % of the driving range	
Savings electricity bill	50 euro/year	25 euro/year	
Single upfront payment	0 euro	1000 euro	

Guaranteed minimum driving range: The systems always guarantees a minimum amount of kilometres. The battery is never fully discharged. Only exceptionally, the battery will be discharged to the level of the guaranteed minimum range. You can determine upfront when the battery cannot be discharged at all.

Savings electricity bill: The battery charges when electricity prices are low (around noon and during the night) and provides energy to the grid when the price for electricity is high (during morning and evening rush hours). This smart charging technique results in lower energy costs for the consumer compared to a system of uncontrolled charging.

Single upfront premium: participants to a V2G scheme can receive a one-time upfront premium as a compensation for allowing their cars to be at the disposal of the energy grid.

People that have a company car are presented with the following choice experiment:

Assume that you have to choose a fully electric car as your next company car. You can choose between vehicles with characteristics as shown in the table below. All the other characteristics of the vehicles (total recharging time, horse power, colour, size, design,…) are the same for both cars. Your personal cost is proportional to the catalogue price of the car. Which car do you prefer? You may also decide not to choose any of the cars.

(Example of a choice set. Each respondent is presented with six choice sets)

	Electric car 1	**Electric car 2**	**None of these**
Attributes of the electric vehicle			
Driving range	300 km	400 km	
Recharging time 100 km (fast charging)	20 minutes	45 minutes	
Purchase price	30 000 euro	55 000 euro	
V2G contract specifications			
Guaranteed minimum driving range	50 % of the driving range	25 % of the driving range	
Savings electricity bill	50 euro/year	25 euro/year	
Single upfront payment	0 euro	1000 euro	

If a respondent consequently (six times) selects "None of these", question 3.5 follows.

3.5 None of the presented vehicles was of interest to you. Can you select why this is the case? (multiple answers are allowed for)

1. I will never buy an electric car.
2. The financial compensation for participating to the Vehicle-to-Grid scheme is too low.
3. I don't believe that the total electricity bill will truly be reduced.
4. The guaranteed minimum driving range is too low.
5. I will always be able to use the full capacity of my car's battery.
6. Other: …

Part 4: Driving habits

4.1 How many kilometres do you drive with your car on an average weekday (Monday-Friday) in a non-corona period?

	0 – 10 km	11 – 30 km	31km – 50 km	more than 50 km
Private car				
Company car				
Car sharing				

4.2 How many trips do you drive with your car on an average weekday (Monday-Friday) in a non-corona period?

	none	1 to 2	3 to 5	6 or more trips
Private car				
Company car				
Car sharing				

4.3 How many trips exceeding 100 km (single way) do you drive during an average month (no lockdown, no corona period)?

	none	1 to 2	3 to 8	8 or more trips
Private car				
Company car				
Car sharing				

Part 5: Socio-demographics

Finally, we would like to ask you some questions about your personal status. We remind you that the answers to this survey will be treated confidentially.

5.1 What is your year of birth?

5.2 What is your gender? (M/F/X)

5.3 Which situation decribes your living conditions best?

I live alone

I live without a partner but with children

I live with a partner (married or not) but without children

I live with a partner (married or not) and with children

I live with one of my parents

I live with my parents

Other living situation

5.4 What is the number of people in your household?

5.5 Select your highest achieved diploma or certificate of education:

1 None

2 Primary school

3 Secondary school: general: not completed

4 Secondary school : other (arts, sports, professional,…): not completed

5 Secondary school: general: completed

6 Secondary school : other (arts, sports, professional,…): completed

7 Professional higher education

8 Academic education

5.6 How many people in your household have a driver's license type B (cars)?

5.7 What is your postal code?

5.8 What is the total net monthly income of your household?

0 - € 1500

€ 1500 - € 2000

€ 2000 - € 3000

€ 3000 - € 4000

€ 4000 - € 5000

> € 5000

I don't want to answer this question

END SURVEY

Annex 2: Data pre-processing

Some respondents did not answer the question on their net income levels. These missing observations were handled by determining the factors that explain the income level of the rest of the sample.

Income is a categorical variable ranging from 1 to 6:

0 - € 1500	1
€ 1500 - € 2000	2
€ 2000 - € 3000	3
€ 3000 - € 4000	4
€ 4000 - € 5000	5
> € 5000	6

A multivariate regression is estimated to explain the income category using the following explanatory variables: a dummy variable that is equal to unity if the respondent has at least one company car and zero otherwise (ccar), a dummy variable that is equal to one if the no car is available to the respondent (no_car), the number of privately owned cars (number_privatec), the number of company cars available in the household (number_companyc), the number of private parking spaces available at home (number_parking), a gender dummy that is equal to one for women and zero for men (gender)[13], the size of the household (family_size), the level of education (education), the respondent's age (age), and regional dummies (VLA and WAL). Brussels serves as the reference region. Because income is expected to initially increase and then decrease with age and household size, a polynomial is included for these variables.

Error! Reference source not found.Error! Reference source not found.Error! Reference source not found. Table A 1 contains the estimation results.

[13] Because we only have two respondents who identify as 'other' with respect to gender, we omitted these observations from the sample.

Table A 1 Linear regression determining the factors behind income categories

term	estimate	std.error	t-stat	p-value
Intercept	-0.748	0.270	-2.773	0.006
Ccar	0.581***	0.157	3.697	0.000
no_car	-0.269**	0.114	-2.349	0.019
number_privatec	0.192***	0.037	5.173	0.000
number_companyc	0.119	0.123	0.968	0.333
number_parking	0.150***	0.026	5.789	0.000
gender	-0.301***	0.045	-6.736	0.000
family_size	0.840***	0.058	14.598	0.000
I(family_size^2)	-0.076***	0.009	-8.974	0.000
education	0.402***	0.022	18.493	0.000
age	0.029***	0.009	3.107	0.002
I(age^2)	-0.000***	0.000	-2.792	0.005
VLA	-0.109	0.084	-1.304	0.192
WAL	-0.363***	0.089	-4.093	0.000
Adjusted R^2	0.412			
# obs	2,447			

The estimated parameters allow to predict the income category for the 51 observations with missing values. Note that the explanatory power of the model is not very high. The adjusted R^2 implies that only 41 % of the variation in income can be explained by the selected variables in the model.

Annex 3: Willingness to participate in V2G scheme by company car users

Table A 2 Determinants of the willingness to participate in V2G among company car drivers

	Value	Std. Error	t value	p value
ccar_EV	-0.49	0.52	-0.94	0.348
ccar_PEV	0.15	0.31	0.49	0.623
EV_familiarity	0.11	0.19	0.60	0.548
v2g_familiarity	0.19	0.16	1.25	0.212
ccar_new	0.06	0.08	0.76	0.449
adv_V2G_price	0.38***	0.12	3.18	0.001
adv_V2G_climate	0.38***	0.11	3.36	0.001
adv_V2G_blackout	0.41***	0.11	3.65	0.000
disadv_V2G_planning	-0.60***	0.13	-4.67	0.000
disadv_V2G_battery	-0.05	0.12	-0.43	0.671
disadv_V2G_privacy	0.05	0.09	0.56	0.578
ccar_trips1	0.26	0.53	0.49	0.623
ccar_trips3	-0.10	0.55	-0.18	0.859
ccar_trips6	0.06	0.57	0.10	0.919
ccar_11_30km	0.34	0.45	0.75	0.454
ccar_31_50km	-0.05	0.47	-0.10	0.922
ccar_50km	-0.24	0.47	-0.51	0.611
ccar_long_trips1	0.09	0.32	0.27	0.788
ccar_long_trips3	0.12	0.36	0.33	0.738
ccar_long_trips8	0.06	0.38	0.16	0.871
parking_1	-0.12	0.33	-0.35	0.724
parking_2	-0.34	0.34	-1.00	0.319
parking_3	0.00	0.34	-0.01	0.992
Gender	-0.06	0.21	-0.28	0.783
education	0.04	0.12	0.32	0.752
Age	-0.01	0.01	-0.96	0.337
Income	-0.04	0.09	-0.42	0.672
VLA	-0.34	0.37	-0.91	0.364
WAL	0.48	0.42	1.13	0.257
Pseudo R^2	0.10			
Residual Deviance	1098			