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MASTER THESIS

The potential of electric vehicles amongst Dutch lease drivers

by

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Abstract

Recent studies examined that regular consumers are not yet ready to adopt electric vehicles (EVs) due to various obstacles. To successfully introduce EVs in the Netherlands the government is focusing on segments that can circumvent some of these obstacles and are considered suitable to adopt EVs. This thesis has examined the potential of electric vehicles amongst one such group; Dutch lease drivers and their companies. A conjoint analysis has been executed amongst 751 lease drivers to analyse what the potential of EVs amongst Dutch lease drivers. The survey included five attributes; monthly net costs, driving range, charging time, charging infrastructure and CO_2 reduction. With a predicted market share of almost 39% there seems to be a big potential of EVs in the lease market. The monthly costs and the driving range are considered most important for lease drivers, whereas the other attributes are not of considerable importance. This is also reflected in their willingness-to-pay, which is much higher for improvements in the driving range than for the other attributes.

Keywords: electric vehicles, conjoint analysis, hierarchical Bayes, willingness-to-pay

Preface

This report is my master thesis for the conclusion of the master Economics at Tilburg University. Moreover, it is also the conclusion of my internship at the department Strategy & Economics, PwC. I would like to thank PwC for the opportunity of writing my thesis within the company. It was a fruitful and educative experience to write my thesis within PwC.

In particular, I would like to express my sincere gratitude to Harry van Til and Geert Kloppenburg for supervising my thesis within PwC. Their advice and critical feedback helped me writing my thesis for which I am thankful. Also, I would like to thank Erik Vis for helping me to understand the lease market in the Netherlands and what kind of decisions a fleet owner has to make before even considering the adoption of electric vehicles. As well, special thanks to Taras Bogouslavskii for helping me to interview 100 employees from PwC for my sample.

I would like to thank prof. dr. van Damme for supervising my thesis at Tilburg University and providing me valuable feedback to ensure that the thesis remained of academic standard.

Further, I want to thank Stijn Otten (New Motion) and Mark Scheurs (Mister Green) for having some lively discussions about the market prospect for electric vehicles and providing me useful market information to improve the quality of my thesis. It was instructive to have various meetings with people who have so much expertise in the field of electric vehicles and are in the center of the market.

Finally, I wish to express my greatest thanks to my family, girlfriend and friends who have supported me throughout my academic career. Without their support it would not have been possible to enjoy my academic career and to become the person that I have become.

Today I finished my thesis and I will continue to challenge myself in the future with what I learned. This is not the end, only the start.

Sander van der Kuip, November 2011.

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Introduction

Within the automotive industry, the growing potential of electric vehicles (EVs) is of particular note, as evidenced by the numerous vehicles being introduced by new and established automotive companies. Also, there are heavy investments in battery technology and various support measures taken by governments around the world. The growing potential of electric vehicles also emerged in the Netherlands as it is seen as a suitable country for the introduction of EVs; the driving distances are relatively short, it has a flat landscape and a modern electricity network (Ministerie van Verkeer en Waterstaat, 2009). The Dutch government has set an ambitious target of 15,000 electric vehicles in 2015, which should be scaled upwards to 200,000 vehicles in 2020 and even one million vehicles in 2025.

Although environmental protection has been cited as the primary driver for change, other factors such as energy independence and the price volatility of fossil fuels also have helped perpetuate a shift towards electric vehicles (Roland Berger, 2009). There are several other reasons why a surge in demand can be expected for electric vehicles in the coming years.

Environmental regulation

First, electric vehicles are seen as one possible solution automakers can focus on to meet increasingly stringent emission regulation around the world. EU-targets state that newly manufactured vehicles should not emit more than 90 g/km CO_2 in 2020. Nowadays vehicles are allowed to emit 154 g/km CO_2, so a considerable reduction is necessary. The Boston Consulting Group (2011) found that to achieve these targets additional investments are necessary that increase the price of gasoline vehicles with approximately €2,000. This makes investing in electric vehicles more attractive for automotive companies since they already emit less than 90 g/km CO_2.

Noise pollution

Besides environmental concerns, noise pollution is another reason why the Dutch government is promoting the use of electric vehicles. Noise pollution is an important issue in big cities in the Randstad. Some neighbourhoods in Amsterdam are suffering from noise pollution and people are therefore moving to other cities in the Randstad. As shown in figure 1, an 80-km road has a severe effect on its surroundings and decreases the quality of life. Electric vehicles can be a solution as they do not make any noise which increases the liveability of such neighbourhoods; EVs have a soundless motor, while also the noise of tires is negligible.

Figure 1 Effect of noise pollution (www.stillerverkeer.nl)

Pool-vehicles

Further, the government has identified an increase in the number of companies that use pool-vehicles which could lead to an increase of electric vehicles (Ministerie van Verkeer en Waterstaat, 2010; Agentschap NL, 2011; VNA, 2011). When a company opts for pool-vehicles employees can go to work by public transport and use cars that are parked at the company to go to clients for example. This increases the flexibility of the employees' working times; they can drop their children at school and hereafter start working in the train for example. An example of a company that has pool-vehicles is the RDW (Rijksdienst voor het Wegverkeer). Using such vehicles lowers the daily mileage amongst lease drivers considerably. Therefore it might be an option to use electric pool-vehicles. In The Hague, Eneco, Rabobank and HaagWonen, a housing corporation, have each acquired ten EVs to check whether pool-vehicles are suitable for electric transport. The companies' findings are positive and suggest a role for electric pool-vehicles. On the other hand, it could also be the case that lease drivers who lease an electric vehicle use a gasoline pool-vehicle to go to a client that is beyond the current driving range of an EV. Then they can just go to work with their electric vehicle, but use gasoline vehicles when necessary.

Motivation for this research

Despite these reasons, the Dutch market for electric vehicles is still in its infancy. At the moment there are only 700 electric vehicles in the Netherlands. This low number can be seen as a representation of the many concerns that consumers have:

- an electric vehicle's buying price is more than €10,000 higher than a comparable gasoline vehicle
- you can only drive about 150 km before you have to recharge your vehicle
- there are only few places available where you can charge an EV
- recharging takes a long time when compared to refuelling

Due to these obstacles it is expected that consumers will not acquire electric vehicles in the coming years (D-incert, 2010; ING Economisch Bureau, 2011). Rather, these studies argue that it is important to target segments that can circumvent these obstacles and which are therefore considered suitable to adopt electric vehicles. With the help of these first adopters the goal of 15,000 electric vehicles can be attained from which consumers' obstacles can be addressed. Identified characteristics of a suitable segment include:

- the users make a lot of kilometres with high fixed and low variable costs resulting in cost savings
- a lot of movements in a particular area
- creating awareness due to Corporate Social Responsibility (CSR)
- it contributes to local environmental advantages, in particular air quality

Several segments fulfil these criteria and are considered suitable. For example logistics and distribution companies are considered suitable. One should not think of big electric trucks, but rather think of electric delivery vans that supply smaller shops or distribute food to households. Several pilots in the region of Arnhem and Nijmegen have been successfully executed by distribution companies with electric vans that distribute food to households.

Taxis and small busses are also seen as a suitable segment. Taxis drive many short distances that add up to a large amount of kilometres which makes electric taxis appropriate. Busses are also considered suitable, but it is questionable whether they are capable of becoming electric due to their weight and size. In Utrecht Green Cab is investing in electric taxis, while the GVU, Utrecht's public transport company, is testing small electric busses that are deployed for school transport.

Also companies and their lease drivers fulfil these requirements and are considered suitable for incorporating electric vehicles (D-incert, 2010; ING Economisch Bureau, 2011). First, lease drivers drive annually approximately 29,000 km which is far more than 'regular' consumers who drive only 14,000 km. This results in big cost savings on gasoline e.g. Second, most of the drives are within the same region, namely the Randstad. Third, many companies have also included the environment in their CSR, so with introducing electric vehicles they can really make a statement about their environmental concerns. These reasons might make companies and their lease drivers a suitable segment for electric vehicles.

Research question

Yet, many of these benefits accrue directly to the companies. They benefit from the positive impact on their CSR for example. On the other hand, company's lease drivers face the obstacles of driving an electric vehicle; their driving range is lowered while it is not longer possible to refuel in a couple of minutes. Until now there has not been an analysis amongst lease drivers what they require from an EV and what their biggest concerns are. My thesis tries to fill this gap. With the help of a conjoint analysis I will examine what lease drivers consider most important when they decide to opt for an electric vehicle and what their willingness-to-pay is for an electric vehicle. Is it a vehicle's driving range, the monthly lease price or maybe the CO_2 reduction? This is essential to understand for (lease) companies, because they should know what to offer their employees. As a result, the following research question has been put forward:

- What is a lease driver's willingness-to-pay for an electric vehicle and its attributes[1]?

A conjoint analysis will support finding an answer to my research question. A survey has been performed under 751 lease drivers to estimate their willingness-to-pay for electric vehicles. The survey included five attributes that will be examined, namely (1) the monthly net costs of leasing an electric vehicle, (2) driving range, (3) charging time, (4) charging infrastructure and (5) CO_2 reduction.

What can be learnt from this willingness-to-pay analysis?

This research might give various parties additional information. As mentioned above, lease drivers are considered suitable for adopting electric vehicles. Such first adopters can be used to address the problems of 'regular' consumers. Therefore it is necessary that lease drivers are successfully approached. By doing a willingness-to-pay analysis (lease) companies get to understand what lease drivers consider most important when they want to lease an electric vehicle. This is useful for them to understand such that they know what to offer to their lease drivers. In this way lease drivers can be approached according to their preferences.

This analysis can also be useful from a government's perspective. Lease drivers form a group that is sensitive to financial incentives, as shown with the successful introduction of hybrids in the Netherlands (VNA, 2011). This thesis can provide information which attributes are considered most important for lease drivers. Therefore it can give insights about where a government can give additional financial incentives or which attributes it should stimulate with additional R&D incentives for further development. It can also give information to the government which measures have the greatest impact. So, this analysis can be helpful for the government to understand how they can most effectively target lease drivers.

Structure

The rest of this paper is organised as follows. Chapter one discusses the market for electric vehicles. It describes the current market situation and it explains which factors and players are influencing the demand and supply of electric vehicles. Chapter two focuses on the lease market and explains why companies and their lease drivers are considered suitable for incorporating electric vehicles. Chapter three discusses the theoretical framework and the survey design that has been used. The analyses' results will be discussed in chapter four while conclusions and possible recommendation are provided in chapter five.

[1] An attribute is a characteristic of a product, which is made up of various levels. For example, colour can be an attribute of a car, while black, blue and white are levels.

Definitions

Lease drivers are defined as those employees who lease a vehicle from their employer. This definition does not include regular consumers who lease a vehicle themselves directly.

The term electric vehicle (EV) is used for full-electric vehicles (100% propulsion from a battery), range-extenders (vehicles with a generator to recharge the battery) and plug-in hybrid electric vehicles (PHEV). The PHEV is completely electric for the first tens of kilometers; thereafter it uses both a battery and a conventional motor for driving. So, full hybrids fall outside the scope of this definition. This description is also used by the Dutch government and is consistent with other (inter-)national studies.

1 The market for electric vehicles

Before doing any analysis it is important to understand what forces are present in the market. This chapter describes the market for electric vehicles and is divided into three parts. The first section discusses the current market situation and describes which electric vehicles are available at the moment. The second part discusses factors that influence the demand of EVs, while the third part discusses factors and players that influence the supply. Although various factors influence both sides, the factors will be discussed in the part where they are most relevant.

Current situation

As noted earlier, the Netherlands is seen as a suitable country for the introduction of EVs and it is expected that the vehicles will gradually be incorporated in our daily life. However, at the moment there are only a few models available:

	Monthly lease price[2]	Price (incl. VAT)	Total costs per km[3]	Driving Range	Safety	Charging Time	
						Regular	Fast
Citroën C-Zero	€695	€35,165	€0.33	130 km	4 out of 5	100% in 6 hours	80% in 30 min
Mitsubishi i-MiEV	€695	€34,930	€0.32	160 km	4 out of 5	100% in 7 hours	80% in 30 min
Peugeot iOn	€675	€35,165	€0.33	130 km	4 out of 5	100% in 6 hours	80% in 30 min
Nissan Leaf	€700	€34,990	€0.32	160 km	5 out of 5	100% in 6 hours	80% in 20 min
Opel Ampera (range-extender)	€745	€44,500	€0.38	450 km (80 km fully electric)	5 out of 5	100% in 4 hours	unknown
Volkswagen Golf (gasoline vehicle comparable to a Nissan Leaf)	€450	€22,290	€0.30	750 km	5 out of 5	Completely refuelled in <5 minutes	

Table 1 Available electric vehicles in 2011

As shown above, full-electric vehicles differ considerably from conventional vehicles, while they also differ from range-extenders. For example, with an EV it is not longer possible to refuel within a couple of minutes. Such differences influence demand and consumer's choices and will be discussed in this chapter.

For the remainder of 2011 and 2012 also Audi, BMW, Ford, Renault, Mini, Volkswagen and Volvo plan to introduce full-electric vehicles, while Chevrolet launches its range-extender, the Volt. These models are relatively similar to the models that are already available and no big improvements are expected in the price or driving range. Nevertheless, it increases the choice for people and it might increase the competition amongst automotive companies. It is anticipated that nearly every automotive company has developed one or multiple models in the coming years.

[2] Prices come from various lease companies and are based on full operational lease for 25,000 km per year and a contract of 48 months (excl. gasoline or charging costs and fiscal addition)
[3] Based on 15,000 km per year and a (conservative) residual value of €0 for EVs after 8 years, while VW Golf has a residual value of €3500 (all costs excl. maintenance costs)

1.1 Factors that influence demand

As already shown in table 1, driving an EV changes various things and has severe consequences for people. These changes can slow or impede the penetration of electric vehicles in the market. In this section the most important obstacles for acquiring an EV will be discussed that influence demand.

1.1.1 Price

One of the most important reasons why consumers are hesitant to make the transition to EVs is the buying price; acquiring an electric vehicle is about €10,000-€15,000 more expensive than a comparable gasoline vehicle.

However, if one takes into consideration the total costs of a vehicle in its lifetime, an electric vehicle is only slightly more expensive than a conventional gasoline vehicle (Boston Consulting Group, 2010:10; Enexis, 2009:19; Ministerie van Verkeer en Waterstaat, 2009). These so-called total costs of ownership (TCO)[4] are almost similar because electric vehicles have low variable costs. These include low charging costs, as well as lower maintenance costs (ING Economisch Bureau, 2011:7). Yet, a recent study (D-incert, 2010) showed that a vehicle's buying price is ranked 3rd in the list of most important aspects when someone buys a new car. On the other hand, usage costs are only ranked 17th, implying that consumers do not take these low variable costs into account. This requires actions from car dealers as they need to make these variable costs more visible to consumers such that they take them into account. If this is done an electric vehicle becomes a more attractive option for consumers.

Further, at the moment there is much uncertainty about an electric vehicle's trade-in value and about its residual value. This is mainly due to the uncertainty about the future performance of batteries which is a main determinant in an EV's price. Little data on electric vehicle's trade-in values currently exists and no good approximations can be made yet. This uncertainty is considered another hurdle for those consumers for whom the trade-in value is a key aspect in their decision-making process. Yet, some progress is being expected due to monitoring boxes that are keeping track of the battery's behavior and the driver's behavior. In this way it might be possible to improve an electric vehicle's residual value.

1.1.2 Driving range

Another aspect that can cause problems in adopting EVs is their limited driving range. At the moment, electric vehicles have a driving range of approximately 150 km, compared to a driving range of 750 km of a conventional vehicle. To put an EVs' driving range into perspective, a Dutch person drives on average about 44 km to get to work and return home again (Ministerie van Verkeer en Waterstaat, 2010:22). This shows that the current driving range of 150 km is suitable for many occasions. Nevertheless, although in reality the majority of people drive less than 100 km per day, most of them request a larger driving range to be able to cover the occasional trip beyond the daily mileage (ECN, 2011). This might be in weekends for family visits or going abroad on holiday. Consumers are more likely to purchase a car that meets their needs 100% of the time as opposed to 90% of the time. Another possible reason for requiring a larger mileage could be the problem that people have in judging whether the capacity of an EV will fit their real driving needs (ECN, 2011:27).

[4] Total Costs of Ownership (TCO) is a term used to describe the total costs of a vehicle in its lifetime

A first solution at hand is range-extenders. These are electric vehicles that have a driving range of approximately 450 km, from which only the first 80 km are purely electric. When the battery is empty a generator takes over that starts recharging the battery which ensures a bigger driving range. This method is somewhat similar to hybrids, except in a range-extender the combustion engine starts recharging the battery and is not directly used for driving. This ensures a lower CO_2-emission and is the reason why a range-extender is considered an EV, unlike full hybrids. Yet, range-extenders have one big disadvantage since they are even more expensive than full-electric vehicles. This makes them not a very good alternative for consumers.

1.1.3 Charging time

Also, with adopting an EV it is not longer possible to refuel within a couple of minutes. Electric vehicles have to be recharged at a charger[5] which can take up to six hours. Charging time can be divided into fast charging and regular charging.

Regular charging

Regular charging will most frequently take place at home and at work. With regular charging it takes about six hours to completely charge the battery, in which the first part of the charge goes faster than the final part; already 80% of the battery is charged in the first three hours, whereas the final 20% takes the remainder of the time. Since people are usually more than six hours at home or at work, regular charging should not be of any concern.

Fast charging

On the other hand, fast charging takes about 15-30 minutes in which users recharge approximately 80% of the battery. Although a fast-charger might seem more appropriate, it comes at quite a high cost. It costs about €75,000 to construct a fast-charger, while a regular charger only has a construction cost of €2,500. Even more, no matter which charging type, electricity is equally expensive for people which makes it more attractive for grid operators to construct regular chargers. Also, fast charging will only be available at dedicated service stations and not at home charging stations because of safety reasons.

Fast charging can be an obstacle for acquiring an electric vehicle since people might not want to wait 15-30 minutes before they are able to continue their journey. Especially if you consider that at the moment it only takes a few minutes to completely refuel a gasoline vehicle. So, this longer charging time can be another obstacle for consumers to acquire an EV.

Switching stations

A new solution to a long charging time and a limited driving range has appeared in Israel where they have established a network of battery switching stations. At these stations an empty battery is taken out and a new, full battery is installed within a few minutes with the help of an advanced robotic system. This sophisticated process implies that it cannot simply be done by people themselves. Due to its success in Israel, this concept is already exported to other countries like Denmark, Japan and Australia. Although switching stations can be a possible solution to overcome range anxiety and a long charging time, it is not the best possible solution according to consumers. A global study of Accenture (2011) examined that 62% of their respondents would prefer to charge, rather than to swap their battery, possibly because of fears of getting a worse battery than their current battery. Therefore it is important to construct a charging infrastructure such that users are not dependent on switching stations.

[5] To understand and see how charging works, check http://www.youtube.com/watch?v=BjpMe6vOD6k

1.1.4 Charging infrastructure

As noted, it is also necessary to develop a charging network such that EV-users are able to recharge their vehicle. However, this is easier said than done. Grid operators are hesitant to invest in chargers, because there are not enough electric vehicles being sold. On the other hand, consumers are not willing to acquire a vehicle due to the lack of a charging infrastructure, amongst other reasons. Consequently, one of the two parties has to make a first, credible move to get this process started. For example, if a grid operator makes a first move and constructs chargers, an EV's value increases for consumers which make them more willing to acquire one. If consumers do so, this increases the value of constructing chargers for grid operators again. This process is known as a cross-side network effect.

Public charging

The Dutch grid operators have acknowledged this network effect and the lack of a charging infrastructure and have set up an association (Stichting E-laad) to construct 10,000 public chargers before the end of 2013. It has been established to share the construction costs and to prevent free-riding by other parties, especially because it is not yet profitable to construct chargers (TNO, 2010). Constructing chargers is subject to economies of scale and can become profitable once the production increases.

At the moment there are about 525 public chargers available.[6] This number is rather small, possibly because Stichting E-laad is somewhat hesitant to invest in chargers because the number of EVs is still small. Yet, the number of chargers is expected to increase the coming months due to initiatives from various municipalities (Amsterdam and Rotterdam e.g.) to construct chargers. Also Total, an oil company, has announced to construct 40 fast-chargers on high priority points in the Randstad.

It is important to reach the goal of 10,000 public chargers such that drivers have the assurance that they are able to charge their EV when necessary. It is expected that many of these public chargers will become fast-chargers. At fuel pumps people want to continue their journey quickly and not be stuck there for several hours. At other places, like shopping malls or in a city centre it is possible to construct regular chargers, but at the highway or supermarkets there should be fast-chargers.

Private charging

Placing private chargers might cause problems for consumers. Only 20% of the Dutch households have a private parking spot (ING Economisch Bureau, 2011). This implies that 80% of the households need a charger at a public parking spot. If this is the case, Stichting E-laad consults both the municipality and the EV-user to reach a satisfactory solution for both parties. Nevertheless, this can result in an unsatisfactory outcome with a charger not in front of your house. It is also a time-consuming procedure. This can be another threshold for the adoption of an EV.

Congestion

Another concern can be congestion at chargers. However, in the coming years this is not likely to happen. If the expected 20,000 electric vehicles are attained in 2013 there is one public charger available for every two vehicles. Because many vehicles will leave with a (nearly) full battery in the morning congestion at chargers should not cause problems. Also, the construction costs will have dropped if the 10,000 chargers are placed at the end of 2013 which ensures that constructing a new charger becomes profitable. This enables a possible enlargement of the charging network and prevents future congestion.

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[6] http://www.oplaadpunten.nl/Auto.aspx

Interoperability

In recent months, issues about interoperability have been dealt with. First, the EU has set a standard plug-in for every charger which ensures that an electric vehicle can be recharged at every charger. Second, the EU has standardized the protocols of charging which makes it easier for users to charge a vehicle. Third, in the Netherlands a single payment system is under construction that will be comparable to a payment system like PIN. It will become a platform in which it does not matter if someone who has a contract with Enexis is charging at a public charger from another grid operator. These measures solve problems about interoperability and make life more pleasant for EV-users.

1.1.5 Other concerns

Expected life time and guarantee

Initially, parties who were interested in EVs (consumers, lease companies and municipalities e.g.) had concerns about an electric vehicle’s life time. For example, lease companies did not know whether a vehicle was lasting for many years and whether the battery remained of high-quality after a lot of kilometres were driven. These concerns have been taken away with the help of several pilots. These showed that electric vehicles were doing much better than expected and that the battery was performing well after a few years. This has made automotive companies less reserved and nowadays they offer better guarantees to lease companies. For example, a Nissan Leaf has a full guarantee of 100,000 km or a guarantee of five years if after this period the vehicle has not driven 100,000 km. The improved guarantee makes the various parties less hesitant towards electric vehicles.

Safety

In previous years people also had concerns about the safety of electric vehicles. The government has recognized this and has made an effort to solve this problem. The RDW (Rijksdienst voor het Wegverkeer) has implemented new legislation for testing the vehicles and it has developed new safety tests. Recently, the Nissan Leaf has been the first electric vehicle to reach the maximum of five stars in the safety test. Emergency departments (fire, police, and hospital) have implemented new trainings such that they can enter an electric vehicle safely and quickly when necessary.

1.2 Factors that influence supply

There are also various players and factors that influence the supply of electric vehicles. These include automotive companies, grid operators and research centres in particular.

1.2.1 Automotive companies

Electric vehicles expand the manufacturing playing field which provides opportunities for automotive companies in emerging markets since no traditional automaker has a significant advantage over another in regards to technology. For example, BYD (Build Your Dream), a Chinese automotive company, and the Chinese government are investing in EVs to achieve a significant position in the market (Ministerie van Verkeer en Waterstaat, 2009). Non-traditional suppliers that offer proven components for electric vehicles are also expected to emerge within the automotive industry. One can think of suppliers of lithium-ion batteries and suppliers of battery systems.

Further, all major automotive companies are developing new models which are expected to be on the market in the coming years. This gives consumers more options and increases the chances for matching consumers' demands, while it also increases competition amongst automotive companies. A fiercer competition pushes companies to be more productive, while competition can also result in lower market prices (Motta, 2004:52).

Yet, car manufacturers are facing a dilemma as they bring EVs to the market; should they target high volumes in order to decrease the price while incurring upfront losses, or should they target first adopters and sell small volumes at a price closer to breakeven? As observed in practice, automakers clearly opt for the latter. Their strategy seems to be sensible, since first adopters can be used to target and solve consumers' problems. If an automotive company would directly target high volumes it can lead to lower prices, but other obstacles that consumers face are not being solved. Hence, this would probably not lead to an increase in sales and can lead to bigger losses for automakers. It might be better to address the various obstacles simultaneously by targeting first adopters.

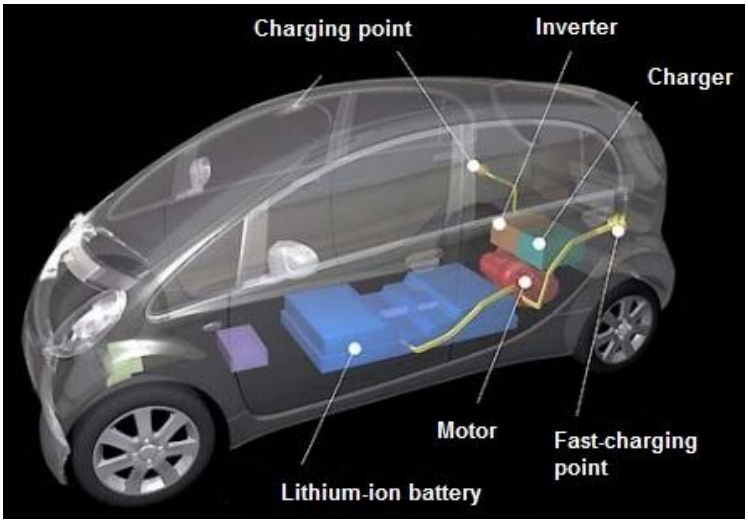
Continued R&D funding by the automakers is necessary to increase efficiencies, decrease consumer cost and improve the EVs to meet consumers' demands. To achieve the necessary R&D investments it is important to create the right incentives to innovate for automotive companies. As noted by Motta (2004:65), innovations and investments are subject to a trade-off between ex ante and ex post efficiency; a competition authority wants to preserve the firms' incentives to innovate, while once firms have innovated it would be better if all the firms in the economy have access to the innovation. Hence, before a company decides whether to invest in R&D, it wants to have the assurance that it is able to benefit from its innovation. For example, with the help of patent laws automotive companies have this assurance and they can benefit from their higher profits due to the innovation. Since patent laws are widely adopted around the world, this should not cause problems and automotive companies should have the right incentives for innovation.

Driving range development

Automotive companies and research centres are cooperating to develop new, better batteries to increase the driving range of EVs. In October 2010 a new, ultra-light lithium-battery has been tested in Germany. A full-electric Audi A2 drove more than 600 km on a single battery and it even had 18% left of its battery capacity. The car drove on average about 90 km/h with a maximum speed of 130 km/h. This experiment shows the potential of increasing the driving range for the coming years as it is anticipated that the driving range will gradually be increased the next years (ING Economisch Bureau, 2010).

Battery development

It is expected that an electric vehicle's buying price will drop the coming years due to an increase in production. Most of the current cost difference (€10,000-€15,000) is directly attributable to the raw materials that comprise a vehicle's battery. The Boston Consulting Group (2010) examined that about 75% of the battery's costs depends on the amount of batteries produced. Anderman et al. (2000) also examined the production costs of EVs' lithium-ion batteries. They concluded that the costs for small-lot production (1000-2000 packs/year) are very high and about €1,500/kWh, while these costs can fall to €300/kWh at production volumes of more than 100,000 EV-battery packs per year at one production plant. Deutsche Bank[7] even believes it will reach €180 per kWh in 2020. A Nissan Leaf has a battery pack of 24 kWh; hence an increase in production can decrease an electric vehicle's price considerably. This lower price, that makes an electric vehicle's total cost of ownership more advantageous, should be achieved with the help of first adopters. A price drop solves the pricing problem for consumers and makes EVs a more attractive alternative for them. This helps attaining a full-grown market for electric vehicles.



1.2.2 Grid operators

The Dutch grid operators also play an important role in developing the market. They benefit from electric vehicles as they provide additional profit opportunities since the vehicles have to be recharged. This is a reason grid operators are actively involved in several pilots and initiatives for establishing a charging infrastructure. As mentioned, the grid operators set up Stichting E-laad to construct a charging network and solve consumers' concerns about the current lack of a charging network. They want to have constructed a charging network of 10,000 chargers before the end of 2013 which possibly can provide them profits.

[7] "Deutsche Bank revises li-ion battery cost forecasts downward to $250/kWh by 2020", Green Auto Blog. Accessed online at http://green.autoblog.com/2011/01/06/deutsche-bank-li-ion-battery-cost-forecast-per-kwh/

Besides additional profit opportunities for grid operators, introducing electric vehicles also leads to an increase in demand for electricity. As part of their social responsibility, this increase should be realised without heavy investments to expand the network and without a drop in the network's quality. The grids operators are actively involved in various pilots to gain an understanding about the effects of introducing electric vehicles and they do not foresee any bottlenecks before 2015 as the current network is able to cope with the expected increase of demand (Enexis, 2009; Ministerie van Economische Zaken, 2010).

Further, the grid operators have recognized that they have to invest in smart grids to be able to cope with an expected increase in demand for electricity. Smart grids synchronise the supply and demand in such a way that the system is optimised which prevents unnecessary costs for expanding the network capacity. In the coming years investments are expected such that smart grids can be rolled out successfully. The government has created a taskforce to coordinate this process. Also, the charging equipment for electric vehicle is already suitable for smart grids and is able to communicate to the grid to synchronise supply and demand. So, even when the number of electric vehicles is expected to increase more rapidly after 2015 no problems are expected due to the roll-out of smart grids.

1.2.3 Research centres

There are also developments anticipated in the coming years that shorten the charging time. There are various research centres that are testing batteries to understand the batteries' technology to be able to improve them. This is happening in cooperation with other companies who are specialized in charging technology and battery management systems, like Epyon, NXP and Philips. This testing can help decrease the charging time by developing better methods to manage the battery power in a more efficient way. Additionally, testing can improve the battery management systems which helps to decrease the charging time and extend the driving range of an electric vehicle.

To conclude, this chapter has shown that there are various factors that make electric vehicles not yet a realistic and attractive option for consumers. Especially the high buying price, the limited driving range and the lack of a charging infrastructure are considered severe problems for consumers. Some other obstacles such as the vehicle's safety and interoperability have been taken hold of. Nevertheless, various developments are still necessary from automotive companies, grid operators and research centres before electric vehicles become a more realistic alternative for consumers and a full-grown market can be attained. These developments should include the construction of a charging network, improvement of the driving range and a lower buying price. These problems can be addressed with targeting segments that are already considered suitable for adopting electric vehicles.

2 Companies and their lease drivers

Previous chapter argued that consumers are not ready yet to adopt electric vehicles. Nevertheless, various other segments are already considered suitable to adopt electric vehicles. These segments help to address consumers' obstacles and help develop the market. One of these suitable segments is companies and their lease drivers. This chapter will describe the Dutch lease market and will clarify why companies and lease drivers are considered suitable for adopting electric vehicles. Also, a closer look at a company's cost savings and investments is provided if it decides to introduce electric vehicles.

2.1 Leasing in the Netherlands

A lease vehicle has become a common term of employment offered by many companies to their employees. For example, about 93% of the multinationals in the Netherlands offer their employees the possibility to lease a vehicle which they can then use for transportation (VNA, 2011:35). In 2010, there were approximately 513,000 lease vehicles in the Netherlands, which is 8% of the total amount of vehicles in the Netherlands. Although this percentage is rather low, the lease market is seen as an important first mover for the automotive sector in the Netherlands since newly sold vehicles are often first adopted by lease drivers; in 2010 approximately 40% of the newly sold cars were lease vehicles.

When a company wants to offer lease vehicles to its employees it starts negotiations with various lease companies about a lease contract and its conditions. After negotiating, a company decides which lease company gets the contract. Hereafter, depending on an employee's job, the company provides each employee a budget for which he can lease a vehicle from the lease company. One should note that an employee is not restricted to his budget; when an employee gets a monthly budget of €500, but only leases a vehicle of €400 he will receive the remainder on top of his gross monthly salary. On the other hand, when an employee exceeds his budget he will receives less gross salary. It should also be noted that an employee is not obliged to accept a lease vehicle. Often he can also renounce from it and get a mobility budget which he can use for public transport or for driving a private vehicle.

If an employee opts for a lease vehicle, he uses his budget and 'pays' every month a fixed amount for the duration of his lease contract. This monthly payment includes all costs such as a vehicle's depreciation, maintenance, taxes and insurance. The costs for gasoline are usually paid by the employer, only occasionally by the employees. On average an employee leases a vehicle for four years. If the contract expires a lease driver can opt for a new vehicle, while the lease company often sells the 'old' vehicle at the second-hand car market and comes into the hands of a 'regular' consumer. This process is also witnessed by the current increase of hybrids among consumers. Many of these hybrids were first in the hands of lease drivers, but after their contract expired many of the hybrids were sold to 'regular' consumers. It shows the importance of the lease market for the automotive sector; often new vehicles are first adopted by lease drivers and eventually passed through to consumers. This process is also the reason why the average age of a lease vehicle is only three years, while for consumers it is eight years (VNA, 2011:22).

Leasing a vehicle has some positive as well as negative consequences for employees. It is of course easy for the lease driver to have a vehicle at his disposal for which he pays a monthly fee and can do whatever he wants. However, if someone drives more than 500 km for private means with his lease vehicle he will have to pay a fiscal addition. This is the case for approximately 80% of the lease drivers (VNA, 2011:7). The height of the addition depends on the CO_2 emission of the vehicle (table 2) and on the listed value of the vehicle, since a lease driver annually has to pay the fiscal addition percentage multiplied by the listed value of his vehicle. This amount comes on top of his pre-taxation income. The fiscal addition can lead to a significant increase in the level of taxes a lease driver has to pay, especially because approximately 70% of the lease drivers fall within the 42% and 52% income taxation-bracket (VNA, 2007; VNA, 2011). A clarifying example of the fiscal addition is shown in the textbox.

Fiscal addition category	CO_2 emission diesel	CO_2 emission gasoline
0%	ELECTRIC VEHICLES	
14%	< 96 g/km CO_2	< 111 g/km CO_2
20%	96-116 g/km CO_2	111-140 g/km CO_2
25%	>116 g/km CO_2	>140 g/km CO_2

Table 2 Fiscal addition

Example fiscal addition

A lease driver chooses to lease a VW Golf with a listed value of €25,000 and a fiscal addition of 20%.

Annually his pre-taxation income increases with 20%*€25,000 = €5,000. If he falls into the 42% income taxation bracket, he has to pay an additional tax of 42%*€5,000 = €2,100 due to the fiscal addition.

So, a lower CO_2 emission means a lower fiscal addition. In this way the Dutch government has introduced a fiscal incentive to stimulate the adoption of environmental-friendly, economical vehicles amongst lease drivers. As observed in practice, this also has led to an increase in the amount of smaller, cleaner vehicles amongst lease drivers in recent years:

- The CO_2 emission from newly sold vehicles has dropped 17% from 168 g/km CO_2 in 2007 to 140 g/km CO_2 in 2010 (VNA, 2011:27)
- The level of smaller vehicles has increased from 4% to 12%, while the number of smaller family vehicles has increased from 24% to 28%. The number of MPVs has decreased from 18% to 9% (VNA, 2011:25). Employees with MPVs have downsized to smaller family vehicles, while employees with smaller family vehicles opt for smaller (city) vehicles

These results indicate that environmental-friendly vehicles have become more important for employees, possibly for financial reasons. Recently some companies have decided to only provide economical vehicles to their employees as part of their corporate social responsibility (VNA, 2011:35) which also helped perpetuate this shift. Both trends are reflected in the strong increase in hybrids and other economical gasoline vehicles in recent years.

Automakers are improving vehicles' fuel efficiency which can lead to too many vehicles in the upper part of table 2. According to the government already 33% of the newly sold vehicles fall in the second and third category, which would increase to 60% in 2015 (Prinsjesdag, 2011). As a solution, the government has announced to renew, and keep renewing, the categories' emission levels such that the system keeps functioning correctly. It is important to realise that these new categories are only applicable to newly sold vehicles. So, when someone currently falls in the 14%-bracket, he will remain there until he orders a new lease vehicle. In this way the fiscal addition can provide the right incentives and can keep working properly.

2.2 Why are electric vehicles suitable for companies and their lease drivers?

There are various reasons why companies and their lease drivers are considered suitable for adopting electric vehicles. This section argues why they are suitable and do not face the same problems as consumers.

2.2.1 Price

Unlike consumers, companies and their lease drivers do not face a price problem. Lease drivers do not have a buying price with variable costs, but rather pay monthly a fixed amount for all costs for the duration of their contract. There are several fiscal incentives that make it equally expensive to lease an electric vehicle or a comparable gasoline vehicle. First, 80% of the lease drivers drive more than 500 km for private means and have to pay a fiscal addition each month. Electric vehicles are exempted from the fiscal addition which can save lease drivers a lot of money (Appendix 1). This advantage is not applicable for consumers who nearly always buy a vehicle and do not lease. Further, electric vehicles are exempted from road taxes which lowers the monthly lease price. The Dutch government has chosen these fiscal measures, because they proved a major success in promoting the use of hybrid cars.

Lease drivers also have larger cost savings on the low variable costs because they drive on average more kilometres per year than consumers; consumers drive only 14,000 km per year, while lease drivers drive approximately 29,000 km (VNA, 2011:5). This makes the costs savings on gasoline and maintenance larger and ensure a big drop in the monthly lease price when compared to a gasoline vehicle.

There are also various reasons that make lease companies willing to invest in electric vehicles. First, lease companies have fiscal instruments provided by the government, like the MIA and VAMIL (Agentschap NL, 2011b). The former ensures that a lease company can subtract up to 36% of the investment costs from its pre-tax profit if an investment is environment-friendly (like EVs). This leads to a lower taxation and a higher post-tax profit. In practice this can result in a 7-9% advantage[8]. The latter provides lease companies the freedom to decide at which pace to depreciate the investment. This gives them an interest- and liquidity advantage. Further, lease companies do not have to pay an acquisition tax (BPM) on electric vehicles which also leads to a lower lease price. Finally, lease companies are able to cope with problems about an electric vehicle's residual value, since they can just take into account a low residual value and increase the depreciation a lease driver has to pay. This leads to an increase in the lease price, as is observed in practice.

To show the impact of all these measures, leasing a Nissan Leaf costs around €725; this is cheaper than leasing a comparable gasoline vehicle like a well-equipped VW Golf (Appendix 2). So, these measures ensure that companies and lease drivers do not face a price problem and might be suitable as first adopter.

[8] Corporate tax of 25% over MIA (36%) = 9%

2.2.2 Charging

Companies that incorporate electric vehicles in their lease fleet will have to construct chargers at the workplace such that their employees can charge at work. Charging at work will mainly be done via regular chargers, because there is often no need to completely recharge an EV within 30 minutes. Of course, a company can construct a few fast-chargers if they want to, but this will not be the dominant type of charging at work.

Charging at work can solve several issues that regular consumers have. As noted above, only 20% of the Dutch households are suitable for a private charger. The remaining 80% has to find a public parking spot, possibly further away from their house. However, if an employee leases an EV via its employer, the company will provide him the opportunity to charge their electric vehicle at work. This can solve the problem with charging at home, since it is not longer necessary to recharge your vehicle at home every day when you can also charge at work. Even more, most of the drives from lease drivers are conducted in the Randstad. It is in this particular region where a (public) charging infrastructure is expected to arise first. Total has announced to construct 40 fast-chargers in the Randstad, while the municipalities of Rotterdam and Amsterdam also have announced to construct chargers.

2.2.3 Other reasons

The leasing market structure is another important aspect why lease drivers are suitable. Lease companies and (big) companies negotiate about a lease contract and its conditions. After negotiating with various lease companies a company decides which lease company gets the contract. When a company signs a contract with a lease company, their employees can choose from several vehicles and select one they possibly want to lease. However, a company can limit the choice for their employees and make only a few vehicles available. So, the company can decide which cars an employee can choose from. Boldly said, if companies decide to introduce EVs their employees have to follow. However, companies need to consider the demands from employees and they will not suddenly stop leasing gasoline vehicles, but they can guide their employees into the direction of EVs. As noted, some multinationals already limit an employee’s choice and provide only certain economical vehicles.

Corporate social responsibility can be an additional driver why companies might want to make the transition to electric vehicles. The goal of CSR is to enclose responsibility for the company's actions and encourage a positive impact through its activities on the environment, consumers, employees and other stakeholders. Adopting EVs can be a useful investment for various companies to show their concern towards the environment. Suitable companies include energy companies and/or consultancies for example. Nowadays many companies pay a compensation fee for every ton of CO_2 emission to become climate-neutral. With incorporating electric vehicles they have to pay less compensation while at the same time they really make a statement towards their CSR and the environment.

2.3 Cost savings for companies

As noted already, lease drivers drive annually more kilometres per year than consumers do. This leads to a more favourable TCO of electric vehicles due to their low variable costs. In this section it will be analysed how big several cost savings are for companies and whether introducing electric vehicles can be a profitable investment.

2.3.1 Charging costs vs. fuel costs

On the one hand, lease drivers might be interested in electric vehicles, because they can use their budget to lease an EV and do not have to pay any fiscal addition which can save them a lot of money. However, it is also more expensive to lease a Nissan Leaf than a comparable Volkswagen Golf (€687 vs. €447), excluding any gasoline costs (Appendix 2). Due to this, companies might be a little hesitant towards including electric vehicles. Yet, the cost savings on gasoline could be able to close this gap and might make electric vehicles more attractive for companies.

Table 3 Monthly fuel cost savings

	Gasoline[9]	Diesel[10]	Electric vehicle[11]	Electric vehicle[12]
Costs	€ 274.51	€ 207.11	€ 45.59	€ 52.91
Gasoline savings	-	-	€ 228.92	-
Diesel savings	-	-	-	€ 154.19

For calculating these costs savings it is assumed that 50% of the EV-charges are done at work, while the remaining part is done at home and other public chargers. As can be seen in table 3, the savings on gasoline are considerable and can almost completely make up for the difference between the lease price of a Volkswagen Golf and Nissan Leaf. However, this only holds for gasoline vehicles and not for diesels. This should be of no concern, since most diesel-users drive annually far more than 30,000 km and are not the ones who are expected to acquire electric vehicles with their limited driving range. Therefore it is just for companies to focus on gasoline users since their fuel savings almost entirely close the gap, even when they drive fewer kilometres per year than diesels.

However, a small cost difference might remain. To close the remaining gap a company has more or less two choices. First, it can decide to close the gap themselves and pay an additional fee on top of an employee's budget since it believes it is important for the company to offer EVs to their employees. Second, a company can ask for a contribution from their employees who want to lease an electric vehicle. Since many employees save money on their fiscal addition this is a realistic approach and is being considered by some companies who are willing to introduce EVs. If the difference is too big it can also opt for a combination of both solutions. There is no clear-cut solution for this and a company must decide themselves what to do, since both options are realistic.

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[9] Calculations based on a gasoline price of €1.47 (excl. VAT), an usage of 0.08 litre per km and 28,000 km per year

[10] Calculations are based on a gasoline price of €1.18 (excl. VAT), an usage of 0.065 litre per km and 32,500 km per year

[11] Calculations based on an electricity price of €0.08 (excl. VAT) for charging at work, €0.18 (excl. VAT) for charging at home and an usage of 0.15 km per kWh and 28,000 km per year

[12] Calculations based on an electricity price of €0.08 (excl. VAT) for charging at work, €0.18 (excl. VAT) for charging at home and an usage of 0.15 km per kWh and 32,500 km per year

2.3.2 CO_2 reduction

Another, smaller cost saving concerns the CO_2 emission of companies that is being compensated by many companies as part of their CSR. By doing this, companies show they are mindful about the environment. CO_2 is being compensated via Gold Standard credits and are traded at a carbon credit marketplace. Currently it costs about €14 to compensate one ton of CO_2. With adopting electric vehicles, a company's can save money due to the lower CO_2 emission of electric vehicles. TNO (2009) has calculated that when one includes electricity generation and transportation, an EV has a 35% lower CO_2 emission than newer, cleaner gasoline vehicles. If the electricity is generated in a conventional power plant using coals, an electric vehicle's emission drops to a reduction of 22%.

CO_2 emission (in tonnes)	Compensation (in €)	22% CO_2 reduction	35% CO_2 reduction
5,000	€70,000	€15,400	€24,500
7,500	€105,000	€23,100	€36,750
10,000	€140,000	€30,800	€49,000
12,500	€175,000	€38,500	€61,250
15,000	€210,000	€46,200	€73,500

Table 4 Savings on a company's CO2 emission

PwC CO_2 emission

With its yearly emission of 9,501 tonnes, PwC can save annually an amount varying between €29,263 and €133,014 if their complete fleet becomes electric.

As shown in table 4, the cost savings on reducing a company's CO_2 emission are not as large as the savings on gasoline, but they are still considerable. Even more, a 100% CO_2 reduction is possible if companies generate the electricity themselves, for example via solar panels or wind turbines. This will lead to even greater savings and might be an incentive for companies to invest in durable energy methods and start generating electricity themselves.

Hence, introducing electric vehicles can have various important effects. First, and most importantly, it saves companies money which can add up to a considerable amount, especially when you consider a 100% CO_2 reduction. Second, adopting EVs sends out a positive signal to a company's stakeholders that the company is not only considering the environment, but also actively helping to sustain the environment. Third, acquiring electric vehicles helps to improve the air quality in a region. If a company compensates its CO_2 emission it is showing their concern about the environment, but the region does not directly benefit from it. With the implementation of electric vehicles the region directly benefits from the CO_2 reduction.

2.4 What do companies need to invest?

Despite these savings, companies also have to make several investments to successfully introduce electric vehicles to their employees. These investments include a charging infrastructure at work, as well as possible changes in the lease contract with lease companies.

2.4.1 Charging infrastructure at work

Depending on the amount of electric vehicles being introduced, a company will have to provide chargers at work. As noted in chapter one, regular charging will be the dominant type of charging at the workplace; many lease drivers are working at the office for several hours which makes regular charging suitable. However, there are also lease drivers who come to the office and have to meet a client during the day. For such instances it is useful that lease drivers have access to a network of fast-chargers. A company can opt to construct fast-chargers at work, but the construction costs (€75,000) are too big to make this a rational investment. Rather, a company can get access to the public network of fast-chargers for a monthly fee of €10 per vehicle, excluding any charging costs. This seems to be a better alternative for companies, since many lease drivers who are willing to acquire an electric vehicle do not exceed an EV's driving range and do not necessarily need fast-chargers. For those who possibly do need it you can provide access to the public network of fast-chargers.

In table 5 various cost scenarios are shown, depending on how many vehicles are being introduced. The scenarios are based on a charger's lifetime of eight years, which is the current estimated lifetime. It is assumed that for every electric vehicle a company adopts it also has to construct one regular charger. It costs about €2,500 to construct a regular charger, while the variable costs of a charger are relatively low; it only costs €10 per month to maintain a charger and read the necessary data for payment. It should be noted that these costs do not yet include any access to a public network of fast-chargers.

Table 5 Charging infrastructure costs

	Number of vehicles					
	25	50	100	250	1000	2000
Total construction costs	€ 62,500	€ 125,000	€ 250,000	€ 625,000	€ 2,500,000	€ 5,000,000
MIA taxation advantage[13]	€ 5,625	€ 11,250	€ 22,500	€ 56,250	€ 225,000	€ 450,000
Total fixed costs after MIA	€ 56,875	€ 113,750	€ 227,500	€ 568,750	€ 2,275,000	€ 4,550,000
Total variable costs	€ 24,000	€ 48,000	€ 96,000	€ 240,000	€ 960,000	€ 1,920,000
Total costs	€ 80,875	€ 161,750	€ 323,500	€ 808,750	€ 3,235,000	€ 6,470,000

[13] Based on a MIA of 36% and a corporate tax of 25% as is currently the case in the Netherlands €62,500*36%*25% = €5,625 e.g.

Further, the investments for a charging infrastructure are subjected to MIA which means that 36% of the costs can be subtracted from a company's pre-tax profits leading to a taxation advantage (Agentschap NL, 2011b:31). The effects of the MIA are also shown in table 5 and lower the construction costs of a charging network.

Again, the company has to decide what it wants to do with these investment costs. First, a company can decide to transfer these costs into the monthly lease price of their employees who adopt an electric vehicle. This would lead to an increase in the monthly lease price of €33.70 per vehicle[14]. Although it is not a significant increase in the monthly lease price it makes electric vehicles less attractive for lease drivers.

Second, a company can also choose to treat the costs as an investment for the wellbeing of their employees, rather than transferring it into their lease price. This option might be preferred for the first few years to maintain a lower lease price and make EVs more attractive for employees. If there are more electric vehicles sold and the buying price drops it might be possible to incorporate the costs in the lease price. Once more, a company can also choose for a combination of both options. What a company chooses depends on its vision, preference and financial position. There is no exclusive solution for such issues and each company has to decide itself what works best and how important it considers the introduction of EVs and how big potential positive externalities can be.

2.4.2 Additional incentives for employees

Some companies already made a first attempt introducing electric vehicles to their employees. These companies offered various incentives to overcome possible obstacles that employees might have. This section will discuss such incentives and why these might be necessary for successfully introducing EVs.

Holidays

A first issue companies might want to tackle concerns holidays since it is not possible to go abroad with an electric vehicle. Therefore, companies might want to include the possibility for employees to rent a gasoline vehicle to visit the French Riviera e.g. Currently, most lease contracts already provide an option to rent a car for 30 days a year. This period can often be absorbed in several times, with a minimum duration of one week. Yet, including this option costs a lease driver approximately €100 per month which adds up to €1,200 per year. In comparison, renting a family car (Ford Focus SW) via Hertz costs €530 for three weeks in July 2011 including insurance and taxation[15]. Although this does not include any fuel costs, this option is cheaper unless you drive more than 4,785 km[16]. So, the current lease contract does not seem to be suitable at the moment and might have to be changed if a company wants to incorporate this option into their lease contract for EV-users.

Alliander

Alliander successfully introduced the Nissan Leaf in 2011. The company offered various additional incentives to their employees to make the introduction successful:

- Possibility to rent a car for five weeks a year free of charge (this car should be from the same category as the Leaf and there is a maximum of getting a rental car for three times a year, while each time the car should be rented for at least one week)
- Alliander constructed a charger, both at home and at work free of charge
- Employees got an iPhone to use for business-ends, because an app has been developed which shows the nearest located chargers
- The costs of charging, insurance, maintenance and road taxes remained compensated

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[14] €323,500 / (100 vehicles * 96 months) = €33.70
[15] http://www.hertz.nl/rentacar/reservation/gaq/index.jsp?targetPage=whatView.jsp
[16] Based on gasoline price of €1.75 and a usage of 0.08 litre per km

However, it might be a better option that the rental car remains optional, because not every lease driver goes on holiday by car. If it is optional a lease driver can choose whether it opts for the €100 per month or save this money and use it to rent a car themselves or use it to go on holiday by train or airplane. This seems a better option as it also gives EV-users who do not go abroad (or go on holiday by train/airplane) the possibility to save €100 per month.

Duration of the lease contract

Companies and their lease drivers also have to consider issues about the duration of the lease contract. At the moment a lease contract usually has a duration of four years. However, there are still many developments expected with EVs and improved models will become available the coming years. Therefore employees might be hesitant to switch to electric vehicles if they cannot switch to these better models when they come available. Employees might rather wait and obtain a better model within two years for example. So, to successfully introduce EVs it might be important that the employees are offered the possibility to swap their electric vehicle for a newer, better model after two years. For the remaining two years companies can deploy the EVs for public use; for example as pool-car or when another vehicle is out for maintenance.

One could also argue to negotiate shorter lease contracts for electric vehicles. However, this leads to a higher depreciation and thus an increase in the lease price which makes EVs less attractive. So, a contract duration of four years keeps the monthly lease price lower, while at the same time it gives employees the flexibility to switch to newer models when they want to. Therefore this option is probably preferred.

To conclude, this chapter has shown that the lease market is an important segment for the Dutch automotive sector due to its big share in newly sold vehicles. Many of these new vehicles come into the hands of regular consumers once a lease driver’s contract expires and he can opt for a new vehicle. His old vehicle is then sold at the second-hand car market. In recent years there has been a shift amongst lease drivers to smaller, economical vehicles, possibly due to the fiscal addition. Further, it has been argued that companies and their lease drivers are considered suitable for acquiring electric vehicles for various reasons. Most important reason being the existence of various fiscal stimuli that make electric vehicles comparable in terms of price. With the construction of chargers at work it is also expected that the need for a public charging network diminishes which solves another problem and makes EVs more attractive. Finally, the chapter considered the cost savings and investments for companies. Especially the cost savings on gasoline for companies are considerable which can make electric vehicles an equally expensive investment to lease as conventional vehicles.

3 Survey design, theoretical framework and model

This chapter discusses the theoretical framework and the survey design that has been used. It will explain why I used a choice-based conjoint analysis with hierarchical Bayes as estimation method to determine lease drivers' preferences. As well, it discusses the various attributes and levels that I selected for my survey and it will describe the model that has been used.

3.1 Theoretical framework

Over the past four decades, conjoint analysis has become marketers' favourite methodology to find out how buyers make trade-offs among competing products and suppliers (Hartmann and Sattler, 2002). In this method, a decision maker has to deal with options that simultaneously vary across multiple attributes. The problem the decision maker faces is how to trade off the possibility that option X is better than option Y on attribute A while Y is better than X on attribute B, and various extensions of these conflicts (Green et al., 2001). An attribute is a characteristic of a product, made up of various levels. As an example, driving range can be an electric vehicle's attribute, while 150 km, 300 km, 450 km and 600 km are the attribute's levels. By observing how respondents evaluate products in response to changes in the underlying attribute levels it is possible to estimate the utility each attribute level has upon overall product preference. Once you learn respondents' preferences for the various levels, you can predict how buyers respond to any combination of levels in the study (Orme, 2002).

There are three types of conjoint analysis. Initially, traditional conjoint analysis was performed via full-profile card sorting. This method requires respondents to evaluate several product concepts, one at a time, defined on all attributes simultaneously. These concepts are printed on separated sheets of paper. Each card has one level of each attribute and respondents have to rank these cards. Due to software improvements and technological improvements card-sorting has become highly outdated and is hardly performed anymore nowadays.

A second method is adaptive conjoint analysis (ACA) which is only occasionally used. With ACA, respondents are first asked to rank their preference for levels within each attribute and are then asked to rank the importance of the attributes. Hereafter respondents evaluate a series of paired-comparison questions. In these questions respondents are presented two product concepts and are asked to indicate their preference using a rating scale, with the middle point indicating both concepts are equally liked. Green and Srinivasan (1990) recommend using ACA for situations with more than six attributes, because each question uses partial profiles and does not include all attributes in each product concept. However, this also means that it is common for an ACA questionnaire to last 45 minutes or more which negatively influences the data's reliability (Lenk et al., 1996). Especially when the number of attributes can be kept down to six or fewer it is better to use a full-profile conjoint analysis (Green and Srinivasan, 1990). Since I have included only five attributes I did not choose this method.

A final technique is choice-based conjoint analysis (CBC). This type of analysis has become the most popular method for measuring customers' preference structures both for commercial use and scientific studies (Hartmann and Sattler, 2002; Haaijer et al., 2000). It does not ask people to rank or rate their preference for concepts. Rather it presents multiple product concepts to respondents and asks which one they would choose. This 'pick-one' task tends to be far easier for respondents and it mimics what is done in the market place. An example of such a question is illustrated in Appendix 3.

3.1.1 Why choice-based conjoint analysis?

For my analysis I chose to use this final method. Choice-based conjoint analysis has several advantages (DeSarbo et al., 1995:137-8). First, data collection involves simulated purchase decisions, which is seen as a more realistic and relatively simple task for respondents than doing ratings or rankings. It is argued that respondents find it easier to choose one product from a few products that are presented, rather than rating these alternatives. The latter method is more arbitrary and is more difficult to interpret for respondents. Second, the derived utilities reflect impact on product choice, rather than a change in rating or ranking. It implies that market shares are directly estimated instead of a process that needs several assumptions. Third, product-specific attributes or levels can be easily adjusted which might be necessary if respondents face difficulties in the questionnaire. Finally, a no-choice option can be included that make the respondents' choices more realistic. This option can be chosen if none of the alternatives fit the needs of the respondent. A no-choice option is also available in reality and makes the choice more pleasant for respondents. It is argued that including this option leads to better responses from respondents.

Of course this method also has its drawbacks. One of these being that choice modelling uses full-profiles, so the number of attributes is generally limited to 5-7 (in contrast to 25-30 for ACA) which makes CBC unsuitable for some problems. However, this problem does not appear in my survey, since I can model my problem with relatively few attributes.

Another primary disadvantage is the inability to derive market segments and individual utilities (DeSarbo et al., 1995). Choice-sets only provide information about which alternative is selected, rather than the strength of preference differences within the set. Therefore it contains less information per observation than ratings (Huber and Train, 2001). Since people have different preferences, it is not always accurate to roll a sample together into a single set of utilities. This can be fixed with traditional estimation methods, but these require each respondent to evaluate a large number of questions in order to obtain individual-level preference parameters, resulting in lengthy questionnaires for products that contain multiple attributes. This causes problems as response rates tend to decrease with increasing questionnaire length and induce response biases (Lenk et al., 1996). Yet, these issues have been tackled in recent years with a new, advanced estimation technique; hierarchical Bayes.

3.1.2 Why combine CBC with hierarchical Bayes as estimation method?

Within hierarchical Bayes (HB), an algorithm estimates how different the respondent's utilities are from the other respondents in the sample. It estimates the average utilities for the entire sample and then uses the respondent's individual data to determine how each respondent differs from the sample averages (Lenk et al., 1996; Huber and Train, 2001; Howell, 2009). This ensures that HB has the ability to produce accurate individual estimates even when few questions are asked to each respondent (Lenk et al., 1996; Sawtooth Software, 2009). These individual utilities are helpful because they can be used to determine when a respondent is willing to choose for an electric vehicle and can be used for market simulations and to detect different preferences amongst groups.

Obtaining individual utilities implies that such Bayesian methods provide a better approximation to the amount of information given by the model and the data than other approaches (Johnson, 2000; Rossi and Allenby, 2003). It also frees researchers from computational constraints which allows them to develop more realistic models of buyer behaviour and decision making (Hauser et al., 2003). Therefore HB has usually been better and almost never worse at predicting individual preference parameters than other available methods and is recommended to use when this is possible.

3.1.3 Hierarchical Bayes model

As said above, I used the choice data in combination with hierarchical Bayes as estimation method. The model allows for obtaining individual preferences from respondents. These preferences are obtained in the form of a utility for each attribute level. Often in conventional statistical analyses you assume your data is described by a particular model with specified parameters and then you investigate whether the data is consistent with those assumptions. By doing this, you investigate the probability distribution of the data and you obtain confidence intervals.

In Bayesian analysis this process is turned around. Again you assume that your data is described by a certain model and you do computations to see if the data is consistent with those assumptions. However, in Bayesian analysis you investigate the probability distribution of the parameters, given the data, by making use of conditional probability. You start with a prior probability of a hypothesis, update it with information from the data, and obtain a posterior probability that combines the prior information with information from the data (Sawtooth Software, 2009:6). This is also done in a model with hierarchical Bayes as will be more carefully explained below.

The estimation method 'hierarchical Bayes' is called hierarchical because it exists of two levels. At the upper level, it is assumed that individuals' preference parameters (part-worth utilities of the attributes) are drawn from a multivariate normal distribution:

$$b \sim N\ (\mu\ , S)$$

Such a distribution is characterized by a vector of means (μ) and a matrix of covariances (S). At the lower level, it uses a multinomial logit model for each individual, where the total utility of each alternative is the sum of the utility of its attribute levels. The respondent's probability of choosing each alternative is equal to its utility divided by the sum of utilities for the alternatives in that choice set:

$$u = \Sigma b_i$$

$$Prob = \frac{\exp(u)}{\Sigma \exp(\,u_j)}$$

As a starting point for the analysis with hierarchical Bayes, one takes initial estimates for b's, μ and S. There is great liberty in choosing these estimates and its results do not appear to depend on starting values. The estimates of b for each individual are the numbers of times each attribute level is present in the chosen alternatives, divided by the number of times each attribute level is present in all alternatives. The initial estimate of μ has all elements equal to zero, and for S the initial variances are set at unity and covariances at zero. The algorithm repeats the following steps in each iteration:

1) Given current estimates of the b's and S, estimate the vector μ of means of the distribution
2) Given current estimates of the b's and μ, estimate the matrix S of variances and covariances
3) Given current estimates of μ and S, estimate a new b vector for each respondent

So, in each iteration an estimate is made for each parameter, conditional on current estimates of the others. During the iterations, values for the vector of means (μ) and the covariance matrix (S) are estimated by regular, well-known statistical calculations. An algorithm which applies Bayesian estimation is used for calculating the values of the b's. Johnson (2000:9-10) has a clear and understandable explanation what is done for each individual at each iteration:

"Define the individual's previous estimate of b as b_{old}. Construct a candidate for a new estimate for that individual by adding a small random perturbation to each element of b_{old}, calling the new vector b_{new}. Using the data and the logit model, you can compute the likelihood of seeing that respondent's set of choices, given each of those two b vectors. Each likelihood is the product of the predicted probabilities of all choices made by that respondent, given the estimate of b. The ratio of these likelihoods is computed as L_{new}/L_{old}.

The hierarchical model regards the individual's b vectors to have been drawn from a multivariate normal distribution with mean vector μ and covariance matrix S. You can use standard statistical formulas to compute the relative probabilities that b_{new} and b_{old} would have been drawn from that distribution, indicated by the height of the distribution's graph at each point. You compute the ratio of those probabilities, p_{new}/p_{old}.

Finally, you can compute the product of the ratios:

$$r = \left(\frac{L_{new}}{L_{old}}\right) * \left(\frac{p_{new}}{p_{old}}\right) = \frac{L_{new} * p_{new}}{L_{old} * p_{old}}$$

With Bayes estimation, posterior probabilities are proportional to likelihoods times prior probabilities. The p's can be regarded as priors, since they represent the probabilities of drawing each vector from the population distribution. Therefore, r is the ratio of posterior probabilities of b_{new} and b_{old}. If r is greater than unity, the new estimate has a higher posterior probability than the previous one, hence we accept b_{new}. If r is less than unity we accept b_{new} with probability equal to r."

These calculations are performed for every individual and for several thousand of iterations. The first several thousand iterations are used to achieve convergence in each parameter to conform to a multinormal distribution. With the iterations the b's converge to a set of estimates that fit the data. After these iterations (often 10,000 or more), the last several thousand iterations are saved for analysis, to produce estimates of the b's, μ and S. However, even after convergence, estimates from successive iterations can bounce around randomly, reflecting the amount of uncertainty that exists in those estimates. To achieve a point-estimate of part-worth utilities for each respondent one can average the estimates of that individual's b's for the last several thousand iterations to obtain solid estimates (Johnson, 2000:9). The obtained utilities for each attribute level are used for analysis, for example to calculate the importances of each attribute and for market simulations.

3.2 Study design

To get a reliable full-profile conjoint analysis it is important not to use too many attributes and levels. On the one hand it increases efficiency, but on the other hand, if you add too many attributes, comparing products will become too difficult and respondents might click randomly through the survey. Literature (Green and Srinivasa, 1990; Orme, 2002 e.g.) suggests that respondents have difficulties in dealing with more than about six attributes. My survey includes five attributes which can be regarded as a solid amount of attributes. Using more attributes is not recommended because respondents will not react in a proper way and using fewer attributes is not suitable because you might miss some important characteristics.

The same reasoning holds for the number of tasks. With a high number of choice tasks respondents might get fatigued or bored and do not answer according to their preferences but click randomly to finish the questionnaire quickly (Lenk et al., 1996; Sattler et al., 2003). For up to 20 tasks there is no evidence for decreasing reliability (Johnson and Orme, 1996; Sattler et al., 2003). I included 16 tasks which thus can be seen as a suitable number of tasks.

3.2.1 Attributes & Levels

I have chosen my attributes based on previous academic literature and several documents from market stakeholders. For example, Hidrue et al. (2007) examined the willingness-to-pay for EVs and their attributes for American consumers, while Potoglou and Kanaroglou (2007) studied the factors and incentives that influence households' choice for cleaner vehicles in the area of Hamilton, Canada. Attributes and findings from these studies can be used for selecting my attributes. Further, the selected levels are based on previous literature and the current market situation as will be explained below.

Monthly net costs

A first attribute that is included in the survey is the monthly net costs of leasing an EV. Fiscal advantages are already included in this, as well as the monthly lease price. The costs are compared to the monthly net costs of leasing a comparable gasoline vehicle. The attribute's importance speaks for itself as it is crucial for the decision whether to start leasing an electric vehicle or remain leasing a gasoline vehicle. At the moment it is cheaper to lease an EV than a comparable gasoline vehicle for an employee due to several fiscal advantages that are present for companies and their employees (Appendix 2). It is expected that being cheaper is a necessary condition for employees to make the transition.

The levels that I included are €200 and €100 cheaper, equally expensive, €100 and €200 more expensive. I include 'more expensive'-levels to check whether employees still consider leasing an electric vehicle if it is more expensive than a gasoline vehicle.

Driving range

Another included attribute is driving range, because it is important that the vehicles fulfil a user's driving needs. At the moment full-electric vehicles have a driving range of approximately 150 km while it is expected that newer models that will be launched in 2013 already have a driving range that exceeds 200 km. Also, Audi's electric A2 already drove more than 600 km during a test. This illustrates the batteries' potential and that it is possible to establish a driving range nearly similar to gasoline vehicles. I included levels 150 km, 300 km, 450 km and 600 km to check what respondents request. The levels vary between the current driving range and what is expected to be achieved in the coming years. It is important to note that the driving ranges are the amount of kilometres that can be driven in practice and it does not represent the advertised driving range.

Charging time

Third, charging time is selected as an attribute in the survey. An important distinction should be made for charging time. First, it might be that users just want to recharge their vehicle at work or at home during the night. In this case it should not matter that it takes about six hours to recharge a battery completely. Second, it might also be that users want to recharge their vehicle quickly in a couple of minutes. This is possible via fast-chargers which takes about 30 minutes. The levels that are chosen are 15 minutes, 30 minutes, 4 hours and 6 hours. So, these include the current charging times for both types of charging as well as a shorter charging time to check if users request this. It is assumed that charging is equally expensive for both regular and fast-charging, as is currently the case.

Charging infrastructure

Fourth, charging infrastructure is incorporated as an attribute in the survey. To make it understandable for the respondents I chose to define the publicly available charging infrastructure as a percentage of the current available gas stations. This has been done in a previous study with good results (Hidrue et al., 2007). It only contains the publicly available chargers; it does not include a charger at home or at work. I did not include those, because when buying or leasing an EV you are allowed to construct a charger at home for free (either at a private or at a public parking spot) and a company will provide a charger at work. Since people get a charger at home and at work it is expected that there are not as many chargers necessary as there are currently fuel pumps. In my survey I used levels of 75%, 50% and 25%. It is assumed that there is no congestion at chargers, which is a realistic assumption due to the relatively small amount of electric vehicles in the coming years.

CO_2 reduction

Finally, CO_2 reduction is incorporated as an attribute, because it can be an additional driver for deciding to lease an electric vehicle. On average, a Dutch gasoline vehicle emits 135 g/km CO_2, whereas newer, more economical vehicles emit about 100 g/km CO_2. TNO (2009) has calculated that an EV has a 35% lower CO_2 emission than these newer, cleaner gasoline vehicles. If the electricity is generated in a conventional power plant using coals, an EV's emission worsens to 22%.

To make the attribute understandable an EV's CO_2 emission level will be compared to the emission level of these cleaner, newer gasoline vehicles. The chosen reductions are 40%, 20% and 0%. A level of 0% is included to check whether respondents consider a CO_2 reduction to be important, whereas the other two levels are based on the report of TNO (2009).

3.2.2 None-option

The survey also includes a none-option. This option represents a comparable gasoline vehicle and it can be chosen if none of the electric vehicles are a good option and the respondent rather leases a comparable gasoline vehicle. The none-option makes the survey more realistic, because it is also available in real life. As well, it makes the experience more pleasant for the respondent; by adding a none-option the respondent is not forced to choose something he or she does not want. A final reason for including a none-option is that it improves the quality of the data, by letting respondents opt themselves out of questions containing alternatives they would never consider. However, if a none-option is repeatedly chosen, you learn very little about the underlying utilities. To overcome this drawback I tested my survey beforehand from which I can conclude that the none-option is not repeatedly chosen and is functioning correctly.

It is important to note that the outside option can also represent a diesel or hybrid car. The characteristics are similar to that of a gasoline vehicle; its monthly costs, driving range, amount of fuel stations and the time it takes to refuel is the same for these types of cars. Even the CO_2 emission of newly manufactured gasoline vehicles is nearly similar to that of hybrids.

3.3 Representative sample

My sample was selected to be representative of Dutch lease drivers over 18 years of age. A qualifying question was asked if the respondents were leasing a vehicle from their employer, or when they are not, if the respondent was interested to lease one. The survey was collected so as to mimic the general population along the lines of sex, age and education. The sample includes 751 completed surveys. Table 6 compares my sample to the population of lease drivers. Since I included quotas, I have nearly the same sex-, age-, and education distribution as the population. My sample only somewhat under-represents the lower educated people, while the higher educated are somewhat overrepresented. Dividing the variables age and education for sex gives similar percentages as the population, which is another indication that the sample is representative.

Variable		Population[17]	Sample
Sex	Male	84%	80%
	Female	16%	20%
Age	< 30 years	14%	14%
	30 – 40 years	31%	31%
	40 – 50 years	34%	34%
	50 – 60 years	18%	18%
	> 60 years	3%	3%
Education	None	1%	0%
	LBO, VMBO, MAVO	13%	7%
	MBO, HAVO, VWO	37%	31%
	HBO, WO	49%	62%
	Anonymous	-	0,5%

Table 6 Population and sample data

To conclude, this chapter has shown that my research can be successfully performed with the help of a choice-based conjoint analysis; I can model my problems with few attributes which makes CBC more suitable to use than an adaptive conjoint analysis. The five attributes that are included in the survey are (1) monthly net costs, (2) driving range, (3) charging time, (4) charging infrastructure and (5) a CO_2 reduction. Further, the chapter has argued that HB leads to the best possible estimations of the individual utilities and should be used as estimation method. Finally, the chapter has shown that the sample of 751 lease drivers is similar to the population and is a representative sample.

[17] Population data source: VNA - Zicht op de zakenautorijder, 2007

4 Results

Next, this chapter will discuss the results from the conjoint analysis. It discusses which attributes are considered most important in the respondents' decision-making process and other results like the significance of the attributes and potential interaction effects. Also, a demand curve for electric vehicles is determined. Finally, it is examined how much a lease driver is willing to pay for an improvement in the various attributes.

4.1.1 Attribute levels' effects and significance

Hierarchical Bayes estimation provides utilities of all the attribute levels. Nevertheless, it is useful to check the results of the logit analysis as they can be used as an indication for significance of the model. A quick glance at table 7 tells us that nearly all attribute levels are highly significant if we check the t-ratios, while also the effects of the attribute levels have the expected signs. Only the variable 20% CO_2 reduction is insignificant, while the level 50% from the attribute 'charging infrastructure' is significant at the 10% level. Although t-ratios can provide useful guidance within such models, it is preferred to look at the log likelihood test to measure whether the model is significant. With 15 degrees of freedom, a Chi Square of approximately 30.58 would be significant at the 0.01 level (Wooldridge, 2009:829). The obtained value of 5208.96 is safely larger than this, so I can conclude that respondent choices are significantly affected by the attribute composition of the concepts and therefore I can use all attribute levels for analyses. Further, the results provide no evidence for the existence of interaction effects amongst the attributes, except one (Appendix 4); there is only evidence of an interaction effect between the monthly net costs and a CO_2 reduction at a 5% significance level. Including it in the model only improves the Chi Square by 13, while it decreases the degrees of freedom by eight (Appendix 5). However, an increase in the Chi Square of more than 13 is required to obtain a 10% significance (Wooldridge, 2009:829). Therefore it will not improve the model and I did not include the interaction effect.

The last column reports the utilities of all attribute levels that are estimated with the help of hierarchical Bayes. Some differences between the various attributes are already noticeable. First, the change in the utilities is largest for the attributes 'monthly net costs' and 'driving range'. The utilities for the other three attributes are remarkably smaller. This could indicate that the monthly net costs and driving range are the most important aspects in a lease driver's decision to adopt an electric vehicle. Second, the change in the levels' utilities for the monthly costs starts out linear, but the change decreases when it becomes cheaper to lease an electric vehicle. This might indicate that lease drivers regard it important that it is not more expensive to lease an EV than a conventional vehicle, rather than being cheaper. The same pattern is present for the attribute driving range; especially the change from 150 km to 300 km is larger than the other changes. This nonlinear relationship might indicate that it is more important to improve the driving range from 150 to 300 km rather than from 450 to 600 km. The utilities for charging infrastructure and CO_2 reduction are smaller and nonlinear. It might indicate that these attributes are not particularly important for lease drivers, while improvements are considered relatively more important when the attribute level is still low. For example, the difference in utility is higher between a CO_2 reduction of 0% and 20% than between a reduction of 20% and 40%. Finally, the attractiveness of each alternative can be compared to the outside option, which has a utility of -78.58. An electric vehicle's utility is the sum of each attribute level that you choose. If you check the various attribute utilities it is well possible that there are electric vehicles that are at least equally attractive as the outside option.

Table 7 Attribute levels' effects, t-statistics and utility levels

Attributes	Levels	Effect	T-ratio	Utility levels
Monthly net costs	€200 more expensive	-1.19	-25.68	-86.38
	€100 more expensive	-0.52	-13.96	-44.19
	Equally expensive	0.29	9.40	26.33
	€100 cheaper	0.57	19.02	44.42
	€200 cheaper	0.85	28.41	59.83
Driving range	150 km	-1.23	-30.53	-103.39
	300 km	-0.11	-3.84	-2.97
	450 km	0.43	15.78	39.31
	600 km	0.91	34.98	67.05
Charging time	15 min	0.55	20.88	38.11
	30 min	0.34	12.96	25.95
	4 hours	-0.30	-10.17	-20.41
	6 hours	-0.59	-18.67	-43.65
Charging infrastructure	25%	-0.20	-8.55	-13.40
	50%	0.04	1.78	1.60
	75%	0.16	7.21	11.80
CO2 reduction	0%	-0.23	-9.94	-15.24
	20%	0.02	0.85	2.80
	40%	0.21	9.74	12.44
None		1.01	38.73	-78.58
Chi-square	5208.96			
Sample size	751			

4.1.2 Attribute importance

It is also possible to determine the relative importance of the attributes that are included in the survey. It shows how important each attribute is considered in the decision-making process to acquire an electric vehicle. These importances are obtained by calculating how much difference each attribute can make in the total utility of a product. That difference is calculated as the difference between the lowest and highest utility level of an attribute, which is called the range of an attribute. Next, you percentage those ranges, obtaining a set of attribute importance values that add to 100%. The importances that are found are ratio data, which means that an attribute with an importance of 20% is twice as important as an attribute with an importance of 10% in a respondent's decision. Hierarchical Bayes also estimates utilities for each individual, which makes it possible to calculate these importances for various subgroups. The percentages reflect how important an attribute is considered in the decision-making process which vehicle a respondent chooses.

Table 8 provides the importance of the attributes for the complete sample. As can be seen, the driving range is the most important attribute in the decision-making process and is closely followed by the monthly net costs. The charging infrastructure and CO_2 reduction are not of particular interest in the decision-making process. It indicates that range anxiety and the monthly lease price can significantly affect a lease driver's choice and can be a barrier for the penetration of electric vehicles. This outcome is in line with Lee and Lovellette's (2011) view that there exists a trade-off between costs and range, since both are considered almost equally important. This trade-off is also observed in practice, where the price of a range-extender is higher than the price of a full-electric vehicle with its smaller driving range. It is important for automotive companies to find the right balance between these two.

The low importance of a charging infrastructure might be explained by the fact that respondents are offered a charging spot at home and at work in the survey. This diminishes the value of a public charging infrastructure, as noted by the low importance in a respondent's decision-making process. This affirms one of the reasons why lease drivers are already considered suitable for EVs, namely that they do not necessarily require a public charging infrastructure. The low importance of a CO_2 reduction indicates that it is not a primary determinant for respondents. One possible reason could be that CO_2 reduction is a public benefit which is not captured by a private individual and is therefore not an important aspect in the decision-making process. The low importance also indicates that promoting EVs based on a CO_2 reduction amongst lease drivers will not lead to a substantial increase in demand. Rather, it is better to stress the various fiscal measures that ensure that electric vehicles are not more expensive to lease than conventional vehicles.

I also examined the attributes' importance for various subgroups (appendix 6). For many subgroups there are no differences present. For example, a respondent's age, level of education, current type of vehicle and income does not lead to substantial changes in the importances. For some other groups there are differences present, as shown in table 8. This might have implications for successfully targeting lease drivers, although there might be correlations problems present as will be explained below.

First, when the annual amount of driven kilometres increases, there is an increase in the importance for an EV's driving range, while the costs decrease in importance. The same is observed for a bigger home-to-work distance. Although this is no big eye-opener, it might show that an EV should match a driver's mobility pattern. It might be that respondents who drive a lot kilometres can be better targeted with range-extenders. These have a bigger driving range and are a little more expensive, hence fit a lease driver's preferences better than full-electric vehicles. The full-electric vehicles might be better for those who do not drive a lot of kilometres. However, the differences in importance might also be (partly) explained by correlations within the sample. Females are overrepresented in the subgroup that drives less than 20,000 km per year for example, while they also have a shorter home-to-work distance than males. A survey of Opel Nederland[18] found results that females are more environmentally aware and put a bigger emphasis on the environment in their decision to acquire a vehicle. This might make females more willing to adopt an electric vehicle. So, the correlation between these two groups makes it difficult to interpret the difference; both subgroups might partly influence the results and lead to these differences in importance. Unfortunately it is not possible to control for such effects, which is a limitation of the model that has been used.

Table 8 Attribute importance of the complete sample and various subgroups

		# of respondents	Monthly net costs	Driving range	Charging time	Charging infrastructure	CO2 reduction
Complete sample		751	32.41%	36.16%	18.29%	6.39%	6.75%
Gender	Male	637	32.16%	36.74%	18.36%	6.24%	6.50%
	Female	114	33.83%	32.88%	17.90%	7.23%	8.16%
Income	<€40,000	127	33.04%	34.60%	18.67%	6.46%	7.23%
	€40,000-€60,000	182	31.78%	36.60%	18.75%	6.20%	6.66%
	€60,000-€80,000	162	32.42%	36.10%	18.29%	6.52%	6.66%
	≥€80,000	151	31.78%	37.44%	18.04%	6.39%	6.35%
Yearly amount of km	<20,000 km	141	36.33%	31.02%	17.53%	6.97%	8.15%
	20,000-30,000 km	225	33.14%	34.05%	19.17%	6.81%	6.84%
	30,000-40,000 km	173	31.35%	38.18%	18.22%	5.90%	6.34%
	≥40,000km	212	29.90%	40.17%	17.91%	5.96%	6.06%
Home-to-work distance (singe trip)	<25 km	227	33.27%	35.26%	18.55%	6.57%	6.35%
	25-50 km	222	32.34%	35.00%	18.76%	6.73%	7.16%
	50-75 km	126	32.78%	36.57%	17.87%	6.00%	6.77%
	≥75 km	176	31.14%	38.48%	17.65%	6.01%	6.73%
Public transport	Never	593	32.28%	37.21%	18.01%	6.17%	6.33%
	< once per week	108	32.18%	33.95%	19.47%	7.17%	7.23%
	≥ once per week	50	34.48%	28.43%	19.07%	7.30%	10.72%

[18] "Vrouwen zijn milieubewust, maar ook zuinig op vervuilende, oude auto", Marketing Online. Accessed online http://www.marketingonline.nl/nieuws/bericht/vrouwen-zijn-milieubewust-maar-ook-zuinig-op-vervuilende-oude-auto/

Also, one could have expected that an increase in income led to a decrease in the importance for the monthly net costs. However, this effect is barely observed and shows that also for wealthier lease drivers the costs remain an important issue. It implies that (lease) companies cannot target lease drivers based on income and have to focus on other criteria, possibly the annual amount of kilometres or the home-to-work distance.

Finally, lease drivers who frequently use public transportation are more concerned about the monthly net costs and CO_2 reduction, while the importance for the driving range decreases. This might be an indication that they choose to regularly use public transportation due to a higher environmental awareness. It might also show that they might be more suitable to adopt full-electric vehicles, due to the smaller importance of the driving range. Yet, again there might be problems with correlations with other subgroups. For example, respondents who use public transportation more than once per week have a shorter home-to-work distance, while also more than 50% does not drive more than 20,000 km per year. These correlations might explain part of the difference. So, issues about correlation make it difficult to explain the difference solely based on public transport.

4.1.3 Demand curve for electric vehicles

With the survey's results it is also possible to estimate a demand curve for electric vehicles, based on changes in the underlying attribute levels. The demand curves are shown on the next page in figure 2, where the assumptions are indicated at the bottom of figure 2. At the y-axis, negative monthly net costs indicate that it is cheaper to lease an electric vehicle than a comparable gasoline vehicle, while positive monthly net costs imply that an EV is more expensive than a conventional vehicle. The market share of electric vehicles is shown at the x-axis. Some important remarks can be made about the various demand curves.

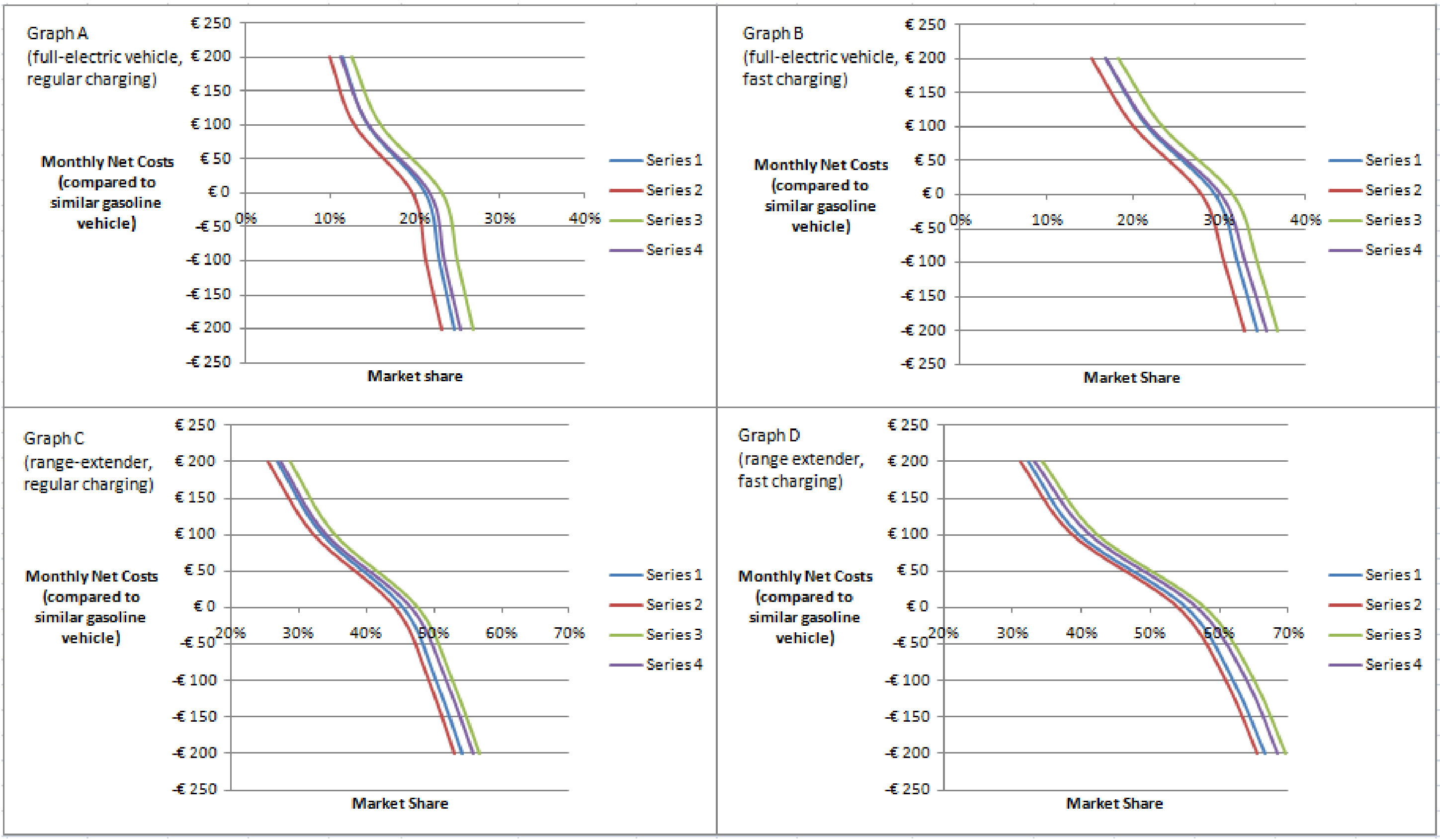
First, figure 2 indicates a strong marginal increase in demand when an electric vehicle is getting equally expensive as a comparable gasoline vehicle. This marginal increase is present in all scenarios and does not depend on the underlying assumptions in other attributes. It shows that it is not necessary for lease drivers that it is cheaper to lease an electric vehicle. Rather, it is important that it is not more expensive. So, the increase specifies the importance of the current fiscal measures which ensure that an EV can compete in price with a conventional vehicle. The government's subsidies also seem to be at the right place; the monthly net costs are considered very important in a lease driver's decision-making process to adopt an EV (table 8). The graphs also show no substantial increase in demand when an electric vehicle becomes cheaper to lease than a conventional vehicle. It might indicate that such stimuli can be removed by the government when an EV's buying price, and hence the monthly lease price, falls due to an increase in production. It will be better for the government to (partly) remove these measures since it does not lead to a substantial increase in demand for electric vehicles.

Second, the demand curves also show a remarkable difference between full-electric vehicles (graph A and B) and range-extenders (graph C and D); the latter is more attractive for lease drivers than full-electric vehicles. A range-extender would be able to capture almost half of the market amongst lease drivers, whereas a full-electric vehicle is able to gain a market share of approximately 10%-30%. This difference in market share shows the potential for electric vehicles when automotive companies are able to extend the vehicles' driving range. These large market shares also show the appropriateness of targeting lease drivers and indicate that they are a suitable segment to make the transition to electric vehicles. So, the government's decision to target lease drivers seems to be justified based on these high market shares, as it is expected that 'regular' consumers are not yet willing to adopt an electric vehicle.

Third, there is a significant increase in demand when regular charging is replaced with fast charging (graph A vs. B and graph C vs. D). In all scenarios there is an increase of approximately 10%. It shows that fast-chargers places can spur demand for EVs which might be important to consider for grid operators. It indicates that it can be important to construct these fast-chargers at public places, for example at shopping centres or highways. It also stresses the importance of Stichting E-laad to share the costs of setting up a public charging infrastructure and prevent free-riding since constructing these fast-chargers is expensive.

Finally, the graphs also indicate that the demand curve is not significantly shifted rightwards with an improvement in the charging infrastructure or an increase in CO_2 reduction. This is as expected since respondents' decisions were mainly based on driving range and costs; not on a CO_2 reduction or on the charging infrastructure (table 8). It might confirm expectations that the existence of a public charging infrastructure is not a necessary precondition for lease drivers.

Figure 2 Demand curves for a full-electric vehicle and a range-extender based on four scenarios



	Charging infrastructure	CO2 reduction
Series 1	25%	40%
Series 2	25%	20%
Series 3	50%	40%
Series 4	50%	20%

Market simulations

I have also performed some market simulations and estimated the market shares of various electric vehicles if these would be introduced amongst lease drivers. These market shares are calculated with the effects that are indicated in table 7. One takes the following steps to determine market shares:

1. Add all the corresponding effects of the attributes for each concept
2. For each concept you take the exponential of the value obtained in step 1
3. Add up the exponential values of each concept
4. Express the total value of each concept as a percentages of the total value of all concepts

Market simulations are performed for the complete sample and for various subgroups. The simulations include a full-electric vehicle and a range-extender, based on their real-life features and some assumptions. For example, the driving range and charging time are based on their real-life characteristic. I chose to use a 25% level for the charging infrastructure, because there are not many chargers at the moment and a full-covering network is not yet around the corner. The full-electric vehicle is given a bigger CO_2 reduction than the range-extender, because the latter uses a generator to extend the driving range which leads to a slightly lower CO_2 reduction. Finally, a range-extender is more expensive to lease than a full-electric vehicle, so also the monthly net costs differ. These price differences are based on actual lease prices. All the attribute levels that have been chosen are shown at the bottom of table 9. All results for the market simulations can be found in appendix 7, whereas the most interesting results are also presented in table 9.

For the complete sample the combined market share of the two electric vehicles is close to 39%, which would be a substantial part of the market. The largest part will come in the hands of the range-extender (30.88%), while the full-electric vehicle gets a considerable smaller market share of 7.92% (table 9). Although this seems a large share, it should be noted that these market shares might be lower in real-life. For example, brand loyalty and design are not taken into account in this survey which might lead to a lower demand. Nevertheless, the market shares for electric vehicles are relatively high, showing the potential of electric vehicles amongst lease drivers. It is also important to realise that these market shares are not obtained tomorrow. It can take a few years before a lease driver's contract expires and someone can choose to opt for an electric vehicle. On average a lease contract has a duration of four years (VNA, 2011:22), so this might be a realistic time-horizon to expect these high market shares.

I also performed these market simulations for various subgroups which might provide some information how electric vehicles are perceived by them. Some notable differences include:

- The market share for both types of electric vehicles is larger for females than males
- Older respondents prefer a conventional vehicle at the expense of both types of electric vehicles
- Lower educated people have a preference for both electric vehicles, while respondents with an university degree have a lower market share for electric vehicles
- Respondents with a lower income have a bigger market share for electric vehicles
- Electric vehicles are more popular amongst people who drive less than 20,000 km per year, while the full-electric vehicle loses market share amongst people who annually drive more than 20,000 km
- People who do not pay a fiscal addition have a stronger preference for both EV-types
- There is a strong increase in the market share for electric vehicles amongst people who use public transportation, especially the market share of the full-electric vehicle increases remarkably

However, one should be cautious with these results. Again, it is possible that there are correlations between various groups which might be part of the obtained differences. For example, on average females drive fewer kilometres per year than males and have a shorter home-to-work distance. This can lead to a lower importance for a vehicle's driving range (table 8) and might be a possible explanation of this difference. There are no other major differences between men and women; their income, education; age is rather similar across these characteristics.

Second, the results show that older respondents prefer conventional vehicles over EVs. This might confirm previous findings that a vehicle is still seen as a status symbol amongst older people, whereas this is not longer the case for younger people (VNA, 2011:7). For younger people the size or exclusiveness of a vehicle is not as important anymore as for older people, which makes electric vehicles a more attractive option for younger people. However, 34% of the respondents who are younger than 30 years drive fewer than 20,000 km per year, whereas this is only 16% for respondents who are older than 50 years. This might indicate some correlation between these two variables and makes it difficult to interpret the difference. The difference might be explained by both characteristics due to the correlation.

Table 9 Market simulations for the entire sample and subgroups providing the market shares for a full-electric vehicle and a range-extender

		# of respondents	Full-electric vehicle	Range-extender	Conventional vehicle
Complete sample		751	7.92%	30.88%	61.20%
Gender	Male	637	7.37%	30.34%	62.29%
	Female	114	10.95%	33.92%	55.13%
Age	<30	104	8.55%	27.07%	64.39%
	30-40	236	9.70%	29.35%	60.95%
	40-50	255	6.97%	35.04%	57.99%
	≥50	156	6.34%	28.93%	64.73%
Education	VMBO/MBO	215	9.39%	36.61%	54.00%
	HAVO/VWO/HBO	368	7.99%	29.92%	62.10%
	WO	163	6.05%	26.44%	67.51%
Income	<€40,000	127	10.14%	38.44%	51.42%
	€40,000-€60,000	182	8.64%	27.81%	63.55%
	€60,000-€80,000	162	6.39%	33.86%	59.75%
	≥€80,000	151	6.40%	32.20%	61.40%
Yearly amount of km	<20,000 km	141	16.08%	36.51%	47.41%
	20,000-30,000 km	225	7.47%	29.50%	63.03%
	30,000-40,000 km	173	5.81%	29.84%	64.35%
	≥40,000km	212	4.68%	29.45%	65.88%
Home-to-work distance (single trip)	<25 km	227	8.44%	30.63%	60.93%
	25-50 km	222	8.19%	31.17%	60.64%
	50-75 km	126	6.01%	30.91%	63.08%
	≥75 km	176	8.26%	30.82%	60.92%
Type of vehicle	Gasoline	329	8.53%	31.64%	59.83%
	Diesel/LPG	360	7.35%	29.30%	63.35%
	Hybrid	62	7.96%	36.00%	56.04%
Fiscal addition	Yes	592	6.48%	28.58%	64.93%
	No	102	11.58%	37.70%	50.72%
Public transport	Never	593	6.20%	29.11%	64.69%
	< once per week	108	12.19%	37.50%	50.31%
	≥ once per week	50	19.06%	37.58%	43.36%

	Full-electric vehicle	Range-extender
Monthly net costs (compared to a conventional vehicle)	€50 cheaper	€50 more expensive
Driving range	150 km	450 km
Charging time	6 hours	4 hours
Charging infrastructure	25%	25%
CO2 reduction	40%	20%

Third, table 9 also shows an increase in demand for electric vehicles amongst lease drivers with a lower income. A possible explanation might be that the annual amount of kilometres that is driven is lower when a lease driver has a lower income. In my sample, only 10% of the respondents with an annual income higher than €80,000 drive less than 20,000 km, while this is 33% for respondents with an income of less than €40,000. Since a vehicle's driving range is considered important in the decision-making process this might explain the difference. Respondents with an income of less than €40,000 also more frequently do not have a fiscal addition, indicating that they use it purely to get to work and to home again. Only 70% within this group pay a fiscal addition, whereas 82% of the respondents with an income of more than €80,000 pay fiscal addition. These different characteristics indicate some correlation between the groups and shows the difficulties of identifying differences in market shares.

Further, there is also a different market share notable for lower and higher educated lease drivers. However, as shown in appendix 6, there are no differences in attribute importance amongst higher and lower educated lease drivers which could possibly explain this difference. It implies that this difference is driven by changes in other characteristics than education. For example, 43% of the respondents who have a university degree earn more than €80,000 per year; only 8% of lower educated respondents (MAVO or MBO degree) earn more than €80,000. It shows that this difference might be ascribed to such correlations.

It is also notable that respondents who do not pay a fiscal addition have a stronger preference for electric vehicles. A possible explanation could be that these vehicles are purely used to get to work. This leads to fewer kilometres per year, as also noted within the sample. Since the average home-to-work distance is only 44 km (Ministerie van Verkeer en Waterstaat, 2010:22) the current available EVs are perfectly suitable for this. This is also reflected in the yearly amount of kilometres; 24% of the respondents without fiscal addition drive less than 20,000 km per year, whereas this is 14% for those who do pay a fiscal addition. However, for these lease drivers it might be relatively more expensive to lease an electric vehicle, because they do not have any savings on the fiscal addition. Whether it becomes more expensive depends on companies' decisions what costs they transfer into the lease price, as argued in chapter three.

Furthermore, there is a remarkable increase in the market share for electric vehicles amongst users of public transportation. This increase can be explained by the fact that they do not consider the driving range very important in their decision which vehicle to lease, while they stress the monthly net costs. Since EVs and conventional vehicles are comparable in terms of price and range anxiety is a smaller problem, public transport users are more willing to adopt electric vehicles. It also helps that they consider the CO_2 reduction more important in their decision, albeit not the major factor in this increase. Yet, once again there are many other correlations possible. For example, frequent users of public transportation are younger, drive fewer kilometres per year and have a lower income. Such differences make it hard to check which way the causation runs.

Finally, one might expect that a bigger home-to-work distance would lead to a stronger preference for range-extenders or gasoline vehicles. However, there are hardly any changes in the market shares in this subgroup. For the annual amount of driven kilometres there are substantial differences. Especially amongst drivers who drive less than 20,000 km per year there is an increase for full-electric vehicles as well as range-extenders. This should be no eye-opener and confirms previous expectations that lease drivers who drive many kilometres per year are not ready to transit to electric vehicles. It indicates that the electric vehicle should fit with a lease driver's mobility pattern. Also, as shown in previous paragraphs many other differences are also driven by the annual amount of driven kilometres. It might indicate that it is one of the main drivers behind the found differences. However, no clear evidence is present for this relationship.

So, subdividing the sample might give additional insights for (lease) companies that are introducing electric vehicles. As shown above, there are different preferences amongst different groups. However, you should be cautious with interpreting these results since these differences can also be explained by differences in other characteristics. As argued above, many results are also driven by differences in mobility patterns, for example the annual amount of kilometres. This might indicate that this is the main driver behind these results and is an important aspect lease companies have to focus on when targeting lease drivers.

4.1.4 Willingness-to-pay

It is also possible to determine the willingness-to-pay (WTP) for the various attributes that are included in the survey. In economics, the WTP is the maximum amount a person would be willing to pay in order to get an improved product. For example, it is possible to get two similar market shares, one for a 150 km driving rage and one for a 200 km driving range by varying the monthly net costs. The difference in price can be seen as a lease driver's willingness-to-pay for this increase in the driving range. Determining the willingness-to-pay can be done via trial-and-error market simulations. Such analysis is done for all attributes, based on different underlying attribute levels. Tables of the willingness-to-pay for each attribute can be found in appendix 8. The graphs of these tables are presented in this section.

Driving range

First, a lease driver's willingness-to-pay for improving the driving range is examined. It has been analysed for changes in charging time and charging infrastructure, but this does not lead to substantial differences (appendix 8). The graphs in figure 3 depict the willingness-to-pay for adding 50 kilometres to an electric vehicle's driving range.

As shown in figure 3, a lease driver's willingness-to-pay is rather high for an improvement in the driving range, when compared to other attributes. For example, if we take a closer look at the current driving range of a full-electric vehicle (point A), a lease driver is willing to pay approximately €48 per month for an improvement in the driving range of 50 km. With the average lease contract duration of 48 months this adds up to an amount of €2,304. It is a considerable amount which might have positive implications for automotive companies and research centres. It shows that investing in new technologies to improve the driving range might be profitable, even if it might raise the buying price (and hence the lease price) of an electric vehicle. On the other hand, improvements in the driving range of range-extenders are considered less important, as noted by the lower willingness-to-pay (point B). Hence, it would be better to focus on improving the driving range of full-electric vehicles.

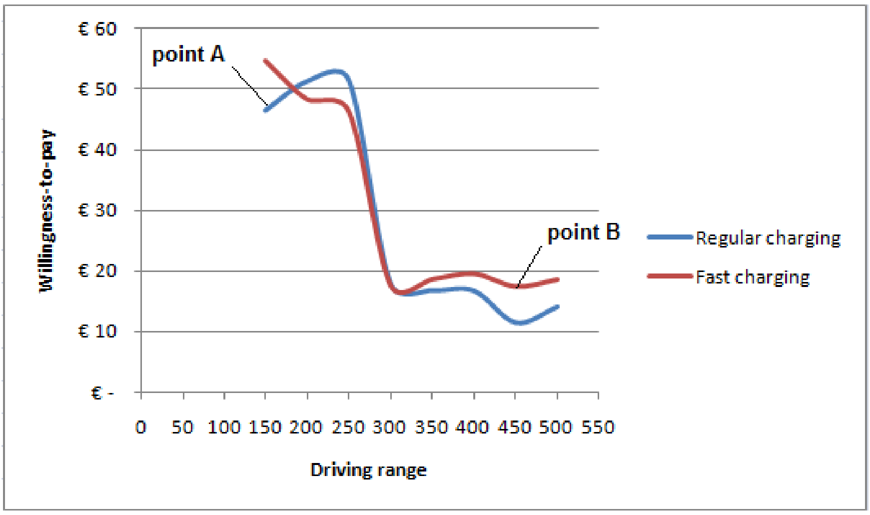


Figure 3 Willingness-to-pay for an increase of 50 km in the driving range

Further, a considerable drop in a lease driver's willingness-to-pay is evident for increasing the driving range beyond 300 km; suddenly it falls approximately from €50 to €18. This might be an indication that there is some sort of threshold for lease drivers, meaning that they require a minimum driving range of 300 km. Beyond this level they are not willing to pay a substantial amount of money to extend the driving range anymore. The results are similar to Deloitte's (2011) study who examined the willingness to adopt electric vehicles amongst consumers in 17 countries. It showed that potential buyers require a minimum driving range of 320 km. This corresponds with these results where the WTP drops severely if the vehicle's driving range exceeds 300 km. From these results it seems useful for automotive companies and research centres to cooperate to be able to develop new methods that extend the driving range to 300 km and satisfy the needs of people. New models that become available in 2012 are expected to have a driving range that already exceed 200 km, so some progress is already expected.

Charging time

Further, a respondent's willingness-to-pay for a shorter charging time has been examined, as shown in figure 4. Graph A represents regular charging and depicts the WTP for a shorter charging time of 30 minutes. It indicates that the willingness-to-pay is almost equal for both types of vehicles and lies around €8 to €10. Graph B represents fast charging and describes the willingness-to-pay for a shorter charging time of five minutes and varies between €4 and €7. The WTP is in both graphs substantially lower than the willingness-to-pay for extending the driving range, indicating that it should not be the centre of attention to improve the vehicle's charging time. One could argue that the relatively low WTP might be ascribed to an uninformed choice of the respondents and the difficulty to estimate the importance of charging time. However, I presume this is not likely to be the case, since respondents were thoroughly informed about the possibilities of charging time in the introduction of the survey, just like the other attributes were explained before respondents entered the survey. Also in the respondents' comments about the survey no such criticism emerged. It might just be that a charger at home and at work makes it less important to improve the charging time, since people can always leave in the morning with a fully-charged vehicle and can recharge at work for several hours. Although this seems plausible in theory, an underestimation of the importance by respondents cannot be fully excluded.

If we look at regular charging (graph A) the willingness-to-pay remains constant when the charging time decreases. This is as expected, since regular charging is mainly done during the night or at work, for which it often does not matter that it takes six, five or four hours. The WTP is also relatively low, on average €9, indicating that it is not a high priority to decrease the regular charging time.

Having a glance at fast charging (graph B), a lease driver's willingness-to-pay is higher for a range-extender than for a full-electric vehicle. This might be explained by the fact that lease drivers who prefer a range-extender drive more kilometres and are more dependent on fast charging. Therefore it might be that these lease drivers have a higher willingness-to-pay to decrease the charging time of fast charging. Nevertheless, in both cases the willingness-to-pay is rather small. Therefore it might be better for research centres and other parties to focus on improving the driving range of electric vehicles.

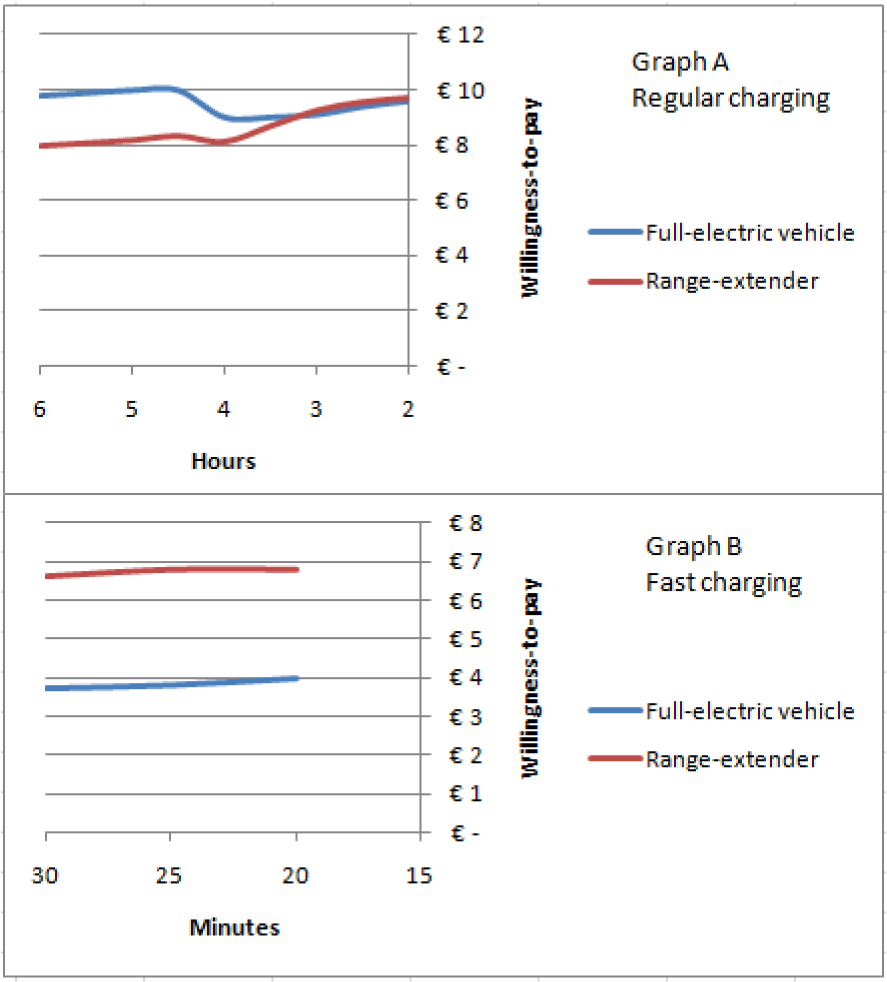


Figure 4 Willingness-to-pay for a shorter charging time for regular charging (Graph A) and fast charging (Graph B)

Charging infrastructure

I also examined the lease drivers' willingness-to-pay for an increase in the amount of public chargers. It has been done for underlying differences in driving range, charging time and CO_2 reduction. The graphs in figure 5 represent the WTP for an increase of ten percentage points for the charging infrastructure.

A lease driver's willingness-to-pay for improving the charging infrastructure varies between €2 and €10.50, based on various changes in the other attributes. The low willingness-to-pay can be explained by the fact that the number of available chargers is not an important aspect in a lease driver's decision, possibly because they are offered a charger at home and at work. This leads to a lower importance for a public charging network and hence a lower willingness-to-pay.

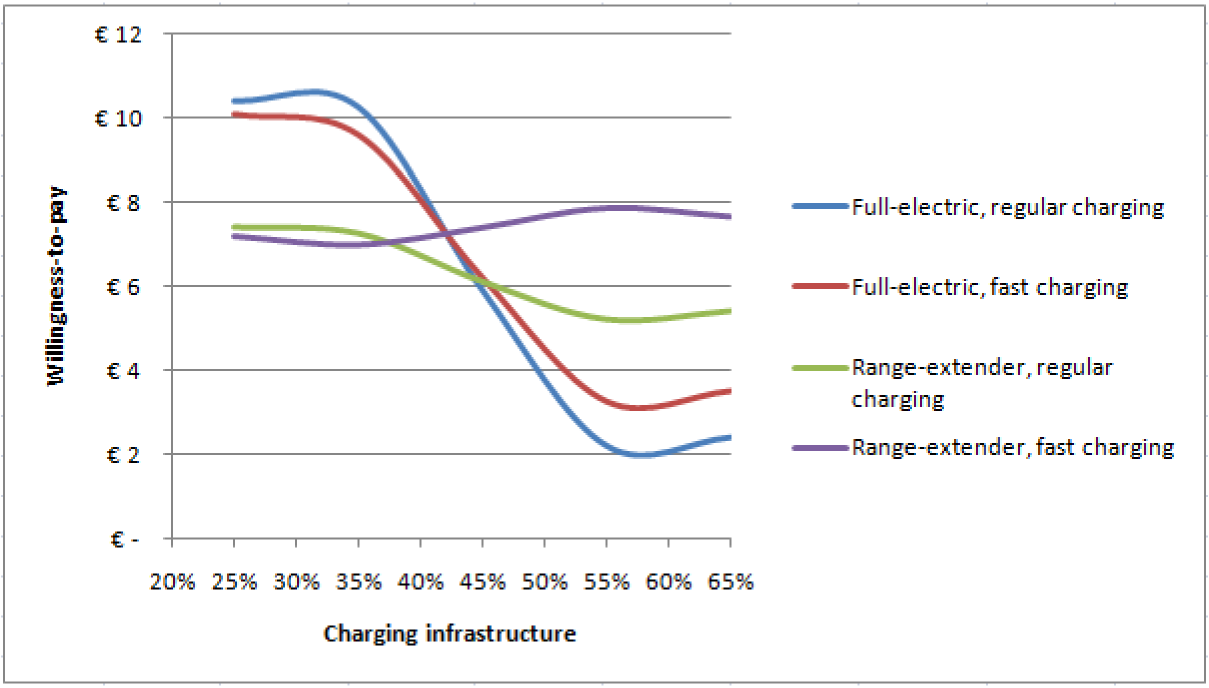


Figure 5 Willingness-to-pay for an increase in the charging infrastructure

A more apparent tendency is the decrease in the willingness-to-pay for full-electric vehicles when the level of the charging infrastructure increases. This is as expected, since lease drivers do not consider a public charging network very important, which diminishes even further when there already exists some basic infrastructure. On the other hand, lease drivers who prefer a range-extender do not have a steep fall in their willingness-to-pay for the charging infrastructure, but it remains fairly stable. This can be explained by the fact that these people often drive more kilometres and are more dependent on a public charging network. It shows that the current option of gaining access to a network of fast-chargers for €10 might be a viable option for lease-riders who prefer to drive a range-extender.

It should be noted that these outcomes are only valid for lease drivers. It is possible that for consumers it is still important to have a full-coverage public network of chargers. This would imply that grid operators are still needed to invest in a charging network to establish a more extensive rollout of electric vehicles in the Netherlands.

CO_2 reduction

Finally, the effect of an increase in a vehicle's CO_2 reduction amongst lease drivers is studied. Their willingness-to-pay for a CO_2 reduction is analysed based on changes in all other attributes. Figure 6 shows four scenarios in which a vehicle's CO_2 reduction is considered. The graphs depict an increase of ten percentage points in an electric vehicle's CO_2 reduction.

A quick glance shows that a lease driver's willingness-to-pay varies between €3 and €17, which is rather low. In all graphs the WTP decreases rapidly when an EV's CO_2 reduction improves. This big fall and relatively low willingness-to-pay might have implications for companies that are willing to invest in methods to generate electricity from renewable resources to achieve a 100% CO_2 reduction. It shows that lease drivers are not eager to contribute to such investments. Rather, it must be a profitable investment for companies to generate their own electricity, since lease drivers that are willing to adopt an electric vehicle are not prepared to pay a substantial amount for such investments.

Also, the willingness-to-pay is higher for lease drivers who prefer a full-electric vehicle rather than a range-extender. This might be explained by the difference in driving range between these two vehicles. Some respondents who consider the driving range less important consider a vehicle's CO_2 reduction more important (table 8). This might be reflected in their willingness-to-pay for a CO_2 reduction.

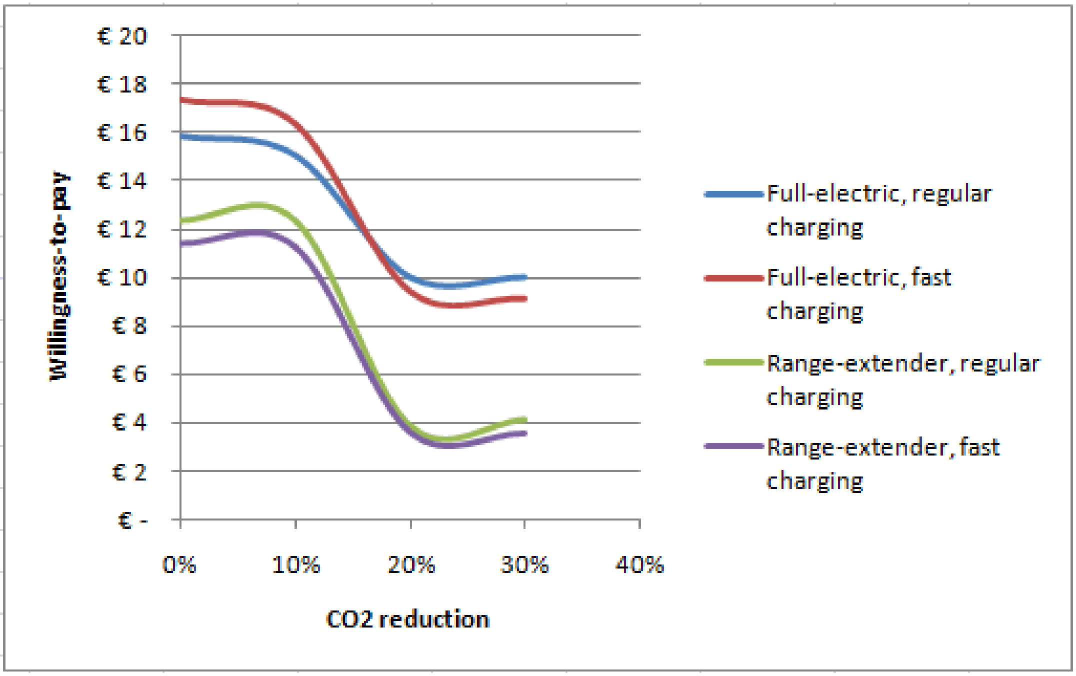


Figure 6 Willingness-to-pay for an increase in an EV's CO_2 reduction

So overall, this chapter has shown that the monthly net costs and a vehicle's driving range are considered the most important aspects in a lease driver's decision whether he opts for an electric vehicle. On the other hand, the rollout of a charging infrastructure is not considered important. This might be the case because lease drivers will have a charger at home and at work which makes them less depending on a public charging infrastructure. They can leave with a fully-charged EV in the morning and can charge at work for several hours which ensures that they will not often have to charge at the side of the road. Nevertheless, underestimation of respondents for the charging infrastructure cannot be fully excluded. A vehicle's CO_2 reduction is also not considered important, possibly indicating that promoting EVs amongst lease drivers based on CO_2 reduction will not lead to a substantial increase in demand. Rather, it might be better to stress that electric vehicles can compete in price with conventional vehicles due to various fiscal measures.

The variation in attribute importance is also demonstrated in estimating a demand curve for electric vehicles. For example, no significant changes are observed when the number of chargers increases or the CO_2 reduction improves. On the other hand, the demand curve shifts greatly rightwards when an electric vehicle's driving range increases, as shown in the different market shares for full-electric vehicles and range-extenders. Also, the demand curves show a steep increase in demand when electric vehicles are getting equally expensive as conventional vehicles. This might stress the importance of the current fiscal stimuli which ensure that the monthly net costs are comparable. It can also imply that the government can (partly) drop or remove these measures when electric vehicles become cheaper due to an increase in production; demand does not increase significantly when it becomes cheaper to lease an EV.

Further, the importances are also translated into a willingness-to-pay for the attributes. First, the WTP for extending the driving range is quite high (€48 for adding 50 km) when the driving range is rather small. However, this falls steeply to €18 when the driving range exceeds 300 km. This might indicate a threshold from lease drivers for the driving range. Since current available full-electric vehicles have a smaller driving range it shows that improvements are necessary and can be profitable since lease drivers have a high willingness-to-pay for this improvement. Cooperation between research centres automotive companies can be fruitful to achieve such developments. Second, the willingness-to-pay for improving the charging infrastructure and CO_2 reduction is rather low; for an improvement of ten percentage points the willingness-to-pay varies between €3 and €17. It shows that the main focus should be on extending the current driving range of full-electric vehicles.

5 Conclusions and recommendations

My master thesis has examined the potential of electric vehicles amongst lease drivers. Various studies found that consumers are not willing to adopt EVs due to a high buying price, a limited driving range, a longer charging time and the lack of a charging infrastructure. Consequently, the Dutch government is focusing on segments that can circumvent (some of) these obstacles and are therefore already considered suitable to acquire an electric vehicle. With the help of these segments consumers' obstacles can be addressed to successfully implement electric vehicles on a larger scale. One of these suitable groups is lease drivers and companies, which was the focus of this thesis. A few important results came forward.

First, the government's vision to focus on lease drivers and companies seems appropriate. Companies might be willing to provide electric vehicles to their employees, since EVs can be equally expensive to lease as comparable conventional vehicles, while they can be a useful addition to a company's corporate social responsibility. Also lease drivers seem interested in electric vehicles. The demand curves and the various market simulations indicate a substantial market share of almost 39% for electric vehicles amongst lease drivers. Approximately 31% falls to range-extenders, while 8% goes to full-electric vehicles. Although this is a substantial market share, it might be lower in reality given that you cannot include all attributes in a choice-based conjoint analysis. For example, a vehicle's design and brand is not included which can hamper the adoption of EVs in reality. It should also be noted that it will take approximately four years before such high market shares can be reached, given that current contracts need to expire before lease drivers have the opportunity to adopt an electric vehicle.

Second, there might also be differences amongst lease drivers which type of electric vehicle someone prefers. It might be important that (lease) companies offer electric vehicles that fit the mobility patterns of a lease driver, meaning that it should focus on someone's home-to-work distance and the annual amount of driven kilometres; someone who drives more kilometres has a stronger preference for range-extenders than full-electric vehicles. Many differences between subgroups were also correlated with differences in the annual amount of driven kilometres and the home-to-work distance. Unfortunately it is not possible to control for this and check whether the differences remain when it is controlled for other characteristics. This is a limitation of the model that has been used. However, many differences between groups also included differences in mobility which might indicate that this is an aspect lease companies can focus on.

Third, chapter four also showed that the driving range and the monthly net costs are the most important aspects amongst lease drivers when they are considering adopting an EV. It indicates that range anxiety and the monthly lease price can be a barrier for the penetration of electric vehicles. An electric vehicle's CO_2 reduction and charging infrastructure are not considered important. The latter might provide evidence that lease drivers can circumvent problems with the lack of a public charging network since they have the opportunity to charge their electric vehicle at home and at work. However, it might be that respondents found it difficult to estimate the importance of a charging network; this cannot be fully excluded. The low importance of the CO_2 reduction might show that targeting lease drivers should not be based on the environmental aspect of EVs. Possibly it could be better to target them by stressing the financial benefits for lease drivers.

Further, the demand curve for electric vehicles showed a strong increase in demand when an EV is getting equally expensive compared to a conventional vehicle. This is currently the case due to various fiscal stimuli that are provided by the government, like the exemption from fiscal addition and the MIA. It might indicate that it is important to keep these measures in place if the government wants to introduce EVs successfully amongst lease drivers. The demand curve also shows no substantial increase in demand when EVs become cheaper than conventional vehicles, implying that such fiscal stimuli can be (partly) abolished when the buying price (and hence the monthly lease price) drops because of an increase in production.

Also, of particular note is the high willingness-to-pay to improve the current driving range of full-electric vehicles. Lease drivers are willing to pay approximately €48 per month for adding 50 kilometres to the current range of 150 km. This amount suddenly decreases rapidly to €18 when it reaches 300 km, indicating that this is a threshold and a preferred driving range by lease drivers. It implies that developing new battery technologies to improve the driving range would accelerate the penetration of full-electric vehicles. The high WTP also indicates that it might be profitable for automotive companies to invest in these new technologies since they can transfer a big part of these investment costs in the lease price, while demand for these improved EVs increases. Improving the driving range of range-extenders is not likely to be necessary and profitable because of the low WTP; only €18 for an increase of 50 km to the current driving range of 450 km.

For the other examined attributes (charging time, charging infrastructure and CO_2 reduction) the lease driver's willingness-to-pay is considerably lower and varies between €3 and €15. This shows that the driving range is the most important attribute that needs improvement and should be the main focus of automotive companies, research centres and other parties.

For further research it might be instructive to examine the possibilities of introducing electric pool-vehicles at companies. Pool-vehicles have been introduced at various companies in previous years, mainly because companies want to offer better mobility possibilities to their employees. Some recent pilots showed the suitableness of electric pool-vehicles, since these vehicles are often used for shorter drives. Investigating the appropriateness of electric pool-vehicles might be interesting and might give information whether it is also useful to focus on this segment within companies. It might also be informative to do further, similar research on other suitable segments, like taxis or smaller busses. Such analysis might disclose preferences or obstacles which can provide useful information for successfully targeting these segments as well. In this way a successful introduction of electric vehicles might be possible in the Netherlands.

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Appendices

Appendix 1 Effects of fiscal addition

The tables below show how much a lease driver can save on the fiscal addition if he adopts an electric vehicle with a 0% fiscal addition. It shows four tables, based on different vehicle's values. Within each table there is a separation between the current fiscal addition categories (14%, 20% and 25% respectively). It also shows the differences for each income bracket.

Vehicle's value	€ 20,000		
	14% addition	20% addition	25% addition
	€ 2,800.00	€ 4,000.00	€ 5,000.00
Savings on taxation			
Per year			
Bracket 1	€ 924.00	€ 1,320.00	€ 1,650.00
Bracket 2	€ 1,174.60	€ 1,678.00	€ 2,097.50
Bracket 3	€ 1,176.00	€ 1,680.00	€ 2,100.00
Bracket 4	€ 1,456.00	€ 2,080.00	€ 2,600.00
Per month			
Bracket 1	€ 77.00	€ 110.00	€ 137.50
Bracket 2	€ 97.88	€ 139.83	€ 174.79
Bracket 3	€ 98.00	€ 140.00	€ 175.00
Bracket 4	€ 121.33	€ 173.33	€ 216.67

Taxation Income Brackets	
Bracket 1: < €18,628	33%
Bracket 2: €18,628 - €33,436	41.95%
Bracket 3: €33,436 - €55,694	42%
Bracket 4: > €55,694	52%

Vehicle's value	€ 30,000		
	14% addition	20% addition	25% addition
	€ 4,200.00	€ 6,000.00	€ 7,500.00
Savings on taxation			
Per year			
Bracket 1	€ 1,386.00	€ 1,980.00	€ 2,475.00
Bracket 2	€ 1,761.90	€ 2,517.00	€ 3,146.25
Bracket 3	€ 1,764.00	€ 2,520.00	€ 3,150.00
Bracket 4	€ 2,184.00	€ 3,120.00	€ 3,900.00
Per month			
Bracket 1	€ 115.50	€ 165.00	€ 206.25
Bracket 2	€ 146.83	€ 209.75	€ 262.19
Bracket 3	€ 147.00	€ 210.00	€ 262.50
Bracket 4	€ 182.00	€ 260.00	€ 325.00

Vehicle's value	**€ 40,000**		
	14% addition	**20% addition**	**25% addition**
	€ 5,600.00	€ 8,000.00	€ 10,000.00
Savings on taxation			
Per year			
Bracket 1	€ 1,848.00	€ 2,640.00	€ 3,300.00
Bracket 2	€ 2,349.20	€ 3,356.00	€ 4,195.00
Bracket 3	€ 2,352.00	€ 3,360.00	€ 4,200.00
Bracket 4	€ 2,912.00	€ 4,160.00	€ 5,200.00
Per month			
Bracket 1	€ 154.00	€ 220.00	€ 275.00
Bracket 2	€ 195.77	€ 279.67	€ 349.58
Bracket 3	€ 196.00	€ 280.00	€ 350.00
Bracket 4	€ 242.67	€ 346.67	€ 433.33

Vehicle's value	**€ 50,000**		
	14% addition	**20% addition**	**25% addition**
	€ 7,000.00	€ 10,000.00	€ 12,500.00
Savings on taxation			
Per year			
Bracket 1	€ 2,310.00	€ 3,300.00	€ 4,125.00
Bracket 2	€ 2,936.50	€ 4,195.00	€ 5,243.75
Bracket 3	€ 2,940.00	€ 4,200.00	€ 5,250.00
Bracket 4	€ 3,640.00	€ 5,200.00	€ 6,500.00
Per month			
Bracket 1	€ 192.50	€ 275.00	€ 343.75
Bracket 2	€ 244.71	€ 349.58	€ 436.98
Bracket 3	€ 245.00	€ 350.00	€ 437.50
Bracket 4	€ 303.33	€ 433.33	€ 541.67

Appendix 2 Nissan Leaf vs. Volkswagen Golf

CASUS: LEASE

Nissan LEAF: VW 1.2 TSI BlueMotion Technology 77 kW H6		
Full Operational Lease 25.000 km, 4 jaar	LEAF	GOLF
Aanschaf		
Aanschafwaarde inclusief btw	34.990	22.680
Aanschafwaarde ex btw	29.403	19.059
Afleverkosten + opties	1.500	1.500
Totale aanschafwaarde ex btw	30.903	20.559
Subsidies		
Mia (36%)*	2.781	-
Mia desinvesteringsbijtelling	-715	-
Vamil (75%)	371	-
Totale aanschafwaarde na subsidies	28.466	20.559
Diensten (per maand)		
Vervangend vervoer	9	9
Verzekering	98	75
Reparatie en onderhoud	30	30
Banden	20	20
Hulpdiensten	3	3
Wegenbelasting	-	38
Admin / fee	16	16
Kosten Totaal Diensten	176	191
Financiële kosten (per maand)		
Restwaarde	7.939	11.814
Aflossing	428	182
Rente %	5,50%	5,50%
Rente	83	74
Totaal Aflossing + Rente	511	256
Energiekosten		
Elektriciteit/benzine**	41	159
Totaal elektriciteit/benzine	41	159
Totaal kosten per maand	728	606
Bijtelling***	-	159
Totaal kosten per maand incl. bijtelling	728	765

*€30,903 * 36% / 4 year = €2,781 per year
**based on €0.22 per kWh, 0.15 kWh per km
based on €1.75 per litre and 5.2l per 100 km
***based on 20% fiscal addition and taxation of 42%. If you have a taxation of 52% the addition changes to €193 which leads to monthly total costs of €799

Appendix 3 Preview survey question

The picture below is an example of the survey questions that have been asked. It shows the different attributes (monthly net costs, driving range, charging time, charging infrastructure and CO_2 reduction). The first three columns are different electric vehicles a respondent can choose, whereas the last column is the outside-option; a comparable gasoline vehicle. The monthly net costs already include the effects of exemption from the fiscal addition. The charging infrastructure is defined as a percentage of the number of public chargers compared to the current number of gasoline stations. It is assumed that lease drivers will get a charger at their house and at their work, which do not belong to the public charging network.

Als dit uw opties zijn, welke auto zou u dan kiezen?

Kies uit één van onderstaande mogelijkheden

Netto maandelijkse kosten*	€200 duurder	€100 goedkoper	Even duur	Geen van deze elektrische auto's: ik kies voor een vergelijkbare benzineauto van dezelfde kwaliteit.
Actieradius	600 km	300 km	450 km	
Oplaadtijd	15 minuten	6 uur	30 minuten	
Oplaadmogelijkheden**	75%	25%	50%	
CO2 vermindering	0%	20%	40%	

*De netto maandelijkse kosten wordt vergeleken met de netto maandelijkse kosten van de benzineauto. In dit bedrag zijn fiscale voordelen zoals een lagere bijtelling al opgenomen.

**De oplaadmogelijkheden zijn het aantal publieke oplaadpunten ten opzichte van de huidige hoeveelheid tankstations. Hierbij zijn oplaadpunten bij u thuis en op uw werk niet inbegrepen. Deze krijgt u standaard bij aanschaf van een elektrische auto.

Appendix 4 Interaction effects

The columns below show the significance of the different attributes and show that there are no interaction effects present, except between monthly net costs and CO_2 reduction. The number behind the attribute levels are percentages. For example, 'even duur' in the first column was chosen 23% of the times that is was presented and available for choice. At the bottom of each attribute the significance is presented, as well as the degrees of freedom.

The attribute's significance levels

Monthly net costs

	Total
Total Respondents	751
â‚¬200 duurder	0.07
â‚¬100 duurder	0.13
Even duur	0.23
â‚¬100 goedkoper	0.28
â‚¬200 goedkoper	0.33
Within Att. Chi-Square	1244.58
D.F.	4
Significance	p < .01

Driving range

	Total
Total Respondents	751
150 km	0.06
300 km	0.17
450 km	0.25
600 km	0.35
Within Att. Chi-Square	1440.26
D.F.	3
Significance	p < .01

Charging time

	Total
Total Respondents	751
15 minuten	0.29
30 minuten	0.25
4 uur	0.16
6 uur	0.13
Within Att. Chi-Square	565.01
D.F.	3
Significance	p < .01

Charging infrastructure

	Total
Total Respondents	751
25%	0.18
50%	0.21
75%	0.23
Within Att. Chi-Square	56.42
D.F.	2
Significance	p < .01

CO2 reduction

	Total
Total Respondents	751
0%	0.17
20%	0.21
40%	0.24
Within Att. Chi-Square	104.68
D.F.	2
Significance	p < .01

Interaction effects amongst the attributes

Monthly net costs x Driving range

		Total
Total Respondents		751
â,¬200 duurder	150 km	0.03
â,¬200 duurder	300 km	0.04
â,¬200 duurder	450 km	0.08
â,¬200 duurder	600 km	0.12
â,¬100 duurder	150 km	0.03
â,¬100 duurder	300 km	0.09
â,¬100 duurder	450 km	0.15
â,¬100 duurder	600 km	0.22
Even duur	150 km	0.08
Even duur	300 km	0.19
Even duur	450 km	0.27
Even duur	600 km	0.39
â,¬100 goedkoper	150 km	0.08
â,¬100 goedkoper	300 km	0.24
â,¬100 goedkoper	450 km	0.34
â,¬100 goedkoper	600 km	0.48
â,¬200 goedkoper	150 km	0.10
â,¬200 goedkoper	300 km	0.28
â,¬200 goedkoper	450 km	0.42
â,¬200 goedkoper	600 km	0.53
Interaction Chi-Square		16,36
D.F.		12
Significance		not sig

Monthly net costs x Charging time

		Total
Total Respondents		751
â,¬200 duurder	15 minuten	0.10
â,¬200 duurder	30 minuten	0.10
â,¬200 duurder	4 uur	0.04
â,¬200 duurder	6 uur	0.04
â,¬100 duurder	15 minuten	0.19
â,¬100 duurder	30 minuten	0.15
â,¬100 duurder	4 uur	0.08
â,¬100 duurder	6 uur	0.07
Even duur	15 minuten	0.33
Even duur	30 minuten	0.28
Even duur	4 uur	0.19
Even duur	6 uur	0.14
â,¬100 goedkoper	15 minuten	0.38
â,¬100 goedkoper	30 minuten	0.35
â,¬100 goedkoper	4 uur	0.22
â,¬100 goedkoper	6 uur	0.17
â,¬200 goedkoper	15 minuten	0.45
â,¬200 goedkoper	30 minuten	0.39
â,¬200 goedkoper	4 uur	0.28
â,¬200 goedkoper	6 uur	0.21
Interaction Chi-Square		16,17
D.F.		12
Significance		not sig

Monthly net costs x Charging infrastructure

		Total
Total Respondents		751
â,¬200 duurder	25%	0.05
â,¬200 duurder	50%	0.07
â,¬200 duurder	75%	0.08
â,¬100 duurder	25%	0.11
â,¬100 duurder	50%	0.12
â,¬100 duurder	75%	0.14
Even duur	25%	0.21
Even duur	50%	0.25
Even duur	75%	0.24
â,¬100 goedkoper	25%	0.25
â,¬100 goedkoper	50%	0.28
â,¬100 goedkoper	75%	0.32
â,¬200 goedkoper	25%	0.29
â,¬200 goedkoper	50%	0.34
â,¬200 goedkoper	75%	0.37
Interaction Chi-Square		9,28
D.F.		8
Significance		not sig

Monthly net costs x CO2 reduction

		Total
Total Respondents		751
â,¬200 duurder	0%	0.05
â,¬200 duurder	20%	0.06
â,¬200 duurder	40%	0.09
â,¬100 duurder	0%	0.11
â,¬100 duurder	20%	0.13
â,¬100 duurder	40%	0.14
Even duur	0%	0.17
Even duur	20%	0.24
Even duur	40%	0.29
â,¬100 goedkoper	0%	0.24
â,¬100 goedkoper	20%	0.30
â,¬100 goedkoper	40%	0.32
â,¬200 goedkoper	0%	0.29
â,¬200 goedkoper	20%	0.32
â,¬200 goedkoper	40%	0.38
Interaction Chi-Square		16,20
D.F.		8
Significance		p < .05

Driving range x Charging time

		Total
Total Respondents		751
150 km	15 minuten	0.09
150 km	30 minuten	0.08
150 km	4 uur	0.05
150 km	6 uur	0.04
300 km	15 minuten	0.25
300 km	30 minuten	0.20
300 km	4 uur	0.12
300 km	6 uur	0.11
450 km	15 minuten	0.36
450 km	30 minuten	0.31
450 km	4 uur	0.19
450 km	6 uur	0.14
600 km	15 minuten	0.47
600 km	30 minuten	0.43
600 km	4 uur	0.29
600 km	6 uur	0.22

Interaction Chi-Square	8,59
D.F.	9
Significance	not sig

Driving range x Charging infrastructure

		Total
Total Respondents		751
150 km	25%	0.05
150 km	50%	0.06
150 km	75%	0.08
300 km	25%	0.14
300 km	50%	0.17
300 km	75%	0.19
450 km	25%	0.22
450 km	50%	0.26
450 km	75%	0.28
600 km	25%	0.32
600 km	50%	0.36
600 km	75%	0.37

Interaction Chi-Square	7.16
D.F.	6
Significance	not sig

Driving range x CO2 reduction

		Total
Total Respondents		751
150 km	0%	0.05
150 km	20%	0.06
150 km	40%	0.08
300 km	0%	0.13
300 km	20%	0.17
300 km	40%	0.20
450 km	0%	0.20
450 km	20%	0.26
450 km	40%	0.30
600 km	0%	0.30
600 km	20%	0.36
600 km	40%	0.39

Interaction Chi-Square	5,62
D.F.	6
Significance	not sig

Charging time x Charging infrastructure

		Total
Total Respondents		751
15 minuten	25%	0.26
15 minuten	50%	0.29
15 minuten	75%	0.32
30 minuten	25%	0.22
30 minuten	50%	0.27
30 minuten	75%	0.28
4 uur	25%	0.14
4 uur	50%	0.15
4 uur	75%	0.20
6 uur	25%	0.11
6 uur	50%	0.14
6 uur	75%	0.13

Interaction Chi-Square	9,88
D.F.	6
Significance	not sig

Charging time x CO2 reduction

		Total
Total Respondents		751
15 minuten	0%	0.24
15 minuten	20%	0.30
15 minuten	40%	0.33
30 minuten	0%	0.22
30 minuten	20%	0.25
30 minuten	40%	0.29
4 uur	0%	0.13
4 uur	20%	0.16
4 uur	40%	0.20
6 uur	0%	0.11
6 uur	20%	0.13
6 uur	40%	0.15
Interaction Chi-Square		3,53
D.F.		6
Significance		not sig

Charging infrastructure x CO2 reduction

		Total
Total Respondents		751
25%	0%	0,15
25%	20%	0,18
25%	40%	0,21
50%	0%	0,17
50%	20%	0,22
50%	40%	0,25
75%	0%	0,20
75%	20%	0,24
75%	40%	0,26
Interaction Chi-Square		4,90
D.F.		4
Significance		not sig

Appendix 5 Adding interaction effects to the model

Adding an interaction effect between monthly net costs and CO_2 reduction increases the Chi Square to 5,221.93 whereas it decreases the degrees of freedom by 8. This leads to an increase of 12.97 (5,221.93-5,208.96) in the Chi Square. However, an increase of more than 12.97 is necessary for a 10% significance in the log-likelihood test. Therefore it is not suggested to add the interaction effect to the model.

		Effect	Standard error	T-ratio
Monthly net costs	€200 more expensive	-1.20	0.05	-25.36
	€100 more expensive	-0.51	0.04	-13.67
	Equally expensive	0.29	0.03	9.03
	€100 cheaper	0.58	0.03	19.03
	€200 cheaper	0.85	0.03	28.35
Driving range	150 km	-1.23	0.04	-30.50
	300 km	-0.11	0.03	-3.81
	450 km	0.43	0.03	15.75
	600 km	0.91	0.03	34.92
Charging time	15 min	0.55	0.03	20.90
	30 min	0.34	0.03	12.94
	4 hours	-0.30	0.03	-10.15
	6 hours	-0.59	0.03	-18.68
Charging infrastructure	25%	-0.20	0.02	-8.58
	50%	0.04	0.02	1.84
	75%	0.16	0.02	7.18
CO2 reduction	0%	-0.22	0.03	-8.64
	20%	0.01	0.02	0.35
	40%	0.21	0.02	9.02
Monthly Net cost x CO2 reduction	€200 more expensive by 0%	0.02	0.07	0.29
	€200 more expensive by 20%	-0.09	0.07	-1.29
	€200 more expensive by 40%	0.07	0.06	1.07
	€100 more expensive by 0%	0.08	0.06	1.33
	€100 more expensive by 20%	0.01	0.05	0.16
	€100 more expensive by 40%	-0.08	0.05	-1.57
	Equally expensive by 0%	-0.13	0.05	-2.73
	Equally expensive by 20%	0.08	0.05	1.68
	Equally expensive by 40%	0.06	0.05	1.22
	€100 cheaper by 0%	0.01	0.05	0.12
	€100 cheaper by 20%	0.05	0.05	1.16
	€100 cheaper by 40%	-0.06	0.04	-1.31
	€200 cheaper by 0%	0.03	0.05	0.73
	€200 cheaper by 20%	-0.05	0.04	-1.16
	€200 cheaper by 40%	0.02	0.04	0.42
None		1.01	0.03	38.69
Chi-square	5,221.93			
Sample size	751			

Appendix 6 Attributes importance

The table below shows the importance of each attribute for the complete sample and all subgroups in their decision for which vehicle to opt. How important each attribute is, is represented by the percentages. The percentages are ratio data, meaning that an attribute with an importance of 30% is three times as important as an attribute with an importance of 10%.

		# of respondents	Monthly net costs	Driving range	Charging time	Charging infrastructure	CO2 reduction
Complete sample		751	32.41%	36.16%	18.29%	6.39%	6.75%
Gender	Male	637	32.16%	36.74%	18.36%	6.24%	6.50%
	Female	114	33.83%	32.88%	17.90%	7.23%	8.16%
Age	<30	104	32.05%	34.69%	19.31%	6.74%	7.21%
	30-40	236	33.63%	35.74%	17.23%	6.33%	7.07%
	40-50	255	31.49%	36.51%	18.97%	6.42%	6.60%
	≥50	156	32.31%	37.20%	18.08%	6.21%	6.20%
Education	VMBO/MBO	215	31.83%	36.74%	18.49%	6.40%	6.53%
	HAVO/VWO/HBO	368	32.74%	35.93%	18.12%	6.26%	6.94%
	WO	163	32.53%	35.71%	18.45%	6.57%	6.73%
Region	East	104	34.19%	35.04%	16.93%	6.83%	7.01%
	North	59	31.01%	37.34%	18.29%	6.37%	6.99%
	South	148	32.05%	36.45%	18.51%	6.21%	6.78%
	West	440	32.31%	36.17%	18.53%	6.35%	6.65%
Contract duration	<1 year	251	31.93%	36.64%	18.12%	6.36%	6.95%
	1-3 years	272	31.35%	37.63%	18.48%	6.33%	6.21%
	≥3 years	127	34.87%	35.07%	18.43%	6.20%	5.44%
Income	<€40,000	127	33.04%	34.60%	18.67%	6.46%	7.23%
	€40,000-€60,000	182	31.78%	36.60%	18.75%	6.20%	6.66%
	€60,000-€80,000	162	32.42%	36.10%	18.29%	6.52%	6.66%
	≥€80,000	151	31.78%	37.44%	18.04%	6.39%	6.35%
Yearly amount of km	<20,000 km	141	36.33%	31.02%	17.53%	6.97%	8.15%
	20,000-30,000 km	225	33.14%	34.05%	19.17%	6.81%	6.84%
	30,000-40,000 km	173	31.35%	38.18%	18.22%	5.90%	6.34%
	≥40,000km	212	29.90%	40.17%	17.91%	5.96%	6.06%
Home-to-work distance (singe trip)	<25 km	227	33.27%	35.26%	18.55%	6.57%	6.35%
	25-50 km	222	32.34%	35.00%	18.76%	6.73%	7.16%
	50-75 km	126	32.78%	36.57%	17.87%	6.00%	6.77%
	≥75 km	176	31.14%	38.48%	17.65%	6.01%	6.73%
Type of vehicle	Gasoline	329	32.63%	35.23%	18.49%	6.55%	7.10%
	Diesel/LPG	360	32.01%	37.17%	18.17%	6.32%	6.33%
	Hybrids	62	33.63%	35.23%	17.90%	5.98%	7.27%
Fiscal addition	Yes	592	32.39%	36.60%	18.38%	6.36%	6.27%
	No	102	31.70%	36.81%	18.09%	6.06%	7.35%
Public transport	Never	593	32.28%	37.21%	18.01%	6.17%	6.33%
	< once per week	108	32.18%	33.95%	19.47%	7.17%	7.23%
	≥ once per week	50	34.48%	28.43%	19.07%	7.30%	10.72%

Appendix 7 Market simulations for subgroups

The table below shows the market simulation for a full-electric vehicle and a range-extender. It provides the market shares if these two types of electric vehicles are introduced amongst lease drivers. The table also presents the results for all subgroups.

		# of respondents	Full-electric vehicle	Range-extender	None
Complete sample		751	7.92%	30.88%	61.20%
Gender	Male	637	7.37%	30.34%	62.29%
	Female	114	10.95%	33.92%	55.13%
Age	<30	104	8.55%	27.07%	64.39%
	30-40	236	9.70%	29.35%	60.95%
	40-50	255	6.97%	35.04%	57.99%
	≥50	156	6.34%	28.93%	64.73%
Education	VMBO/MBO	215	9.39%	36.61%	54.00%
	HAVO/VWO/HBO	368	7.99%	29.92%	62.10%
	WO	163	6.05%	26.44%	67.51%
Region	East	104	7.56%	34.16%	58.28%
	North	59	5.17%	41.19%	53.65%
	South	148	8.88%	34.35%	56.76%
	West	440	8.04%	27.56%	64.40%
Contract duration	<1 year	251	8.55%	31.33%	60.11%
	1-3 years	272	5.12%	27.58%	67.30%
	≥3 years	127	8.84%	27.97%	63.19%
Income	<€40,000	127	10.14%	38.44%	51.42%
	€40,000-€60,000	182	8.64%	27.81%	63.55%
	€60,000-€80,000	162	6.39%	33.86%	59.75%
	≥€80,000	151	6.40%	32.20%	61.40%
Yearly amount of km	<20,000 km	141	16.08%	36.51%	47.41%
	20,000-30,000 km	225	7.47%	29.50%	63.03%
	30,000-40,000 km	173	5.81%	29.84%	64.35%
	≥40,000km	212	4.68%	29.45%	65.88%
Home-to-work distance (single trip)	<25 km	227	8.44%	30.63%	60.93%
	25-50 km	222	8.19%	31.17%	60.64%
	50-75 km	126	6.01%	30.91%	63.08%
	≥75 km	176	8.26%	30.82%	60.92%
Type of vehicle	Gasoline	329	8.53%	31.64%	59.83%
	Diesel/LPG	360	7.35%	29.30%	63.35%
	Hybrid	62	7.96%	36.00%	56.04%
Fiscal addition	Yes	592	6.48%	28.58%	64.93%
	No	102	11.58%	37.70%	50.72%
Public transport	Never	593	6.20%	29.11%	64.69%
	< once per week	108	12.19%	37.50%	50.31%
	≥ once per week	50	19.06%	37.58%	43.36%

Appendix 8 Willingness-to-pay simulations

The following tables show the willingness-to-pay for improving the five attributes that were included in the survey. The WTP is analysed based on differences in the other attributes to check whether this leads to a different willingness-to-pay.

Driving range

The willingness-to-pay for the driving range is examined for an improvement of 50 km to the listed driving range in the column on the left-hand side. It is examined for changes in the driving range, varying from a base level of 150 km to 500 km. It is also checked whether the WTP changes if the other attribute levels change, as indicated by the headers in the columns.

		Charging time 30min		Charging time 4h		Charging time 6h	
		25% infrastructure	50% infrastructure	25% infrastructure	50% infrastructure	25% infrastructure	50% infrastructure
Driving range	150 km	€ 54.60	€ 51.25	€ 51.75	€ 52.25	€ 46.50	€ 49.00
	200 km	€ 48.25	€ 47.75	€ 55.25	€ 53.50	€ 51.30	€ 51.75
	250 km	€ 46.25	€ 46.20	€ 50.10	€ 48.70	€ 51.50	€ 50.40
	300 km	€ 17.60	€ 18.40	€ 16.40	€ 17.00	€ 18.00	€ 17.80
	350 km	€ 18.60	€ 19.50	€ 16.35	€ 17.20	€ 16.90	€ 17.05
	400 km	€ 19.50	€ 20.25	€ 17.10	€ 18.05	€ 16.80	€ 17.10
	450 km	€ 17.40	€ 18.70	€ 13.50	€ 14.75	€ 11.55	€ 12.40
	500 km	€ 18.55	€ 18.95	€ 16.60	€ 17.60	€ 14.17	€ 15.10

Charging time

The willingness-to-pay for the charging time is examined for regular charging as well as fast charging. For regular charging it is estimated for an improvement of 30 minutes. An improvement of 5 minutes is assumed for fast charging. There are again checks performed for changes in the other attributes.

		150km				450km			
		25% infr.		50% infr.		25% infr.		50% infr.	
		20% co2	40% co2	20% co2	40% co2	20% co2	40% co2	20% co2	40% co2
Regular charging	6 hours	€ 9.50	€ 9.80	€ 9.60	€ 9.90	€ 7.90	€ 8.00	€ 7.90	€ 7.90
	5.5 hours	€ 9.90	€ 9.90	€ 9.60	€ 9.80	€ 8.00	€ 8.10	€ 8.00	€ 8.10
	5 hours	€ 10.00	€ 10.00	€ 9.40	€ 9.80	€ 8.10	€ 8.20	€ 8.10	€ 8.20
	4.5 hours	€ 9.80	€ 10.00	€ 9.20	€ 9.70	€ 8.20	€ 8.35	€ 8.10	€ 8.35
	4 hours	€ 8.70	€ 9.00	€ 8.60	€ 8.90	€ 7.70	€ 8.15	€ 8.50	€ 9.00
	3.5 hours	€ 8.70	€ 9.00	€ 8.70	€ 9.00	€ 8.20	€ 8.70	€ 9.00	€ 9.50
	3 hours	€ 8.90	€ 9.10	€ 8.90	€ 9.20	€ 8.70	€ 9.25	€ 9.45	€ 9.85
	2.5 hours	€ 9.10	€ 9.40	€ 9.30	€ 9.40	€ 9.15	€ 9.55	€ 9.80	€ 10.15
	2 hours	€ 9.40	€ 9.60	€ 9.50	€ 9.60	€ 9.45	€ 9.70	€ 10.00	€ 10.30
Fast charging	30 minutes	€ 3.30	€ 3.70	€ 3.60	€ 3.80	€ 6.30	€ 6.60	€ 6.90	€ 7.20
	25 minutes	€ 3.50	€ 3.80	€ 3.70	€ 3.80	€ 6.60	€ 6.80	€ 7.10	€ 7.30
	20 minutes	€ 3.80	€ 4.00	€ 3.90	€ 3.90	€ 6.55	€ 6.80	€ 7.05	€ 7.25

Charging infrastructure

The willingness-to-pay for improving the charging infrastructure is examined for an increase of ten percentage points. It is examined for five base levels of the charging infrastructure. The WTP is also checked for changes in the other attribute levels. The first column shows different WTP-scenarios for the driving range, the second column for charging time, while the third column shows two different cases for CO_2 reduction.

			Charging infrastructure				
			25% to 35%	35% to 45%	45% to 55%	55% to 65%	65% to 75%
150 km	**30min**	**20% co2**	€ 10.30	€ 9.80	€ 6.20	€ 3.10	€ 3.25
		40% co2	€ 10.10	€ 9.60	€ 6.20	€ 3.25	€ 3.50
	6h	**20% co2**	€ 10.00	€ 10.20	€ 5.90	€ 1.70	€ 1.80
		40% co2	€ 10.40	€ 10.25	€ 5.90	€ 2.20	€ 2.40
300 km	**30min**	**20% co2**	€ 7.25	€ 7.25	€ 6.50	€ 6.20	€ 6.35
		40% co2	€ 7.25	€ 7.10	€ 6.75	€ 6.80	€ 6.70
	6h	**20% co2**	€ 8.70	€ 8.20	€ 5.70	€ 3.60	€ 3.70
		40% co2	€ 8.40	€ 8.00	€ 5.90	€ 4.30	€ 4.25
450 km	**30min**	**20% co2**	€ 7.10	€ 7.00	€ 7.20	€ 7.75	€ 7.70
		40% co2	€ 7.20	€ 7.00	€ 7.40	€ 7.85	€ 7.65
	6h	**20% co2**	€ 7.20	€ 7.05	€ 5.80	€ 4.80	€ 4.90
		40% co2	€ 7.40	€ 7.25	€ 6.10	€ 5.20	€ 5.40
600 km	**30min**	**20% co2**	€ 6.65	€ 6.30	€ 6.70	€ 7.45	€ 7.35
		40% co2	€ 6.60	€ 6.30	€ 6.80	€ 7.55	€ 7.30
	6h	**20% co2**	€ 6.80	€ 6.70	€ 6.05	€ 5.55	€ 5.55
		40% co2	€ 6.80	€ 6.70	€ 6.25	€ 5.85	€ 5.75

CO_2 reduction

The willingness-to-pay for a vehicle's CO_2 reduction is examined for an improvement of ten percentage points. In total there are four different scenarios examined for the CO_2 reduction. It is checked for changes in the driving range, charging time and the charging infrastructure as shown in the first, second and third column.

			CO2 reduction			
			0% to 10% reduction	10% to 20% reduction	20% to 30% reduction	30% to 40% reduction
150 km	**6h**	**25% infr.**	€ 15.85	€ 15.05	€ 10.00	€ 10.00
		50% infr.	€ 16.30	€ 15.75	€ 9.70	€ 9.70
	30min	**25% infr.**	€ 17.35	€ 16.35	€ 9.40	€ 9.10
		50% infr.	€ 17.50	€ 16.60	€ 8.30	€ 8.25
300 km	**6h**	**25% infr.**	€ 17.00	€ 15.65	€ 5.60	€ 5.70
		50% infr.	€ 16.20	€ 15.00	€ 5.10	€ 5.60
	30min	**25% infr.**	€ 12.45	€ 12.30	€ 4.10	€ 4.50
		50% infr.	€ 12.45	€ 12.35	€ 4.15	€ 4.50
450 km	**6h**	**25% infr.**	€ 13.65	€ 13.15	€ 4.15	€ 4.40
		50% infr.	€ 13.10	€ 12.90	€ 4.15	€ 4.50
	30min	**25% infr.**	€ 11.45	€ 11.30	€ 3.65	€ 3.60
		50% infr.	€ 11.55	€ 11.45	€ 3.65	€ 3.40
600 km	**6h**	**25% infr.**	€ 12.95	€ 12.60	€ 3.95	€ 3.90
		50% infr.	€ 12.90	€ 12.45	€ 3.90	€ 3.75
	30min	**25% infr.**	€ 11.15	€ 10.95	€ 2.80	€ 2.40
		50% infr.	€ 10.95	€ 10.65	€ 2.40	€ 2.05