ISCTE Business School
Instituto Universitário de Lisboa

CONSUMER' ACCEPTANCE OF ELECTRIC VEHICLES IN LISBON

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Dissertation submitted as partial requirement for the conferral of

Master in International Management

Supervisor:

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November 2018

ISCTE IUL
Instituto Universitário de Lisboa

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Abstract

The need for a cleaner environment with less pollution is noticeable. Car brands are anticipating this development and are launching more electric vehicles on the market. This has a positive effect on the market share of electric vehicles, also in Portugal. While there are more electric vehicles visible on the streets, it is unknown if they will completely replace the diesel and gasoline driven vehicles in the future. Many people still see a lot of disadvantages towards electric vehicles. To lower the barriers of buying electric vehicles, governments and organizations are trying to invest in better charging infrastructures and policy incentives. Still, it is not known if these investments will count for a full electric future. The acceptance and awareness of these new vehicles are two factors in this matter that cannot be ignored.

This research examines the level of acceptance of electric vehicles by consumers in Lisbon. In order to reach this, the consumer's awareness, perception and preferences towards electric vehicles have been studied. The charging infrastructure and policy incentives play a central role in this research. The research is supported by primary as well as secondary data but mainly depends on the primary data. This primary data collection is done by questionnaires that are answered by people living or working in Lisbon. The outcomes of these questionnaires in combination with the secondary data will provide a valuable perspective of the current situation and can potentially improve the environment of the electric vehicles and drivers in Lisbon.

Keywords: Electric Vehicles (EVs), consumers, acceptance, Lisbon

JEL Classification system:

- M19: Business Administration, Other
- O18: Urban, Rural, Regional and Transportation Analysis

Resumo

A necessidade de um ambiente mais limpo com menos poluição é notória. As marcas de automóveis estão a antecipar esse desenvolvimento e estão a lançar mais veículos elétricos no mercado. Isto tem um efeito positivo na quota de mercado dos veículos elétricos, também em Portugal. Embora existam mais veículos elétricos visíveis nas ruas, não se sabe se eles irão substituir completamente os veículos movidos a diesel e gasolina no futuro. Muitas pessoas ainda vêem muitas desvantagens em relação aos veículos elétricos. Para diminuir as barreiras de compra de veículos elétricos, governos e organizações tentam investir em melhores infra-estruturas e incentivos políticos. Ainda assim, não se sabe se esses investimentos contarão para um total futuro elétrico. A aceitação e consciência desses novos veículos são dois fatores que não podem ser ignorados.

Esta pesquisa examina o nível de aceitação do consumidor em relação aos veículos elétricos em Lisboa. Para isso, a consciência, a percepção e as preferências do consumidor em relação aos veículos elétricos têm sido estudadas. Os postos de carregamento e incentivos políticos, desempenham um papel central nesta pesquisa. A pesquisa é apoiada por dados primários e secundários, mas depende principalmente de dados primários. Esta recolha de dados primários é feita por questionários respondidos por pessoas que vivem ou trabalham em Lisboa. Os resultados destes questionários em combinação com os dados secundários apresentam uma perspetiva da situação atual, e podem melhorar potencialmente a situação dos veículos elétricos e condutores em Lisboa.

Palavras-chave: EVs, consumidores, aceitação, Lisboa

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1. Introduction

In the recent years, car brands are anticipating on the need for a cleaner environment with less pollution. In order to fulfill this need, many new electric vehicles (EVs) are launched on the market. While gasoline and diesel driven vehicles still dominate the roads worldwide, the market share of EVs is growing. On national and international level organizations and parties aim for agreements that will make the world much greener and liveable. The climate deal of Paris set an objective of limiting emissions per country and worldwide (UN, 2015). Also, urban areas like Lisbon are integrating ‘Low Emission Zones’ to ban dirty vehicle and make these areas less pollutant (Da Silva, 2014). EVs have to potential to solve these pollution problems and become part of a cleaner environment.

That EVs are helpful for reducing emissions is interesting, but the main part of the vehicles being used is not electric. Compared with gasoline and diesel driven vehicles, EVs are quite new on the market. It is possible that consumers are not well-known with these vehicles yet. To make EVs more attractive, governments, local authorities and organizations are implementing charging infrastructures to make the charging process easier and faster. Another element that can potentially make EVs more attractive are policy incentives. These incentives are integrated by the government to reduce the costs gap between ICE-driven vehicles and EVs. Still, it is not sure of the improvement of the charging infrastructure and implementing incentives will be enough for consumers to make their switch to EVs.

In this market research, it will be essential to examine on which level EVs are accepted by the consumers. This includes detecting the most important reasons for consumers to buy an EV. Also, the research tries to find the main barriers that make consumers stay away from buying them. To reach this, it is crucial to inquire the opinion of consumers that spend most of their time in Lisbon. After achieving this, it is possible to give an overview of the current EV situation in Lisbon.

1.1 Research question

This research will focus consumer' acceptance of EVs in Lisbon. It will try to measure the level of awareness, perception and preferences towards EVs, their infrastructure and policy incentives. To ensure this, the following main research question needs to be answered:

What is the level of acceptance by consumers that live or work in Lisbon towards EVs?

In order to support and fulfill the main research question, the next four sub-questions need to be answered:

a. What is the current status of the EV infrastructure in Lisbon?
b. Which main barriers keep people in Lisbon from buying an EV?
c. Which preferences do consumers have concerning EVs and their infrastructure?
d. What is the level of awareness towards EVs?

1.2 Thesis structure

This research is divided into seven chapters, as mentioned in the figure below. The first chapter introduces the research topic and the research questions. Chapter two will outline the literature review for this topic. This includes the EV market, EV barriers, the infrastructure for EVs and more. In chapter three a theoretical framework is developed to select the most relevant literature review for the research methods. These research methods will be discussed in chapter four under methodology. In chapter five the results of the data collection will be visible. Out of these results, certain conclusions can be made concerning the research topic and questions. This will be done in chapter six. Finally, in chapter seven potential recommendations regarding the research will be made.

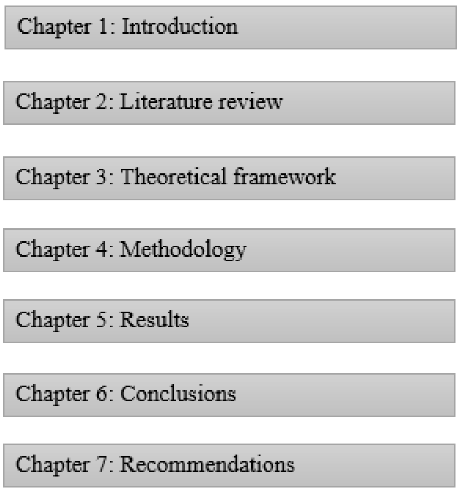


Figure 1: Research structure

1.3 Scope

This research will cover the consumer acceptance towards EVs in Lisbon. The vehicles that are the most valuable for this topic are the vehicles that need the charging infrastructure. These EVs include the BEV and the PHEV.

The geographic area wherein this research takes place is the city Lisbon, in Portugal. This geographic area will also relate to the participants. The profile of the participants needs to match with the area that will be used in this research. Therefore, the research participants will either work or live in Lisbon.

2. Literature review

To make EVs more understandable, this chapter will start with the history of EVs, the types of EVs and its characteristics. Also, the battery uses will be discussed. In the second section will examine the EV market with a market research, which includes the European and Portuguese EV market. After that, the literature review part covers the most important barriers for EV adaption and policy incentives concerning EVs. The last two parts of this chapter will explain the term range anxiety and will mention the impact of EVs on the environment.

2.1 Introduction of EVs

There are several authors who claim that different people were responsible for the first vehicle driven by an electric motor. Following Guarnieri (2012) the first EV was built and used by the Slovak-Hungarian Ányos Jedlik in 1827. In the years after others invented other vehicles powered by electricity. At the end of the 18th century, the first rechargeable batteries were made. After 1920, the electric vehicles disappeared and got replaced by ICE driven vehicles who were much more popular (Curtis & Anderson, 2010). In the early 90’s, there were three sorts of cars available: steam-driven ICE’s, gasoline-driven ICE’s and EVs. The car market at that time was divided because nobody knew what exactly the best option was. EVs were, comparing to both ICE’s, slow and expensive, but also clean and quiet. In the early history of cars, the EV’ reputation grew to environmentally friendly. In the cities New York, Boston and Chicago, one-third of the cars at that time were electric. This later changed, because EVs could not keep up with the higher demand and expectations of the customer. The attention of the market was caught by vehicles with longer distance and higher speed. Reasons for this were the quality improvements of roads and the development of fuel stations. Besides that, countries starting to introduce to charge cars by their weight. Because EVs carried an onboard battery, they became more expensive. As a result, more people started to buy an ICE-driven vehicle. EVs were not able to keep up with this development (Curtis & Anderson, 2010).

EV drivers at that time also faced other issues. One of these issues is concerning EV charging: *“If charging stations could readily be found in every town where there is electric service, the use of electric pleasure cars on the fairly long run would become much more common than it is now”* (Curtis & Anderson, 2010).

Types of Electric Vehicles

Vehicles driven by electricity are categorized as Alternative Fuel Vehicles (AFVs) (Jansson, 2011). The vehicles that will be described in detail are the Hybrid Electric Vehicle, the Plug-in Hybrid Electric Vehicle and the Battery Electric Vehicle. Other types of EVs are mentioned in more detail as well. Table 1 summarizes all the types of EVs.

- Hybrid electric vehicle (HEV):

HEV's are hybrid-electric vehicles that have an internal combustion engine (ICE) and a small electric motor. With most HEVs, the electric power is generated while driving or when using the brake. To save the energy that is generated, the vehicle uses an energy storage device. There are two different technologies regarding HEVs. The first one is called 'parallel hybrid', which connects an internal combustion engine with an electric motor that both give power to the vehicle. The second technique being used for HEVs is the 'power-split hybrid', which makes HEVs able to drive fully electric. This is only possible at low speed and lasts only on short range. HEVs cannot be charged with a (charging) cable. The 'hybridization' can be seen as a technology that strives for fuel efficiency and being less polluted to the environment. Examples of HEVs are the Toyota Prius, Honda Civic Hybrid and the Lexus C200h (EEA, 2016).

- Plug-in hybrid electric vehicle (PHEV):

PHEVs are vehicles that consist of an electric motor and an ICE. They are not fully electric. The electric motor will be used at low performance and speed. When more power is needed, the ICE will support or take over the driving process. This also happens when the battery is low or empty. The batteries of PHEVs are normally small, because of the limited space inside the vehicle. This results in a predicted driving range of 20 to 80 kilometers. PHEVs feature a plug-in for to charge the vehicle with a charging cable (EEA, 2016).

- Battery electric vehicle (BEV)

Battery electric vehicles are vehicles that only run on electricity via onboard batteries. Like PHEV's, BEV's have charging plug-ins to charge their battery. They do not have an ICE. This makes them 100% dependent on electricity. BEVs can be recharged by charging cables. Batteries inside a BEV are normally bigger to ensure a longer driving distance without charging. An important technique that most BEVs contain is 'regenerative braking'. The energy that comes free during braking is normally heat that will be spilled. With regenerative braking, vehicles can save this heat and transform it into power. This will lead to a longer driving range. The predicted driving range of BEVs lays between 70 and 400 kilometers (EEA, 2016).

- Other electric vehicles

There are two other electric vehicles in the market: the *Fuel cell electric vehicle (FCEV)* and the *Range-extended electric vehicle (REEV*). The FCEV is a vehicle with integrated solar cells that can be charged by the sun. At this moment, there are only five different FCEVs on the European market (EAFO, Fuel Cell Electric Vehicles, 2018). A REEV is an electric vehicle which can use its APU (Auxiliary Power Unit) to recharge the battery and extend the driving range. Therefore, it looks a bit like a PHEV because the APU is a combustion engine driven on liquid fuel. A test using vehicle simulators showed that the engine performance of the REEV is not competitive with modern vehicles (Wahono, 2014).

Term	**Shortcut**	**Explanation**
Electric Vehicle	EV(s)	A vehicle that is completely or partly driven by electricity.
Battery Electric Vehicles	BEV(s)	A vehicle that has a motor which is completely powered by electricity. This electricity comes from the battery pack that can be charged.
Plug-in Hybrid Electric Vehicles	PHEV(s)	A vehicle that is partly driven by electricity. Contains an ICE, a small electric motor and a small battery pack.
Hybrid Electric Vehicles	HEV(s)	A vehicle that has an ICE and a small electric motor. Most of the HEV’ electricity is generated by the vehicle itself.
Internal Combustion Engine	ICE *(-driven vehicle)*	Heat engine where fuel and an oxidizer create a working process. The major part of the ICE-driven vehicles run on gasoline or diesel.

Table 1: Clarification of terms

Characteristics of EVs

The powertrain of an ICE-driven vehicle consists of an ICE, a tank and a transmission. For EVs this is different. There are more parts and technologies added to EVs. These parts and technologies of the EVs differ per type. The powertrain of the PHEV and BEV will be discussed in this section. Within the PHEV, the ICE is the fundamental driving force. Together with this ICE, an electric motor and a small battery fulfill the driving unit.

Depending on the technique and vehicle brand, the driver can select different driving modes: fuel efficiency (electric motor helps ICE) or full-electric (only electric motor and battery). The electric driving range of a PHEV is reasonably short comparing with a BEV. This because the batteries used in a PHEV are smaller than in a BEV. The batteries of a PHEV can be charged via a plug-in charger.

For BEV this is different As mentioned before, a BEV does not have an ICE. The vehicle is fully dependent on an electric motor in combination with a battery. The BEV also has a power electronics, a transmission and a plug-in outlet. Within the BEV, the batteries take up most of the space in or under the vehicle. The range of the BEVs depends on the size and type of battery. Table 2 shows all differences down below.

Type of vehicle	**Propulsion**		**Energy source**		
	ICE	Electric motor	ICE	Plug-in	Fuel-cell
ICE	✓		✓		
HEV	✓	✓	✓		
PHEV	✓	✓	✓	✓	
BEV		✓		✓	
REEV		✓	✓	✓	
FCEV		✓			✓

Table 2: Sorts of EVs

Battery usage EVs

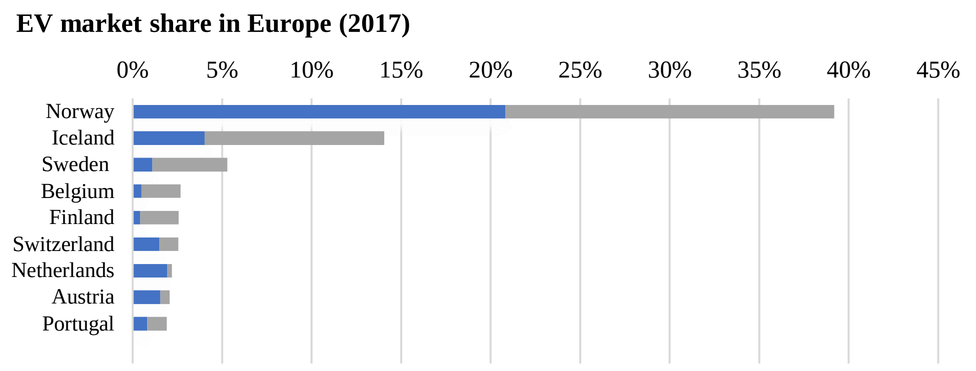
The batteries that are used in EVs are made of lithium and other components. These batteries are called lithium-ion batteries. Every specific battery type has a different level of safety, life-span, performance and costs. Dinger (2011) mentions that the safety of the battery is the most important criteria. Batteries can easily cause a fire. To prevent this, EVs need a cooling system that protects the vehicle. Regarding the lifespan of batteries, the cycle stability is valuable because batteries can be weakened to their original capacity after a certain number of charging. Normally, batteries stay utile for some years. Performance-wise, the major challenge for EV batteries is the difference of weather conditions. Generally, batteries perform better with cold temperatures than when its warm. Another point towards performance is the energy storage per kg of weight. The energy storage is related to the total range of the vehicle. The issue with energy storage is that the specific energy outcome is only 30 to 40 % of the nominal maximum energy density. Even if this increases to 70 to 80%, the rise in the vehicle' range is minimal. Also, the type of battery influences the total time of charging an EV. Lastly the battery costs. Batteries are made out of different components. Some are made out of nickel, others out of titanite or manganese. A manganese battery is for example more expensive than a titanite battery. As well as the cells that are needed for the battery. Besides that, the batteries need to be adjusted to the criteria above. This development increases the costs (Dinger, 2011).

2.2 EV market analysis

In this chapter, a market analysis of the electric vehicles in Europe and Portugal are introduced to show the insights of the EV market. Next to that, it will show the role that car brands have in the EV market.

2.2.1 EV market Europe

This part will cover the EV market share, EV sales and several initiatives concerning EVs in Europe. The total amount of BEVs in Europe is 414.394 passenger cars and 59.245 light commercial vehicles. For PHEVs, this total is 443.982 passenger cars (EAFO, 2018). Table 1 shows the EV market share in Europe. Norway is the market leader with a market share of 39,19% of the total cars bought in 2017. 20,82% of these are BEVs, that's one-fifth of the total sales in 2017. After Norway, the countries that have the biggest EV market share are Iceland, Sweden and Belgium. Portugal is the 9th country on the list of EV market share in Europe (EAFO E. A., 2018). Although Germany does not have less EVs than Portugal, the EV share of the total market in percentages is lower. This because Germany counts more passenger cars in total. The figure below gives an overview of the market share of EVs in European countries that were mentioned before.



	Portugal	Austria	Netherlands	Switzerland	Finland	Belgium	Sweden	Iceland	Norway
BEV	0,81%	1,54%	1,92%	1,49%	0,42%	0,49%	1,11%	4,01%	20,82%
PHEV	1,10%	0,52%	0,28%	1,06%	2,15%	2,19%	4,17%	10,04%	18,37%

Figure 2: EV market share Europe (2017)

- Sales in Europe

Table 3 shows the sales of PHEVs within Europe in 2017. The most sold PHEVs are the Mitsubishi Outlander, the VW Passat GTE and the Mercedes GLC350e. The sales of the BEV market is marked by a top three of the Renault Zoe, Nissan Leaf and the Tesla Model S as the most sold BEVs. These are showed at table 4 (EAFO E. A., 2018).

Brand	**Model**	**Sales**	**Market share**
Mitsubishi	Outlander	19202	6,6%
VW	Passat GTE	13621	4,7%
Mercedes	GLC350e	11285	3,9%
BMW	225xe AT	10872	3,7%
BMW	330e	10155	3,5%
VW	GTE	9316	3,2%
BMW	530e	6166	2,1%
Porsche	Panamera PHEV	4055	1,4%

Table 3: PHEV sales Europe (2017)

Brand	**Model**	**Sales**	**Market share**
Renault	Zoe	30683	10,6%
Nissan	Leaf	17460	6,0%
Tesla	Model S	15561	5,4%
BMW	i3	14562	5,0%
VW	e-Golf	12902	4,4%
Tesla	Model X	12637	4,3%
Hyundai	Ioniq	6126	2,1%
Kia	Soul EV	5556	1,9%

Table 4: BEV sales Europe 2017

- Initiatives in Europe

The first initiative is the ‘Electric Vehicles Initiative’ by CEM (Clean Energy Ministerial): They introduced this initiative together with the International Energy Agency the Electric Vehicles Initiative (EVI) in 2009. The EVI is a multi-governmental policy forum that works for a faster deployment of EV sales worldwide. In 2017, the EVI counted 10 countries as members who endeavor the EV development in Europe. This development was presented with the Global EV Outlook in 2017 and included the sales EVs, the role of governments and local authorities, the charging infrastructure, battery technologies and the adaption of EVs by the consumer (IEA & CEM, 2017).

IONITY (2018) is a joint venture of car markers BMW Group, Daimler AG, Ford Motor Company and Volkswagen Group together with Shell. Their goal together is to build a network that consists of fast charging points all over 19 European countries. In countries like Spain, Portugal, Italy, Finland and Iceland, IONITY is not represented. IONITY will offer fast charging stations at attractive spots at important European roads says COO of IONITY, Markus Groll. Besides that, the focus with IONITY will also lay on creating a trust for EV drivers. *“Customers want to be able to travel long distances in electric vehicles – with the knowledge that there are a reliable, convenient means of charging their vehicles”* (Reuters, 2017).

2.2.2 EV market Portugal

The first time that Portuguese consumers were able to discover EVs was during a demonstration project in 2004. In Cascais, the local police and other organizations could test small electric vehicles for daily usage. With the launch of Plano de Mobilidade Eléctrica and MOBI.E in 2009, Portugal was getting ready for a ‘car revolution’ that would lead the country to an environment with only electric cars (both initiatives will be mentioned later in Literature Review). In 2016, Portugal counted 4.692.000 registered passenger cars, with a population of 10.311.000 people. In total there are 6.208.350 cars in Portugal, including heavy weighted vehicles. 63.8% of all these vehicles are driven by diesel and 34.9% gasoline driven. (Governo Portugal, Plano de Ação para a Dinamização da Mobilidade Elétrica, 2015)

Before the consumers were able to get in contact with EVs, the Portuguese Association of the Electric Vehicle organized already in 2000 one of the first events concerning electric mobility, together with other local institutions. A year later, the developments of electric mobility were mentioned in *'Compromisso Lisboa'*: "Mobility and Technology of 2001: What policies for tomorrow?". The advanced technologies and fuel problems of that time and the long-term vision regarding the environment and the quality of life were motives to narrate the EV market and future.

Market share in Portugal

At the end of 2017, Portugal counted a total 4007 BEVs and 4253 PHEVs. This is a total of 8260 EVs. Figure 3 shows the development of new EV registrations in Portugal. The first registrations of EVs were in 2011 with 201 new BEVs and 0 PHEVs. Since 2013 there is a visible growth of EV registrations. From 2015, Portugal counted larger amounts of new EV registrations with 2017 as peak till now. Furthermore, the PHEV registrations overtook the BEVs in 2016 (EAFO E. A., 2018).

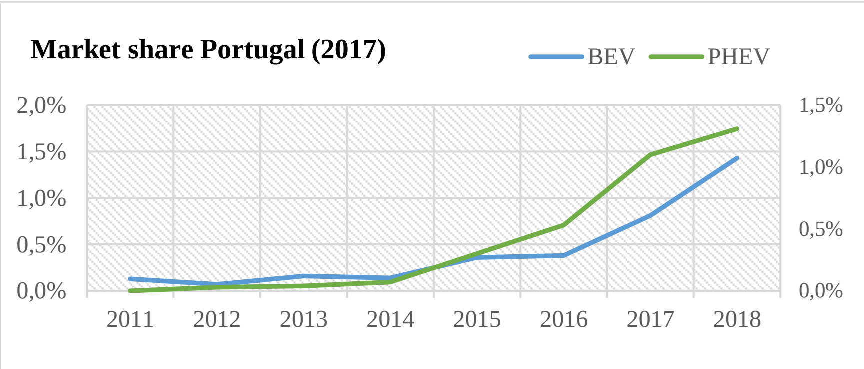


Figure 3: Market share Portugal

New registrations also have an impact of the total car market share. In 2012, the EV market share in Portugal was 0,1%. In 2017, the EV market share was 1.91% of the total market (0.81% BEV; 1.1% PHEV). The EV market share in 2016 was 0.91%. BEVs grew in 2017 by 113,2% and PHEVs by 107,6%. The market counted 2.444 PHEVs and 1.793 BEVs that were newly registered in 2017 (EAFO E. A., 2018).

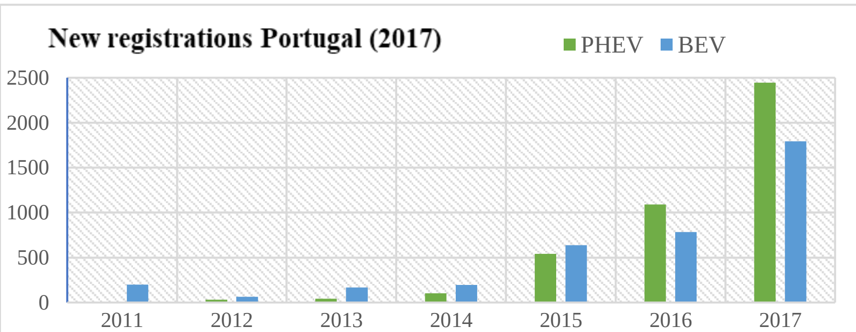


Figure 4: New EV registrations

Sales in Portugal

Concerning the EV sales, there will be a separation between BEVs and PHEVs. For the PHEV models, the BMW 330e, 530e and the Mitsubishi Outlander PHEV had the biggest market share in 2017. The top three BEVs with the highest market share in 2017 were the Renault Zoë, Nissan Leaf and the BMW i3. An overview of the best sold BEVs in 2017 is presented below (EAFO E. A., 2018). Both PHEV and BEV sales are shown in table 5 and 6.

Brand	PHEV model	Sales 2017	Market share 2017
BMW	330e	352	8,3%
BMW	530e	327	7,7%
Mitsubishi	Outlander PHEV	240	5,7%
Mercedes	GLC350e	219	5,2%
Mercedes	C350e	215	5,1%
BMW	225xe AT	197	4,6%
Volvo	XC60 PHEV	118	2,8%
Mercedes	E350e	114	2,7%
Mini	Countryman PHEV	98	2,3%

Table 5: PHEV sales in Portugal (2017)

Brand	BEV model	Sales 2017	Market share 2017
Renault	Zoe	751	17,7%
Nissan	Leaf	318	7,5%
BMW	i3	255	6,0%
Smart	Fortwo ED	90	2,1%
Tesla	Model S	81	1,9%
Kia	Soul EV	60	1,4%
Smart	Forfour ED	47	1,1%
VW	e-Golf	43	1,0%

Table 6: BEV sales in Portugal (2017)

EV Initiatives in Portugal

The *Plano de Mobilidade Éléctrica* is a mobility plan done by the Portuguese government that focused on a 'greener' energy transport system. Central in this plan are the electric vehicles in Portugal and the infrastructure that is needed. The aim was to expand the number of public chargers for EVs and the prospect of adding more incentives (Governo Portugal, 2015).

Later, the Portuguese Government (2014) introduced a similar plan called electric mobility. This plan included a strategy regarding the charging infrastructure in Portugal. These goals are the necessity of a service period shorter than 30 minutes, the restriction of 100 km vehicle’s autonomy, the goal of 50 km maximum of finding the nearest charging point and lastly the optimization of charging placement near main roads.

In 2010 MOBI.E started as an electric mobility plan that wanted to promote driving EVs and the charging infrastructure. They were one of the first with implementing charging stations in Lisbon. In the eight years, they are operational, they utilized more than 650 charging stations around Portugal. Besides opening more charging stations around Lisbon and other places in Portugal, they are also in charge of a payment system concerning the charging of EV (MOBI.E, 2018).

Legislation Portugal

The Portuguese government introduced a law called ‘*Decreto-Lei n. º 39/2010’*, which includes incentives for low emission vehicles with the goal to lower gas emissions produced by vehicles. It can be described as a future mobility plan that emphasizes cleaner transport and vehicles. The goal is to reduce to emission level. This plan also accelerated the implementation of the charging infrastructure. Besides that, the first policy incentives were mentioned in this plan (Ministério Economia, 2010).

2.2.3 Most important EV car brands

Previously, the sales of EVs were indicated. More and more EVs are being sold in Europe and Portugal. In the latest years, car brands give the consumers more and better options to choose from. The next part will include the role of car brands in this thesis. Some international car brands will be highlighted to describe their plans regarding EVs in the future. What do they offer and how do they promote the consumers to invest in an EV?

Currently, automotive news and publications are full of opportunities concerning EVs. “Manufacturers, suppliers and tech companies are investing enormous amounts of money to make these technologies a reality”. Besides that, they mention that car brands have to focus on vehicle safety, brand trust and vehicle costs to gain acceptance and engagement from the consumers (Giffi, Vitale Jr, Schiller, & Robinson, 2018). Lastly, they notice the importance of the battery prices.

- Volvo

The Swedish car manufacturer Volvo already has PHEVs on the international market. It has been sold to the Chinese car manufacturer Geely in 2010. China now is a world leader in EV sales. In 2017, Volvo’s CEO Håkan Samuelsson said that all Volvo cars being sold in the future will contain an electric motor from 2019. “*This announcement marks the end of a solely combustion engine-powered car”* and *“Volvo cars has stated that it plans to have sold a total of 1 million electrified cars by 2025”* (FT, 2017).

- Toyota

Toyota has a strong market position regarding the environmental aspect of the market, mainly due to the introduction of the Prius in 2000. In December 2017, Toyota announced their sales aims concerning EVs for the decade 2020-2030. This sales aim is the backbone of a mid-to-long-term initiative to fulfill the Toyota Environmental Challenge 2050 (Toyota, 2017). The announcement contained the following targets:

- By 2030, Toyota wants to sell more than 5.5 million EVs, including 1 million zero-emission vehicles (BEVs, FCEVs)
- Accelerating the total amount of BEVs, which includes more than ten BEVs worldwide available from 2020.
- Expand the number of HEVs and from 2020 also the amount of PHEVs
- Eventually, as a result of these targets, the number of vehicles without an electrified engine will be zero

- Tesla

Specifying the brand, price, performance and sales, Tesla can be seen as the premium brand in the EV market. In 2003, engineers wanted to show the consumers that EVs can provide better quality than gasoline cars. and started the company Tesla. With the first model in 2008, they started to sell cars for a certain niche market. Years after the introduction of Model S, the focus on niche market shifted to mass production worldwide. Right, Tesla has one of the highest market shares in the EV market (Iberg, 2015). Customers can charge their Tesla at home via normal plug-in charging or can you the *Powerwall* system. This home battery saves energy that is generated by solar panels and charges the vehicle. Another asset that Tesla has concerning charging infrastructure is the Tesla Supercharger. These chargers are only operational for cars from Tesla and are 16 times as fast as normal public chargers (Tesla, 2018).

- Porsche

Porsche is car brand based in Germany and owned by Volkswagen Group. The models Panamera and Cayenne are available on the market as a PHEV. Also, the Porsche 918 that entered the market in 2015 is PHEV. In 2018, Porsche introduced 'Porsche E' which will develop and deliver only EVs to the market. The major project will be the introduction of 'Mission E', which is a future sports car that is fully electric. Mission E is a concept car, so the chances of actually entering the market are not substantial (Porsche, 2018).

2.3 Barriers for EV adaption

Liao, Molin, & van Wee (2016) identified that the financial and technical features of EVs are valuable aspects of the utility of EVs. The financial features contain the purchase price and operation costs. The purchase price of EVs has a high and negative influence on the utility. The operation costs are indicated with the costs per kilometer or the fuel efficiency and fuel costs. A higher or lower fuel price has a consequence on the purchase of an EV. In addition to that, people with a higher income concern less about a higher fuel price than lower incomes. The technical features include range, charging duration, performance and brand variety.

2.3.1 Cost barriers

- Purchase Price

Car manufacturers that develop and produce EVs are using different techniques and processes than ICE-driven vehicles. In general, EVs have a higher purchase cost than the standard ICE-driven models. One major cost factor with EVs in the past were the battery packs. The costs of batteries are now decreasing due to technology improvements and economies of scale. (Bloomberg, 2017). Nevertheless, the purchase price depends on the demands of the customer. Appendix 1 shows a price comparison of ICE-driven vehicles and EVs from different car brands. Most of the PHEV or BEV versions that car brands sell are more expensive than ICE-driven vehicles. But this is not always the case. At Volkswagen, the GTI and GTD versions of the Golf are for example more expensive than the GTE, which is a PHEV version. Another example is the BMW 3 series. The 330i (gasoline) and 330d (diesel) versions have a higher purchase value than the 330e (PHEV). The most expensive BEV brand that is on the market right now is Tesla. The purchase price of the Tesla models S and X is higher than all the models mentioned before. Not only does Tesla offer a longer range, styling wise it offers more than the others as well. Hence, the purchase price of a vehicle depends on consumers preferences. In addition to that, it is hard to compare ICEs with BEV because they differ a lot. The style and performance of a BMW 3 (ICE) series differ a lot from a BMW i3 (BEV). While EVs, in general, are more expensive than ICE-driven vehicles, PHEVs are not evidently more expensive than ICE-driven vehicles. In some cases, PHEVs are less expensive than ICE-driven vehicles.

- Annual (operational) costs

Several studies compared the traveling costs of EVs and vehicles driven on gasoline. Because both the gasoline price and the price of kWh are fluctuating, it is not possible to find consensus. However, it is possible to observe the difference between the two. A study by the ICCT (2018) analyzed the difference between electricity and gasoline in the US. They used a BEV, a PHEV and an ICE-driven vehicle. They divided the PHEV in electricity and gasoline costs. Although the prices of electricity are significantly different per city, it showed that the costs per mile for the BEV and PHEV are lower than the ICE-driven vehicle on gasoline. In two cities, it is less expensive to drive the PHEV with gasoline than the BEV.

Tesla (2018) compares the costs of charging with the fuel costs on their own website. Charging a Tesla Model S will be less expensive than the costs of fuel for a similar ICE-driven vehicle. Taking into consideration that the costs of Tesla supercharging is €0.24 per kW and the costs of gasoline are €1.41 per liter (with an average of 7.7 liters per 100 km). For a distance of 500 km, charging the Tesla costs €22, -. This is €32,- less expensive than gasoline for the same distance (€54,-). Per kilometer, the savings are €0.064 per kilometer. Still, these numbers and conditions were used at a certain date and can differ every moment.

In addition, the increase in fuel price has an impact on EVs market share. The market share of BEVs can potentially increase with 1%. For ICE-driven vehicles on gasoline, this has a negative effect. It has a positive effect on diesel-driven vehicles (Valeri & Danielis, 2015).

2.3.2 Technical barriers

- Vehicle Range

The range of an EV can be described as the maximum distance the vehicle can drive on a full battery. The range of an EV is important for consumers. In line with (Franke, Experiencing Range in an Electric Vehicle - Understanding Psychological Barriers, 2012), a vehicle with a longer range increases the likelihood of purchase an EV. A threefold range increase of EVs has a positive impact of 1,8% of the market share (Valeri & Danielis, 2015). The importance of the vehicle' range also depends on the charging time and charging density.
In the last years, the median range of EVs increased. The U.S. Department of Energy (2017) found out that the maximum range of EVs increase compared with 2011. The maximum range within the BEV market in 2017 was 539 km (335 miles). The median range is 183 km (114 miles). In 2011, the maximum range on the EV market was 151 km (94 miles) and the median 117 km (73 miles). In Europe, the Tesla Model S and Model X have the longest range with respectively 507 km and 474 km. The e-Golf and the Hyundai Ioniq have a range of 201 kilometers. The vehicles with the lowest range in the market are the Smart ForTwo Electric and the Kia Soul, with a range of respectively 154 and 150 kilometers.

- Charging duration

The charging duration depends on the charging equipment that is used and the total driving range of the vehicle. The charging options are AC Level 1, AC Level 2 and DC Fast Charging. Charging an EV at home on level 1 can take up to 8 to 10 hours. Level 2 charging will take 2 to 4 hours. The fasted way to charge an EV is via DC Fast Charging. With this way, EVs can be charged in 20 to 30 minutes. One hour of charging results per type in more or less range: level 1 charges for 3-8 km; level 2 charges for 16-32; and DC Fast charges for 95-130 km (AFDC, 2017).

2.3.3 Other barriers

- Consumer awareness

EVs are quite new comparing them with ICEs. Consumers In general, there is a low understanding of EV by people (Burgess, 2013). A survey found out that the general knowledge about EV costs, benefits and driving experiences is low. A research done by Singer (2016) studied the consumer views on PHEVs. The awareness of PHEVs was one of the main aspects. 52% of the respondents were not able to name a specific PHEV brand and model. Besides that, 43% of the respondents were never near or in a PHEV.

Krause (2013) conducted a survey about the knowledge of consumers concerning EVs. About 95% of the respondents answered wrong to questions about EVs. 75% of the respondents did not know about the benefits EVs have. Besides that, a part of them did not know about incentives or government policies. The Department for Transport (2016) in the UK researched the knowledge and attitude of consumers towards EVs. 33% of the respondents were not aware of government grants for EVs. For 13% of this part, it would be more presumably to buy an EV.

- Experience

The effect of an EV trial period is examined by several studies. Franke (2015) identified that range preferences for BEVs are higher than the average daily driving distance on working days. Also, the study discovered that people who have practical experience with a BEV show less difference in range needs and preferences. This practical experience can potentially lower market demands for consumer regarding EVs. Another study from Franke (2012) mentions that the reference point for range preferences only work for experienced EV drivers. It is possible that consumers without experience do not estimate their needed range accurate.

2.4 EV infrastructure

Before describing the infrastructure that is important regarding EVs, infrastructure in general will be explained first. Jochimsen (1966) was one of the first to define infrastructure: *“infrastructure is the sum of material, institutional and personal capacities available to economic agents.”* Furthermore, he outlined infrastructure as: *“1. the totality of all earning assets, equipment and circulating capital in an economy that serve energy provision, transport service and telecommunication; 2. structure for the conservation of natural resources and transport routes in the broadest sense and; 3. buildings and installations of public administration, education, research, health care and social welfare.”*

Later, Buhr (2003) described infrastructure *as “the sum of all relevant economic data such as rules, stocks, and measure with the function of mobilizing the economic potentialities of economic agents”*. Infrastructure can be divided into two criteria. Torrisi (2009) divided the infrastructure in *capital good* and *public good*. As capital good, it is delivered in large units as investment consumption on long-term and is classified as inseparable. Infrastructure is also a public good, in the perception of not being consumed exclusive and rival in the market. It is available for everyone. Furthermore, infrastructure is classified by Torrisi (2009) in diverse ways. In line with this thesis, the categorisation of transportation (roads and highways) as infrastructure will be mentioned below:

1. Hansen: Road and highways as economic infrastructure. Components who are classified as economic overhead capital (EOC) focus the direct support of productive activities or movements of goods.
2. Aschauer: Road and highways as core infrastructure. These core infrastructures have the highest influence on productivity estimations.
3. Main roads as basic infrastructure. This research showed that basic infrastructure projects have contributed to the Dutch industrial revolution in a positive way.
4. Transportation network as material infrastructure. Material infrastructure includes capital goods that are not mobile and non-circulating. These capital goods essentially strengthen services that are needed to meet with basic social and physical requirements.
5. Roads as network infrastructure. In total, network infrastructure covers all the transport and energy networks.

The quality of a country’s infrastructure is an important indicator of the economic vitality. Reliable transportation is one of the basic elements of a productive economy and civil society (Aschauer, 1990). Furthermore, infrastructure development will lead to a higher productivity within a country. A reduction of public investment will at the same time lead to a fall in productivity growth.

The previous part mentioned the general infrastructure elements. This next section will discuss the infrastructure that is needed for EVs. Both BEVs and PHEVs batteries need to be charged to drive electric. EV charging involves a different technique and infrastructure than for ICE-driven vehicles. A valuable factor concerning the utility of EVs is the density of charging spots. This is spread of the total amount of charging points of the population within an area is described as charging point density. Sierzchula et al. (2014) mentioned that the charging infrastructure within a country will predict the EV market share the best. Finally, to promote the adaption of EVs, further development of charging infrastructure is needed (Liao, Molin, & van Wee, 2016).

2.4.1 Charging options

For electric vehicles, there are three different options to charge the vehicle: plug-in charging, wireless charging and battery swapping.

- Plug-in charging:

The plug-in charge technique is the most used method by EV drivers. To charge the EV, users need to plug the charging cable into the power socket and the vehicle. Table 2 shows an overview of the different charging options that EV drivers have. Normal and fast charging require different electricity and connector types that can generate and transfer the power which is required. Fast chargers will generate more power which makes the charging process faster than slow or normal chargers (IEA & CEM, 2017).

- Wireless charging:

The second charging option is wireless charging. With this technology, EVs are connected and charged without any plug. This means there is no physical contact between the vehicle and the charger. A system under the vehicle connects with a charging pad via an electromagnetic field (EEA, 2016). This technology is fairly new which means that most of these products are pilots and still under development, like the wireless charging system of Prodrive (Prodrive, 2018).

- Battery swapping:

The last option the charge an EV is battery swapping. With battery swapping, you replace the used battery that is in the EV for a new full battery. Normally, it is a fast way to get recharge the vehicle. The major disadvantage is that it needs to be done in special swapping stations, which are rare.

2.4.2 Normal versus fast charging

Charging an EV at home with a standard outlet (120-volt) can take around ten hours. To make charging faster, different connectors were introduced on the market and are available for consumers. These connectors offer a higher power, but that are classified as normal charging. These connectors can be used for home and public charging spots. With these chargers, the total charging time can be lessened from ten to two hours. A consumer that want a less time-consuming way can use fast chargers. Fast charging methods can reduce the total charging time significantly. Charging at a fast charging station will only take 20 minutes (Dinger, 2011). Table 7 provides an overview of the EV charging classification.

Classification	**Level**	**Type**	**Power**	**Connector type**
Slow/Normal chargers	L1	AC	<3.7 kW	Household connector
	L2	AC	3.7 kW - <22 kW	IEC 62196 (type 2)
	L2	AC	<22 kW	Tesla connector
Fast chargers	L3	AC	22 kW - <=43.5 kW	IEC 62196 (type 2)
	L3	DC	< 150-200 kW	CCS Combo 2
	L3	DC		Tesla connector

Table 7: Charging classification

2.4.3 Estimation of charging points

Member states of the EU presented a plan, which is part of the Alternative Fuels Infrastructure Directive, to the EU Commission. They assessed the optimal number of charging points. EU Members need to have at least one public charging point for every 10 vehicles. It takes into consideration the vehicle, battery and charging developments and that the major part of private EV owners uses their own charging points (Parlement, 2014). Next to that, *"Member States should ensure that recharging points accessible to the public are built up with adequate coverage, in order to enable electric vehicles to circulate at least in urban/suburban agglomerations"* The IEA organization uses a different optimal number for charging points. They state that one charging spot per 15 EVs is sufficient. Harrison and Thiel (2017) showed that if the charging point ratio decreases from 25 to 5, the EV market share increases. The number of fast charging points and charging points at work are also in correlation with the market share (Slowik and Lutsey, 2017).

2.4.4 EV charging behaviour

The interaction(s) between the EV charging point and the EV user can be seen as charging behaviour. Nicholas A. (2017) found out that the range of an EV has an effect on the charging behaviour. Every mile that a PHEV recovered increased the likelihood of plugging in the vehicle. Contrariwise, when this PHEV had time restrictions because of charging or parking the likelihood of plugging in decreased. The factors that influence the charging behaviour are the charging location, the charging duration, the charging frequency and the charging moment.

The place where the EV is charged is termed charging location. The three main charging locations for EVs are home charging, work charging and public charging. Axsen & Kurani (2012) state that if EV drivers are capable to charge their vehicle at home, they have to plan their daily trips less often. Although charging at work or at local public places requires more planning of trips, it is seen as convenient by EV drivers. The public charging spots that are available in central areas normally count as free parking for EVs. In big cities, EV owners charge their vehicles more often at public charging points than at home. In London, only 48% of the owners are able to charge at home, while in the rest of the UK the average of home charging is 72% (PWC, 2018). A study in the US showed that PHEV drivers in the California region mostly charge their vehicle at home and that public charging is used less often (Nicholas A., Tal, & Turrentine, 2017). In the next section, the charging locations in Portugal and Lisbon will be discussed.

1. Public charging

Consumers can use public and semi-public charging spots. Public charging spots are located in city centres, near parking spots and on highways. Semi-public charging spots are charging spots inside parking garages and shopping centres (EEA, 2016). The number of charging spots in Portugal is increasing. This is also visible at table 8. The normal power outlets increased with 10,9% (1192 in 2017). The high-power outlets increased with 178% (92 in 2017). Comparing the charging spots with the total amount of EVs, the number of EVs per charging position is 7. The work charging spots are not included in this part.

Charging spots Portugal	**2016**	**2018**
Normal power (<22 KW)	1192	1322
High Power (>22 KW)	58	256
Total	1250	1578

Table 8: Number of public charging spots

At the end of 2017, MOBI.E (2017) had 147 normal charging spots operational in the city centre of Lisbon. Although there are some smaller operators on the market that offer charging spots, MOBI.E has the major share of charging spots in Lisbon and Portugal. The exact charging locations of the other operations are unable to find.

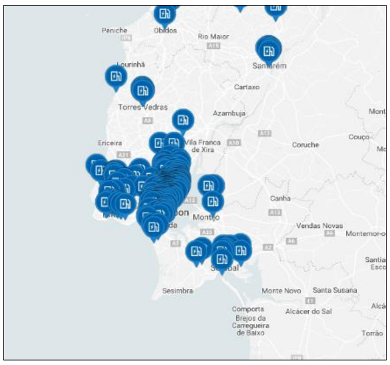


Figure 5: Normal charging spots Lisbon

In total, the city centre of Lisbon counts four working fast charging spots. Outside the city centre, there are five more fast charging spots. These are all operated by MOBI.E (2017).

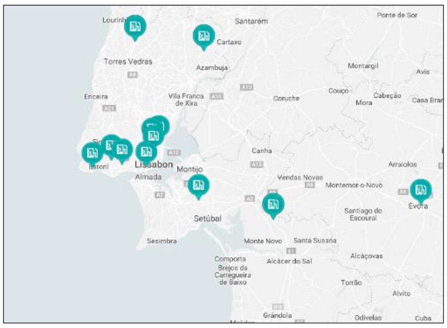


Figure 6: Fast charging spots Lisbon

The superchargers of Tesla able to charge 'ultra-fast'(120 to 145 kW). This results in charging in less than 30 minutes. Currently, there are five Tesla Superchargers operational in Portugal. In the future, there will be added six more Tesla superchargers in Portugal. There is no Supercharger available in Lisbon. There are two charging spots available close to Lisbon. One in Montemor-o-Novo and one in Alcácer do Sal.

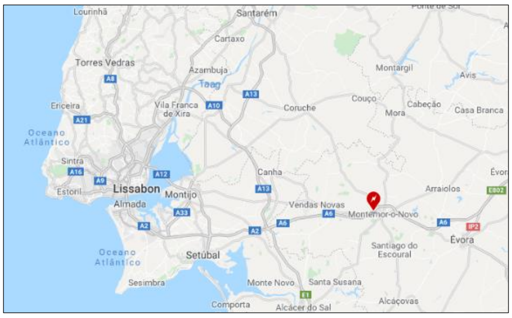


Figure 7: Tesla charging spots Lisbon

2. Home charging

It is already mentioned above that in big cities, EV users charge their vehicle more often at public charging spots than at home. In Lisbon, most of the residential areas and buildings in Lisbon do not have accessible parking spaces. Therefore, EV users in Lisbon mainly have to recharge their vehicle at public charging spots (Frade, Ribeiro, Gonçalves, & Antunes, 2015). Investing in home charging most of the time results in normal charging systems.

3. Work charging

The third option that EV drivers have is charging their EV at work. Companies or organisations can install their private charging point for their employees. The systems that are used can be compared with the home charging, mentioned above.

The second point concerning charging behaviour is the charging frequency. A longer maximum driving range does not mean that users charge their vehicle less often. During a study, the participants that were using the Chevrolet Volt PHEV (which had the longest driving range) charged their vehicle more repeatedly than participants that were using a Nissan Leaf or a Prius with a lower driving range. Besides that, some PHEV owners do not plug-in their vehicle frequently. This is mainly because of the gasoline price and the engagement that the owner has with the vehicle (Tal, Gil, M., & Turrentine, 2018).

Thirdly, the charging moment. Nicholas A. (2017) examined the behaviour and adaptation of EV users regarding charging. One part of this study analysed the daily charging moments on different charging levels (level 1, level 2 and DC fast charging). Most EV drivers that use level 1 start charging at 5, 6 or 7 p.m. The rest of the evening and noon are favoured times to charge. At level 2, most EV drivers start charging their vehicle at 7 or 8 a.m. and midnight. For DC fast charging, the busiest charging moments are at 8 a.m. and from 2 p.m. till 17 p.m.

2.4.5 Lack of EV infrastructure

The lack of infrastructure and public charging stations are two major obstacles for EV owners (Krupa, 2013). Besides that, EVs will only become competitive once a supporting infrastructure is accessible. While several AMT participants mentioned that public infrastructure like public charging points/stations and battery exchange services would have a positive influence on the willingness to consider a PHEV, even more of them stated that having charging facilities at home (for overnight charging) would be important.

2.4.6 Electricity demand

An increase of EVs within a country will also increase the electricity demand of that country. A study from the UK showed that in 2050, as a result of 3 kW EV charging points, the domestic power demand (GW) can potentially increase to 12 kW compared with 2015. With 7 kW charging points, the power demand can increase by 29 kW on peak moments (Robinson, Blythe, Bell, Hübner, & Hill, 2013).

2.5 Policy incentives

To make it more interesting for consumers to buy an EV, governments are starting to imply incentives to make EVs more attractive. Langbroek, Franklin and Susilo (2016) showed that policy incentives have a positive effect on the adaption of electric cars. Incentives for consumers and EV users are crucial to reduce the purchase costs and the total costs of ownership (TCO) gap between EVs and ICE-driven vehicles (IEA & CEM, 2017). A research of Plötz (2017) examined that the effect of incentives on the PHEV sales in Europe. They found out that an incentive of €1.000, - would increase the sales of EVs by 16% on average. Another study by Bjerkan (2016) examined the effectiveness of incentives in Norway. The results showed that the exemption of purchase tax and the exemption of VAT are the two most critical incentives for buying an EV.

2.5.1 Policy incentives Portugal

EVs in Portugal get a payback on their investment. It is a reduction on ISV (Imposto Sobre Veícolus). This because EVs have lower C02 than ICE-driven vehicles. With BEVs this amount is €2250, -. For PHEVs this amount is less. They get a reduction on their investment of €562,50,- (IUC, 2018). Not only do consumers that purchase an EVs get money back on their investment, there are also tax benefits concerning for BEVs and PHEVs. BEVs are exempt from registration tax (ISV). The taxes for PHEVs are 5 till 17,5%, depending on the purchase value of the car.

PHEV registration tax	Tax
Cars with a purchase value that is <25.000€	5%
Cars with a purchase value of €25.000-€35.000	10%
Cars with a purchase value that is > €35.000	17,5%

Table 9: PHEV registration tax

ICE-driven vehicles pay a higher amount of tax than EVs. In comparation with PHEVs, cars with an ICEs with the same purchase value as listed above pay respectively 10%, 27,5% and 35%. For companies, VAT from EVs is deductible. This is only possible if the purchase price of the EV is lower than €50.000.

A study of McKinsey showed that Portugal has one of the lowest percentages of subsidy that consumers get back when they buy their EV (2%) (Hertzke, Müller, & Schenk, 2017). Countries like Denmark and Norway offer higher purchase subsidies for EVs, that give a payback of respectively 45% and 49% of the EV price. In numbers, these subsidiaries are on average €925 per vehicle in Portugal. In contrast to Denmark (€19.466 per vehicle) and Norway (€15.907).

2.5.2 Incentives in other countries

To understand the importance of incentives, the next part will cover incentives in other European countries. It will focus on the countries that have a high EV market share in Europe. The countries that will be mentioned in this part are Norway, Sweden and the Netherlands. These incentives include road tax exemption, purchase tax exemption, purchase grants, company incentives and others. To give a clear overview of the policy incentives in these countries, the incentives are sorted in the table below.

Country *Incentive*	**Sweden** (Regeringskansliet, 2018) (Transportstyrelsen, 2018)	**Norway** (Elbilforening, 2018)	**The Netherlands** (RVO, 2017)
Road tax	- *Till the end of 2017:* BEV: first five years 0% - *From 2018:* The road taxes for pollutant vehicles will increase from €285,- to €670,- depending on the vehicle.	Zero annual road taxes	*Tax bracket system:* 0 gram of C02 pollution means zero road tax (BEVs) Vehicles with higher C02 pollution pay higher road tax. Bracket 1 is €19,- per gram of C02 and bracket 2 is €282,- per gram of C02. PHEVs in bracket 1 get 50% exemption.
Purchase tax	X	- 25% VAT exemption on EV purchase - Zero registration tax for BEVs	X
Grants	- *Till the end of 2017:* €4000,- for vehicles with <50 gram of C02 pollution (BEVs). €2000,- for vehicles with more pollution (PHEVs). - *From 2018:* A bonus system for zero pollution vehicles (BEVs) in form of a grant. The maximum grant is €5700,-. The grant for vehicles with more pollution is around €1100,-	X	Local city grants for company and taxi.
Company incentives	Option to reduce the value of fringe benefits for BEVs and PHEVs	Company car tax reduced by 40%	The option to counterbalance 36% of the costs of an EV with €50.000 as a maximum for BEVs and €75.000 for PHEVs.
Others	X	- 25% VAT exemption on leasing - No toll road charging - 50% discount on ferry	Lower lease aggregation for BEVs

		- Free municipal parking - In Oslo bus lane access during rush hours for BEVs	

Table 10: Policy Incentives in Sweden, Norway and The Netherlands.

2.5.3 Consumer preferences respecting infrastructure and incentives

Lieven (2015), researched the consumer' preferences regarding EV infrastructure and incentives. The customers had several options to choose from. The policy measures are divided into three categories: (1) Monetary; (2) Traffic regulations; and (3) Charging infrastructure. Each of these categories has different measurements. Monetary consists of 'direct subsidies for EV purchase' and 'road tax exemption'. Traffic regulations include 'free use of bus/fast lanes' and 'free city centre parking'. Lastly, charging infrastructure contains 'charging at public parking', 'charging at workplace' and 'charging network on highways'.

The strongest dissatisfaction was caused by missing charging facilities and, especially, a missing charging network on freeways. Therefore, Lieven mentioned these attributes as a 'must have' requirement (M). These must-have features should be included in the infrastructure, otherwise "a purchase is very unlikely". High subsidiaries are founded attractive but not must-haves, in this research called as one-dimensional (O). Drivers are willing to give up some cash grants, in return for an adequate/sustainable charging infrastructure. The features that got the highest grade of attractiveness (A) was a road tax exemption. This feature is not a must-have, but the level of satisfaction can increase highly when the feature is available for the customer.

These three different requirements (M, O and A) can be converted into levels of dissatisfaction and satisfaction. The feature that has the lowest level of dissatisfied (the feature is not available at EV environment), as well as the lowest level of satisfaction (the feature is available at EV environment) is the free usage of bus/fast lanes. In other words, usage of bus or fast lanes as a traffic regulation for EVs has the lowest impact on the customer's choice for EVs. The other traffic regulation, free city centre parking scores higher than the usage of bus lanes but is not the most important feature. A purchase grant after buying an EV would lead to pleased EV drivers: 'No tax refund + $12.000 purchase grant' was the feature that led to the highest satisfaction of all options. Although is not seen as a must-have, because it is not leading to the highest level of dissatisfaction, it is still a feature that countries or cities should consider.

A survey done by the Department of Transport (2016) found out that 31% of the respondents considered a government grant as important. Of these 31%, 9% would not buy an EV without this grant, 12% would be more likely to buy an EV and 10% thinks it is important but not crucial. 4% of the respondents would consider buying an EV regardless of any grants.

Valeri and Danielis (2015) studied the change in market share after introducing incentives for EVs. Five possible scenarios were tested at consumers: 1. EV subsidy; 2. Threefold range increase for EVs; 3. 20% fossil-based fuel price increase; 4. €5.000,- price reduction for EVs; 5. Combination of all scenarios. All five scenarios have a positive effect on the market share of EVs. The biggest increase in market share is found in scenario 5. If all scenarios will be used, the effect of BEV on the market share is 21,16%.

2.7 Range anxiety

The meaning of range anxiety is the "worry of the part of a person driving an electric car that the battery will run out of power before the destination or a suitable charging point is reached". The demand and sales of EV cars are related to this range anxiety. The major reason for not buying an EV the range anxiety. The main issue with range anxiety can be clarified by one question: *"Do I have enough charge to get there and do I have enough charge to get back?".* A poll by the Union of Concerned Scientists identified that concern that the number one concern with purchasing EV's was the range and second the charging abilities. Another survey found out that 71.7% of the respondents are more willing to buy a PHEV if charging stations were located at or near their working place or trip destination.

An automotive report of Deloitte mentioned that the main obstruction for German and Chinese consumers to buy BEVs is the anxiety of how far cars can drive with one-time battery charging. Also, Graham-Rowe (2012) interviewed several people, who were given an EV for a week, about their driving experience. These interviewees mentioned limited range as well as range anxiety and the lack of technological developments as barriers to buy an EV.

2.8 Impact EVs on the environment

With the Paris Agreement (2015), countries agreed on new steps that will strive for a low-carbon economy with less emission of C02. The automotive industry counts as a major industry that can help lowering pollution which will improve air quality. To meet this goal, all fossil fuel-driven cars must be sold/gone in the future. The European Union (2017) wants to accelerate the transformation of greener cars via new EU targets. In 2030, the average C02 emission of new cars and vans need to be 30% lower than it is now. These new EU targets will help car manufacturers embrace future (innovative) changes to anticipate this long-term transformation. This signifies that the share of green cars will enlarge, and the share of combustion-engine cars will drop.

3.8.1 EU climate regulations

In 2016, the European Commission started an action plan to ensure more effective and efficient measures that will help to lower the emissions. This plan has three key elements: (1) the higher efficiency of the transport system, (2) low-emission alternative energy for transport, and (3) low- and zero emission vehicles. This action plan states that an improved efficiency transport system and transition to low-emission energy alternatives need to be supported by international and local policies.

The European Commission introduced ten goals for a competitive and resource-efficient transport system. One of these ten goals is stated under the subgroup *'developing and deploying new and sustainable fuels and propulsion systems'*. For the research, this is the most relevant subgroup because they target vehicles. The goal is to: 'halve the use of 'conventionally-fuelled' cars in urban transport by 2030; phase them out in cities in 2050; achieve essentially C02-free city logistics in major urban centres by 2030. Yet, this is only one of the ten goals being set by the European Commission. All ten goals must be reached to get closer to a better and cleaner transport system. For fulfilling this vision, innovation is crucial. Without faster innovation and transition, these goals most likely will not be reached. Besides the previously mentioned vision of the EU, there are also sustainable objectives that influence the shift towards cleaner transport. The increased scarcity of oil, health benefits due to the improvement of air quality and a more competitive automotive industry are to most relevant.

2.8.2 Impact of EVs

Vehicles driven by ICEs contain several emissions that contribute to climate damage. The primary emissions that contribute to ambient air accumulation are PM (particulate matter), 0_3 (ozone), and NO_2 (nitrogen dioxide). The largest contributor of the total of NO_2 emission is the road transport sector. A research in the US showed that the replacement of diesel-driven cars by electric cars (in this case PHEV) improves the air quality. With the consequence that 428.000 people died in the EU in 2014. In Portugal, 6630 people died because of bad air quality.

Focussing on Portugal, the Lisbon (50-70) and Porto (40-50) regions score high in daily PM concentration. 0_3: Lisbon (100-120) and Porto (80-100). NO_2: Lisbon (40-50), Porto (>50). Electrification has to potential to undertake three challenges: EV's are able to (1) produce less greenhouse gas (GHG) when powered by electricity instead of gasoline; (2) reduce tailpipe emissions, which negatively impact people and the environment; (3) reduce the consumption of gasoline, that can encourage national independence on imported oil.

A study of PNAS showed that *"BEV's have the potential to offer great reductions in emissions and oil consumption if air emissions from electricity generation are substantially reduced, battery prices drop dramatically, gasoline prices rise, high-power charging infrastructure is sufficiently deployed, and battery-life is increased beyond vehicle life."*

What are the results of replacing CV cars with EV cars? A research in China examined the effect of replacing CV cars with EV cars has on heat emissions in Beijing. The average heat emitted by a CV (per mile) was 6.31 million joules. The emission produced by an EV per mile 1.25 million joules. This showed that the total EV emissions were 19,8% of the total CV emission (Li & al., 2015).

2.8.3 Noise pollution

In addition to emission pollution due to vehicles, noise pollution is another issue that is caused by road traffic. Inside the urban areas as well as the outside zones, road traffic is the biggest source of noise pollution. The EEA rapport (Electric vehicles in Europe) expresses that noise pollution "harms human health and well-being". This noise is generated by two sources: the engine and the tires of the vehicle. In urban areas/cities, where vehicles normally drive at lower speed, the engine noise is the biggest cause. This because vehicles have to stop and accelerate more often than in higher speed zones. The environment where people live influences the quality of life. So, air pollution does not only bring health and environment issues, it is also a great factor regarding people's amenities of life quality. Environmental resources and services that people value differ from basics, such a clean water, to more sophisticated conveniences, like open-air space and places that are noise-free. People qualify their quality of life less good if they are surrounded in dirty air.

2.8.4 Low Emission Zones

Since 2005, Lisbon exceeds national and European PM10 limits, which is a concentration caused by vehicles. Partly thanks to a warning of the European Justice Court in 2011, Lisbon started to act. The so-called 'PPMQAr-LVT' plan proposed to implement a Low Emission Zone (LEZ) in Lisbon (Da Silva, 2014). Brown (2007) describes a low emission zone as a specific zone that is only accessible for vehicles that suffice with certain emission standards.

Before starting with the LEZ, the city started a traffic study to examine the exact emissions caused by vehicles within the city. A notable outcome was the part that taxies have in the total amount of emission. 17% of the vehicles within the city centre is registered as a taxi. Additionally, their pollution counts for one-third of the total emission. The utilization started in 2011. The plan was to implement the LEZ in separate phases. The first phase included a ban for light and heavy vehicles that do not meet the EURO 1 Emission Standard, which contains vehicles produced before 1992. This only applied at Av. da Liberdade and the Baixa district during weekdays from 08.00 to 20.00. Some vehicles (emergency, public transport etc.) were discharged from the LEZ. During the second phase, the city established two zones in the city centre. Zone 1 for light and heavy vehicles that do not meet with the EURO 2 Emission Standard, which contains vehicles built before 1996. This applies from 07.00 till 21.00 on weekdays within Av. da Liberdade and Baixa. Zone 2 counts for vehicles that do not meet EURO 1 Emission Standard in a larger area of Lisbon. With third and last phase, vehicles in Zone 1 must meet with Euro 3 Emission Standard (vehicles built before 2000). In Zone 2, vehicles have to meet with Euro 2 Emission Standard.

The results of these zones were tested some months after the implementation. The concentrations that cannot exceed emission limits are NO2 (maximum of 18 surpasses per year) and PM10 (maximum of 35 surpasses per year). During emission assessment in 2012, the results showed that PM10 concentrations were reduced by 16% and NO2 concentrations by 6%. If taxis were not excluded from restrictions by the zones, the emission reduction would be higher.

- LEZs other European countries

In Germany, all big cities and most of the normal to small cities use a sticker system within the LEZs. Every vehicle that wants to drive in the certain zones needs to have this sticker on their vehicle. In cities like Frankfurt, Munich, Berlin and Leipzig vehicles that have a minimum standard of Diesel Euro 4 or Petrol Euro 1 get a green sticker. In Hamburg, vehicles must meet with Diesel Euro 6 to receive a green sticker from the 31st of May. With a green sticker, drivers can enter the low emission zones. Vehicles with Diesel Euro 3 get a yellow sticker, which includes entering restrictions in some areas. Vehicles with Diesel Euro 1 and 2 are not allowed to enter these zones. Today, London is using low emission zones in the city centre. In April 2019, they will start to implement an Ultra-Low Emission Zone in central London. The standards will be Euro 3 for motors; Euro 4 for gasoline vehicles; Euro 6 for diesel vehicles; and Euro VI for lorries and busses. This will affect around 60.000 vehicles per day. Cars, vans and motors that do not meet the restrictions and drive within the ULEZ will be charged £12.50 per day. For busses and trucks, this will be £100,- per day.

2.8.4 Role of cities and local authorities

Although a major part of the elements mentioned in the strategy is intended being answered on a national level, cities and local authorities play also an essential role for the delivery of this strategy. While these authorities are already carrying out incentives for more alternative low-emission energy and vehicles, the need to accelerate more initiatives is high to meet future emission goals. In a new mobility plan, the European Commission (2017) encouraged cities to ‘include reduction targets and clean air strategies in their mobility plans’. It also ‘urged the commission to make more funds available for cities’. These funds can be requested for improving infrastructure or technologies that can strengthen decarbonising the public transport and can reduce pollution within cities. One of the examples regarding infrastructure is: ‘public recharging stations for electric vehicles’. Furthermore, it affirms to ‘promote and incentive the purchase of cleaner, less polluting vehicles by both public authorities and private fleets’.

3. Theoretical framework

In the previous part, the literature review regarding this topic was outlined. To find the best answers for the research questions, the most important and relevant literature review needs to be selected. The selection of this literature will create the theoretical framework. The theoretical framework is a structure that supports the theory of this research study (Abend, 2008).

Together with this selected information, additional new data regarding the topic might be needed to cover all questions.

3.1 Framework

The literature that is essential for this research will be discussed further in this part. These subjects will be part of our research method. Potentially, it can help to answer the research questions and to achieve the goal of the research. The following literature selection is made:

- EV infrastructure

The research needs to find out what the role is of the infrastructure for the consumers. A part of the EV infrastructure will be mentioned at consumer preferences.

- Adaption barriers

In the literature review, it is shown that costs and technical barriers have an effect on the consumer's perception and buying intentions. In addition to this, the adaption barriers cover sub-question B.

- Consumer awareness

The literature review showed that there is a lack of awareness of EVs, their infrastructure and policy incentives. This will be used in our research to find out if this is relevant for the consumers in Lisbon.

- Consumer preferences

Examining the consumer's preferences towards EVs, the infrastructure and policy incentives will create an overview of what the consumer really needs when driving an EV. This can potentially have a positive effect on the consumer's acceptance. In line with the research structure, it will answer sub-question C.

- Policy incentives

Using policy incentives can make it more attractive for consumers to buy an EV. In this research, the incentives will be used to identify which of them has a significant importance for consumers.

4. Methodology

In this part, the research method that will be used in this research will be outlined. This will cover the data collection, type of survey, sampling technique and research structure. Also, it underlines the reason for these choices.

4.1 Data collection

In accordance with Homburg and Kromher (2006), presenting data is the basis for a market research. The data collection for a research can be primary data or secondary. Information that is already available is named secondary data. When there is not enough sufficient secondary data available, the researcher needs to collect data. Collected information by the researcher is cited as primary data. In this research, primary and secondary data will be used. The focus will mainly lay on primary data.

Secondary data contains information about EV, presented in the literature review part. Several sources have been used, like reports, analyses, journals and information on websites. Primary data can be qualitative, quantitative or a mix of both. A qualitative research is exploratory which gives insights about the research problem(s) and tries to find the underlying reason(s) of these problem(s). With quantitative research, the gained information will be quantitative such as numbers, statistics and figures. This is a descriptive approach (Blumberg & Cooper, 2011). In addition to this, observations, interviews and surveys are several quantitative research techniques that can be used. In this research, the collection of primary data is done by a survey to explore consumers view on EVs and its needed infrastructure. Thus, the primary data collected is quantitative. The design, structure and aim of this survey will be explained in the next section.

4.2 Type of survey

There are several options to conduct a survey for a research. This can be a personal interview, a self-administrated interview, a telephone interview or a web-based survey. After examining the options above, the survey choice led to the web-based survey. There are certain reasons for choosing this option. Firstly, a web-based survey is easy to access a specific group. Also, this type of survey is time effective compared with the others. Finally, a web-based survey has the lowest costs of all options. On the contrary, web-based surveys have weaknesses as well. Depending on the length and depth of the survey, the survey can be time-consuming for the respondents. Furthermore, it is possible that respondents have a lack of knowledge about the topic or need assistance answering the survey. This can result in the risk of non-respondence or not responding to the survey seriously (Blumberg & Cooper, 2011).

4.3 Sampling technique

The previous explained the method of data collection and the type of survey being used in this research. Now, the sampling technique will be discussed. The sampling part shows the selection of the participants that will answer the survey. Blumberg (2011) mentions that a general study needs to have a sample size of at least 50 to 100 participants. The sampling technique that will be used in this research is non-probability sampling. This means that the selection of the population is random, so not known. The survey will be publicized on social media and via mail. With Facebook, the survey can be spread out to other people which potentially can result in more respondents. This is called snowball sampling.

The total amount of participants in this research is 182. Because a part of them did not match the profile of either living or working in Lisbon, therefore the number of utile participants is lower. This resulted in a sample size of 145 participants.

4.4 Aim and structure

With this questionnaire, the goal is to find out what the consumer’ opinion is about EVs and its infrastructure. Following our main research question that focusses on consumer acceptance, the participants are asked about their perception towards EVs. Additionally, the respondents are requested to give their preferences towards EVs, in line with sub-question C. Furthermore, the respondents are asked about the importance of the infrastructure and policy incentives concerning EVs. In addition, the questionnaire concentrates on people who live or work in Lisbon. This because to research focusses on the infrastructure for EVs in Lisbon.

- Structure

For this research, the questionnaire is structured into four parts. The first part asks about the profile of the respondent. This includes the demographics of the respondents. The advice of Kothari (2004) to leave these questions to end is acknowledged. It is ambivalent for this questionnaire because the living/working area is essential for may or may not participating in the rest of the questionnaire. The next part requests the vehicle usage of the participant. This covers the type of vehicle they use, how many times per week they use their vehicle and how many times per week they enter the city centre of Lisbon. The third part contains questions about electric vehicles in general. In this part, the participants are asked to answer if they see themselves drive an EV in the future, what the most important reasons are to buy and not to buy an EV and what they think the average range of an EV is. Lastly, part four which covers the infrastructure for electric vehicles.

The questions of part three and four are essential for this research. The reason for this is that the goal of these questions is to target the consumer’s perception, preferences and awareness regarding EVs. Although these four parts are framed in this order, the results will be shown in consumers perception, preferences and awareness concerning EVs. Some questions include both the consumer’s preferences and awareness. An example is question 3.2 ‘What is the most important reason not to buy an Electric Vehicle?’. This question asks about the preferences of consumers towards EVs, but it also contains the option ‘The risk of running out of power’ which relates to consumer awareness. Regarding these parts, the next correlations can be made: *Consumer awareness - Public charging; Consumer awareness - Policy incentives; Consumer awareness - Range (anxiety); Consumer perception - Consumer preferences; Consumer preferences - EV infrastructure;* and *Consumer preferences - Policy incentives.*

According to Sahlqvist (2011), shortening a questionnaire has a positive effect on the response rate. The length of the questionnaire that is used in this research is fairly short. There are 16 questions in total divided into four sections. In line with Kothari (2004), the questionnaire needs to be short and simple to be successful. Most of the questions are multiple-choice or short answer questions The advantages of multiple-choice questions are easy handling, simple to answer and not time-consuming for the respondent. Furthermore, the respondents have the option to add their own specific answer. This can result in additional information that was not included in the literature review To give the respondents to freeness to answer in their own opinion, they have the option to fill in their response which is not selected as a structured answer. Receiving a reply from a respondent in his own words can be seen as a major advantage (Kothari, 2004).

- Aim

Already mentioned in the previous section (structure) is that the focus lays on three elements: the consumer’s *perception* towards EVs, the *awareness* that consumers have of EVs and the consumer’s *preferences* concerning EVs, infrastructure and incentives. The goal is to collect results that potentially can add value to the EV market.

4.5 Validity, reliability and errors

The validity of the research is the degree of accuracy of what is measured in the study (Heale & Twycross, 2015). In other words, it refers to how good enough the instrument is measuring what it supposes to measure. This degree of accuracy will be ensured by the theoretical framework. With reliability, the results of an instrument need to be consistent and stable (Heale & Twycross, 2015). To ensure the reliability of this research, the questionnaire was tested before it got launched.

4.5.1 Sampling errors

The variation in the sample estimation in contrast to the true population can be described as sampling errors. These errors happen randomly and the value of can be seen as equal to zero. With increasing the total number of samples, the risk of sampling errors decreases (Kothari, 2004).

4.5.2 Non-response errors

Not all respondents are able to start or submit the questionnaire. With website-based questionnaires, the non-response rate is generally high. A person is included in the sample but is not reached or does not answer for any reason. Many people do not respond or are not able to finish all the questions. Reasons for this could be the lack of knowledge about the topic or no time and interests (Zikmund & Babin, 2006).

4.5.3 Ethics

A part of the research’ aim is to collect data that is based on the truth and the avoidance of any errors. This is in line with ethical norms within the research society. Another point concerning ethics is related to the participants of this research (Resnik, 2015). The participants were guaranteed that personal information would stay confidential. The questionnaires were generated by Google Docs, which does not send personal details like names, locations and mail addresses. This is also mentioned in the introduction of the questionnaire.

5. Results

The next chapter will provide the analysis of the research results. It contains six sections. Firstly, the demographics of our samples will be identified. After that, their vehicle usage will be visible. The third part of the results is the consumer's perception towards EVs. Next to that, the consumer's awareness will be shown. The last section covers the consumer's preferences. This includes the preferences towards EVs, their infrastructure and policy incentives.

5.1 Demographics

The first part of the results will cover the demographics of the participants. This includes gender, age, degree, income and lastly the living and working area (Lisbon). Of the 145 participants, 79 are female and 66 are male. In percentages, females have a share of 54,5% and males a share of 45,5%. The age of the participants ranged from 18 to 65. The participants of the questionnaire are distributed in four age groups, visible at the table below. The overall age median is 41. The median of female participants is 40 and for the male participants 44.

	18-29	**30-49**	**50-64**	**65+**	**Total**
Female	15,17%	24,14%	15,17%	0%	54,48%
Male	13,79%	17,24%	13,79%	0,69%	45,52%
Total	28,97%	41,38%	28,97%	0,69%	100%

Table 11: Demographics of respondents

The results regarding the highest degree are categorized into five parts: 12th grade, bachelor's degree, master's degree, doctorate and other. For 3,45% of the participants, the 12th grade is the highest degree. 46,21% (of the participant have a bachelor's degree and 42,67% a master's degree. The share of doctorates is 1,38%. At last, 6,21% of the respondents fulfilled a different degree then mentioned. The last part concerning the demographics is the yearly income. The income is classified into six groups, visible at table 12.

	€0-€10.000	**€10.000-€20.000**	**€20.000-€30.000**	**€30.000-€40.000**	**€40.000-€50.000**	**More than €50.000**
Female	5,52%	16,55%	12,41%	6,90%	4,14%	8,97%
Male	1,38%	12,41%	8,97%	8,28%	3,45%	11,03%
Total	6,90%	28,97%	21,38%	15,17%	7,59%	20,00%

Table 12: Responents divided by income groups

5.2 Vehicle usage

The second part of the questionnaire covers the vehicle usage of the respondents. The first questionnaire asks the respondents about which sort of vehicle they own and use. 46,21% of them uses a vehicle driven on diesel. Gasoline-driven vehicles have a share of 35,17%. Furthermore, 2,07% of the respondents use a PHEV. BEV and HEV user both have a share of 0,69%. Also, two participants answered with motorcycle (1,38%). Lastly, there are also respondents who do not use or drive a vehicle. This part has a share of 13,79%.

The second question concerning the vehicle usage inquires the respondents about the number of days they use their vehicle per week. Of the participants 4,83% uses their vehicle once a week, 11,72% two to three times per week, 8,28% three to four times per week, 11,72% five to six times per week and 51,72% uses their vehicle every day of the week. In addition, 11,72% does not use a vehicle at all.

The last part of this sections demands the average amount of days per week the participants enter the city centre of Lisbon with their vehicle. 9,66% enters the city centre once per week, 4,83% two times per week and 6,9% of the respondents three times per week. The last share (6,9%) also counts for the respondents that enter the city centre both five and six times per week. In addition, 3,45% enters four times. 33.79% of the respondents enter the city centre every day of the week. 12,41% does not enter the city centre with a vehicle at all.

5.3 Consumers' perception towards EVs

Regarding the consumer' perception towards EVs, the next section asks the respondents about the future interests in buying an EV. To the question of 'Do you see yourself driving an EV in the next five years?' 23,45% answered 'Yes as soon as possible', 30,34% 'Yes but I prefer to wait some months or years', 37,95% 'Maybe' and 8,28% 'No'. This is also visible at figure 8.

The answers of this question are compared with the education level of the respondents. From the respondents that possess a bachelor's degree, 20,9% sees themselves driving in EV as soon as possible. 34,3% of them prefers to wait for some months or years. 38,8% answered maybe and does not see themselves driving an EV in the future. The respondents that have a master's degree, 27,4% wants to drive an EV as soon as possible, while 9% prefers to wait. 32,2% replied with maybe and 11,2% with no.

In the same way, the consumer's perception is compared with the income of respondents. The most important findings of this comparation will be selected in the next part. The participants that opted the most for 'as soon as possible' are found in the income groups €40.000-€50.000 (36,4%) and > €50.000 (31%). The most participants that choose for 'I prefer to wait' are listed in income groups €10.000-€20.000 (35,7%) and €30.000-€40.000 (36,4%). Lastly, the participants of the income groups €40.000-€50.000 and > €50.000 replied with respectively 18,2% and 13,8% the most with 'no'.

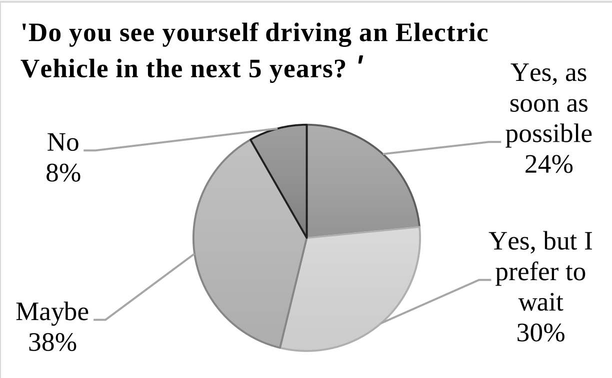


Figure 8: Consumers perception towards EVs

5.4 Consumers' awareness towards EVs

In relation to the consumer's awareness regarding EVs, we asked the respondents to the average range of an EV and about charging knowledge. The results regarding range awareness are presented at the table below. Concerning the awareness of awareness, the respondents were asked if they know how to charge an EV. To this question, 51,39% answered with yes and 48,61% with no.

Vehicle range	Respondents share
Up to 50 km	11,11%
Up to 100 km	3,70%
Up to 200 km	16,05%
Up to 300 km	30,86%
>300 km	19,75%
I don't know	18,52%

Table 13: Consumers awareness: Range

5.5 Consumers' preferences towards EVs

In the next section, the results regarding the EV preferences of the participants will be shown. Firstly, the most important reason for not buying an EV. 29,66% of them gave 'too expensive' as most important factor. 21,38% chose 'the risk of running out of power' and 20,69% 'I am not able to charge at home'. 6,9% of the participants answered with 'I prefer driving an ICE-driven vehicle'. 4,83% opted for 'I do not want to charge every day'. Lastly, the reasons 'vehicle charging takes too much time' and 'others' both had a share of 8,28%.

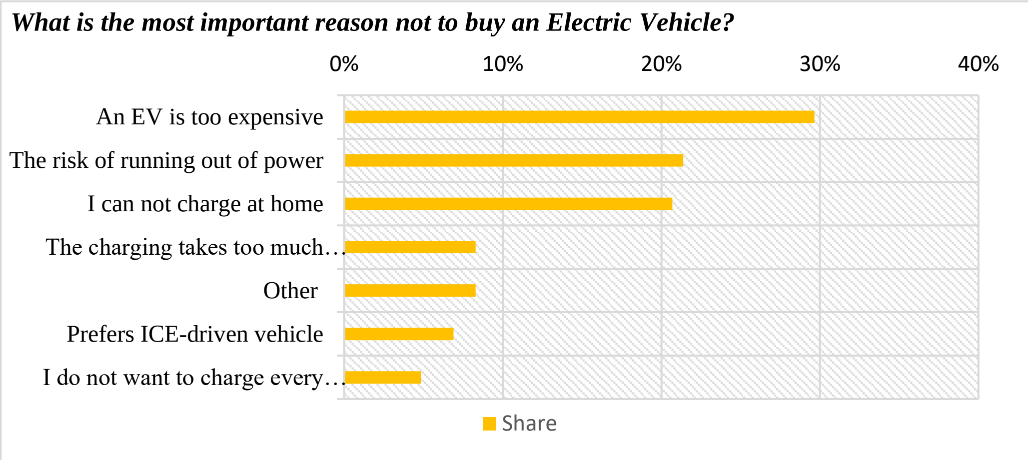


Figure 9: Consumers preferences (1)

The second part of this section inquires what the most important factor for buying an EV is. For 56,2% of the participants EVs being 'environmentally friendly' is the most important reason. 20,1% of them chose 'EVs are the future' and 16,7% gave 'Paying less or no tax' as number one reason. 4,2% gave the answer 'liking the technology' and 2,8% gave another reason. None of the respondents chose the option 'liking the design'.

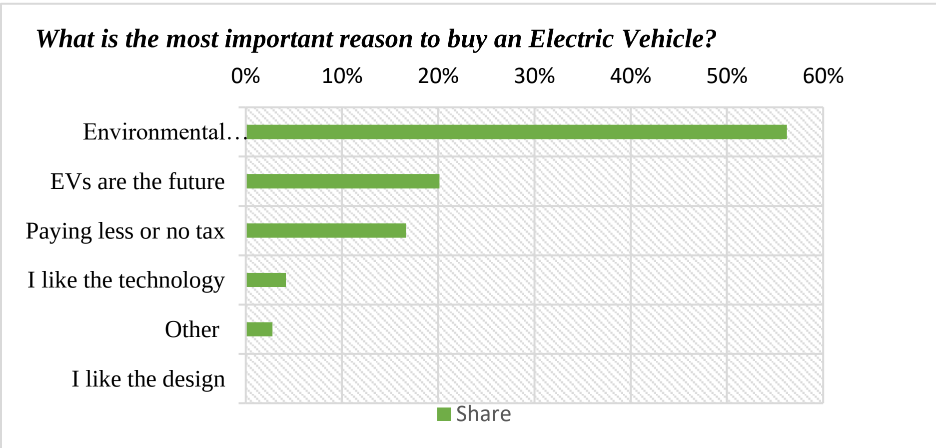


Figure 10: Most important reason to buy an EV

4.4.2 Consumers' preferences regarding infrastructure

Besides the EV preferences of the consumers, the preferences towards the EV infrastructure was asked. The participants needed to rate the following infrastructure options: charging spot at home, charging spot at work, public charging spots in the city centre, public charging spots on the highways, (public) fast charging spots and free parking spots. The rating series consisted of crucial, important, neutral, not important and I do not know.

Firstly, the home charging spots. 69% of the respondents voted this as crucial, 25,5% as important, 4,1% as neutral, 0,7% as not important and 0,7% as I do not know. Secondly, the charging spots at work. 31% found this crucial, 52,4% important, 12,4% neutral, 2,8% as not important and 1,4% did not know. Thirdly, the public charging spots within the city centre. 50,3% answered this as crucial, 37,9% as important, 10,3% as neutral and both options not important and neutral with 0,7%. Furthermore, the respondents were asked about the importance of charging spots at the highway. 58,6% answered with crucial, 31% with important, 8,3% with neutral, 1,38% with not important and 0,7% with I do not know. Another infrastructure element is the (public) fast charging spots. Of all the respondents, 60% chose crucial, 29,7% important, 8,3% neutral, 0,7% not important and 1,38% did not know. Finally, the free parking spots for EVs. 26,2% voted this as crucial, 42,8% as important, 25,5% as neutral, 4,14% as not important and 1,38% as I do not know. Figure 13 shows the share of participants that voted for crucial per element.

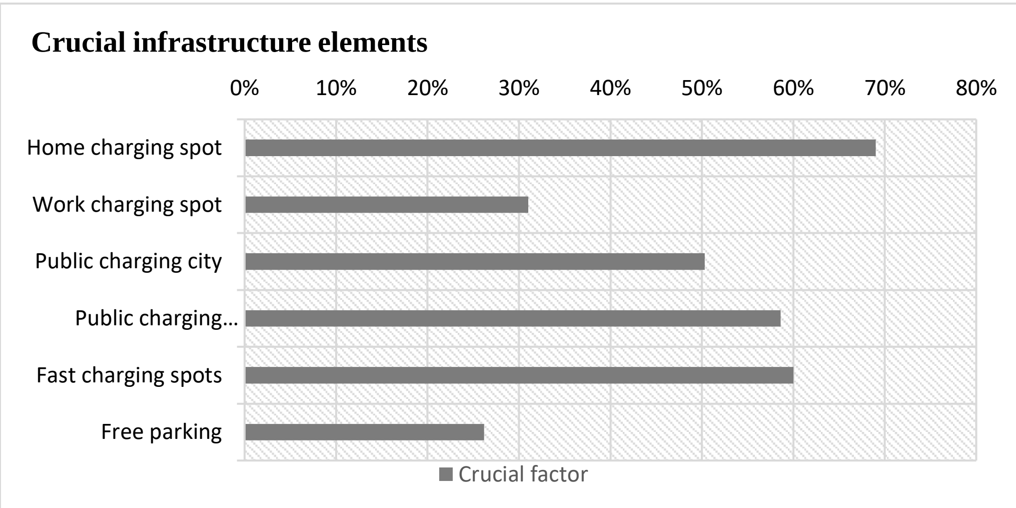


Figure 11: Crucial infrastructure elements

The participants were asked about another infrastructure point. This question examines if people would buy an EV if there was not a sufficient charging infrastructure available. 15,2% of them would buy an EV, 60% would not buy an EV and 24,8% answers with maybe.

In addition to this, the infrastructure preferences are divided into three groups: the participants that live and work in Lisbon, the participants that live in Lisbon and the participants that work in Lisbon. This can be seen below. The group that works and lives in Lisbon prefers home charging, public chargers in the city and the on the highway and fast charging spots. People that live in Lisbon prefer charging spots on the high way, fast charging spots and home charging. Finally, the people that work in Lisbon choose for charging spots at home. A big part of them also selected fast charging spots as crucial.

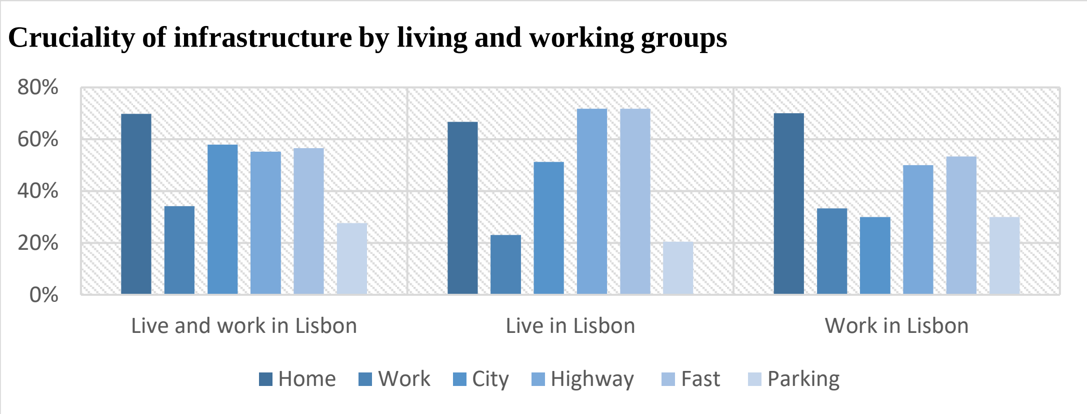


Figure 12: Cruciality of infrastructure by living and working groups

4.3.1 Consumers' preferences towards incentives

Concerning the incentives for EVs, the questionnaire inquired what the most important incentive is when buying an EV. 32,4% of the respondents chose for 'paying no or less purchase tax', 31% for 'paying less or no road tax', 29,6% for 'getting money back when buying an EV', 2% for 'Via Verde discount' and 4,8% chose 'other'. Additionally, the infrastructure preferences can be compared with the income of the respondents. Table 13 shows the share of votes of every income group.

	Less/no purchase tax	**Less or no road tax**	**Grant when buying an EV**	**Discount Via Verde**	**Other**
€0-€10.000	20%	30%	20%	10%	10%
€10.000-€20.000	35,7%	28,6%	30,9%	2,4%	2,4%
€20.000-€30.000	32,3%	29%	38,7%	0%	0%
€30.000-€40.000	22,7%	40,9%	27,3%	0%	9,1%
€40.000-€50.000	27,3%	18,2%	27,3%	9,1%	18,2%
>€50.000	41,4%	34,5%	20,7%	0%	3,4%

Table 13: Incentives preferences per income group

5.6 Additional information

Some of the respondents gave their own answers. Although these are counted as 'others', some of the answers could possibly add value to the research. Relevant answers are found in the question 'What is the most important reason not to buy an Electric Vehicle?', also mentioned in section 4.3.1. Three of them mentioned that they do not want to spend money on a vehicle because theirs is still working. Three other answers are: 'I do not see a reason to buy an EV', 'I do not know what the costs of saving/paying extra per month are comparing with a diesel car' and 'I think EVs are only effective in cities and short trips'. These three answers can be directly related to consumer awareness.

6. Conclusions

In the last years, the sales of EVs in as well as the market share in Portugal are growing. At the end of 2017, the share of EVs increased to almost 2% of all vehicles on the market. In percentages of the total market, Portugal belongs to the top ten countries with the highest share of EVs.

In Lisbon, most of the residential areas and buildings in Lisbon do not have accessible parking spaces. Therefore, EV users in Lisbon mainly have to recharge their vehicle at public charging spots. Concerning the public charging infrastructure in Lisbon, there were 147 normal charging points operational by MOBI.E at the end of 2017. At the same time, there were four fast charging points functional in the city centre of Lisbon. In the city centre there are no Tesla charging spots available. While the total numbers of EVs are 8260 (end of 2017), the total number of public charging spots is 1572. Following the charging number rule, one charging spot per 10 EVs (EU standard) or per 15 EVs (IEA standard) the number of normal charging spots in Portugal overall is sufficient. On the other hand, fast charging spots are rare in Lisbon and Portugal. Moreover, there are no Tesla charging spots operational in Lisbon. The last important note concerning the charging infrastructure is that Portugal is not a member of the IONITY infrastructure project. Besides a sufficient charging infrastructure, policy incentives make it also more attractive for consumers to buy an EV. When comparing incentives with the market share in Europe, it is certain that incentives in countries like Norway and Sweden, who both use an advanced incentive program, have a major impact on EV sales.

The main conclusions that are founded from the questionnaires will be discussed next. Concerning the consumer's perception, 54% of the respondents see themselves driving an EV in the future and of this part, 24% wants to drive an EV as soon as possible. 38% of the respondents did answer with maybe. Additionally, the share of respondents that sees themselves driving an EV is higher with people that have a bachelor’s or master’s degree than people with a lower degree. The same relationship is found with the respondents in the two highest income groups. The highest share of respondents that answered with ‘no’ are in these groups as well. Nevertheless, this share is way lower than the ones that opted for yes. Thus, consumers with a higher degree and income show more interest in driving an EV.

Regarding the consumer's awareness, almost 19% of the respondents do not know what to answer when they got asked about the EV range. Concerning the charging of EVs, 48% of the respondents do not know how to charge an EV.

Looking at the preferences of consumers towards EVs, the reasons 'too expensive, 'the risk of running out of power' and 'not being able to charge at home' are the major buying barriers for the respondents. Conversely, EVs 'being environmentally friendly' is seen as the most important reason for buying an EV. Also, the tax benefits and 'seeing the EV as the future' are buying stimulants for the respondents. Not one respondent opted for liking the design. Concerning 'too expensive', section 2.3.1 'cost barriers' showed that the EVs annual costs are not higher than ICE driven vehicles. Furthermore, there are EVs that have a lower purchase price that ICE driven vehicles.

The outcomes of the consumer' preferences for the infrastructure noticed a significant need for home charging spots. People that live in Lisbon show major importance in public charging spots, both in the city centre and on highways. Respondents show less interest in work charging spots and free parking for EVs. People that work in Lisbon do not show a significant interest in charging spots within the city centre.

Regarding EV incentives, respondents show almost similar importance in three options: pay less or no road tax, pay less or no purchase tax and receiving a grant while buying. A possible discount for Via Verde does not show a great interest. Participants with a yearly income that is higher than €50.000 prefer less or no purchase tax as an incentive. Participants with a lower income show more interest in grants and paying less or no road tax.

To summarize, EVs are not completely accepted by people in Lisbon yet. Most of the respondents drive a diesel or gasoline-driven vehicle. A part of them sees themselves driving an EV in the future but prefers to wait a bit. An important reason for this could be the lack of EV awareness and especially the awareness of their costs and range. The most mentioned barriers for this problem were the EVs being 'too expensive' and 'the risk of running out of power'. While in practice these specific barriers are not that high with most of the EVs available on the market. Another crucial point is the lack of home charging spots whilst the demand for home charging is high.

6.1 Research limitations

The sample size of this research of 145 is sufficient, but to be really sure if the outcomes of this research really represent the consumers more research needs to be done with a larger sample size. There are two research limitations found. Firstly, there are not enough participants with an income between €40.000 and €50.000. Secondly, Not enough participants with the age of 65+. One reason for this is that the search process for participants was time-consuming. Therefore, a larger sample can bring more realistic and reliable results regarding this topic.

7. Recommendations

Create more EV awareness

To increase the awareness of EVs and their infrastructure, local authorities together should encourage and educate consumers in Lisbon about EVs. They can do this together with organizations, like car brands. A suggestion to make this possible is via an open day for Electric Vehicles in Lisbon. In 2004, when there were no EVs on the roads, a day like this was already organized in Cascais to introduce consumers to EVs. Restarting an initiative like this, the consumer can learn about the EVs and their charging methods. Not only education is useful on this day, but it is also a day for car brands to promote their vehicles in a big city like Lisbon that carries so many attractive scenes.

An opportunity could be emerged by creating a platform or organization that can interact with EV drivers and consumers that want to know more about EVs. MOBI.E provides a part of this information like the possible charging spots in Portugal and information about legislation etcetera. To increase the level of awareness for consumers this is not enough. It lacks important information that the market and its consumer need. To be more precise, it lacks general news about EVs, user test or reviews, publications, simple charging instructions and other practical items that make it easier for the consumer to get in touch with the product. Local authorities, organizations and companies like Municipal de Lisboa, universities, environmental organizations and road management companies like Brisa might be interested in partnerships. This platform working together with several partners can potentially reduce the lack of EV awareness over the long-term and can add value to its market.

Another option is to let car brands visit companies, universities and even lower schools. In this way, a large group with a various age range is able to get in contact with EVs and learn about the EVs capabilities, costs and charging methods. A major part of the respondents sees EVs as 'the future'. This part will surely agree that especially the younger generation needs to be educated towards EV development.

Increase the number of fast charging spots in Lisbon

From the respondent's perspective, fast charging is the most demanded infrastructure element after home charging spots. To increase the number of fast charging points to a sufficient level, local authorities need to invest in more fast charging spots in the city centre of Lisbon. This can via operations like MOBI.E or in collaboration with fuel stations. Another way to make this happen is by becoming a partner with IONITY. This joint venture is opening fast charging spots all over Europe.

Redevelopment of policy incentives

On a macro level, the incentives scheme in Portugal should be reviewed. Other countries in Europe, especially Norway and Sweden, proved that the right choice of policy incentives can lower the barriers of purchase for consumers. Although Portugal economy-wise is not comparable with Norway and Sweden, there are elements that could be introduced in Portugal as well. The policy incentives that are used right now should be discussed and possibly redeveloped by the government. In the future, a bonus-malus system that is used in Sweden can be an option for Portugal to promote the usage of EVs and to reduce the polluted vehicles that are being used now.

All in all, EVs need to become more attractive for consumers. The acceleration of a high-standard EV infrastructure together with redevelopment of incentives can lessen the gap with ICE-driven vehicles in the future. This in combination with conceiving more EV awareness can potentially change the car market in Portugal and Lisbon.

Additional research

The research was well prepared and with the sample size of 145 respondents was sufficient. However, there are some limitations that needs to be acknowledged. With testing the questionnaire on a larger sample, it will be clear if the results of this research are valid for the complete population of Portugal. Also, it need to embrace all the demographic groups that are mentioned in this thesis.

Even though the emphasis within this research lies on the public charging infrastructure, the home charging situation cannot be ignored. The results of this research showed that there is a serious need for home charging spots by consumers in Lisbon. A new research or study must examine the need for home charging more in-depth for consumers in Lisbon.

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9. Appendix

Appendix 1 Questionnaire structure

Infrastructure for Electric Vehicles in Lisbon

Welcome,

This is a questionnaire for my Master Thesis regarding Electric Vehicles in Lisbon. This thesis is for the Master International Management course at ISCTE-IUL. The questionnaire is short. It will take around 5 minutes to answer the questions. Your personal information will not be used in this research.

Thank you for your participation.

Feel free to contact me for any questions or information at bob_vrosch@iscte-iul.pt

1. Personal information

AGE:
…

GENDER:
- Female
- Male
- Other…

HIGHEST DEGREE:
- Doctorate (Doutorado)
- Master’s degree (Mestrado)
- Bachelor’s degree (Licenciatura)
- Other…

INCOME (YEARLY):
- €10.000-€20.000
- €20.000-€30.000
- €30.000-€40.000
- €40.000-€50.000
- > €50.000
- Other…

DO YOU LIVE OR WORK IN LISBON?
- Yes, I live in Lisbon
- Yes, I work in Lisbon
- Yes, I live and work in Lisbon
- No, I do not live or work in Lisbon

2. Vehicle usage

WHAT KIND OF VEHICLE/CAR DO YOU USE?
- Battery electric vehicle (Full electric motor that needs to be charged. Without normal engine)
- Plug-in hybrid (Vehicle that has a normal engine and electric motor that can be charged)
- Hybrid (Normal engine and small electric motor that can not be charged)
- Gasoline (Normal engine)
- Diesel (Normal engine)
- LPG (Liquid Petroleum Gas)
- I do not have or drive a car
- Other…

HOW MANY DAYS DO YOU USE YOUR/A CAR WEEKLY?
- Every day
- 5-6 days
- 3-4 days
- 2-3 days
- Once a week
- I do not use a car at all
- Other…

HOW MANY DAYS PER WEEK DO YOU ENTER THE CITY CENTRE OF LISBON?

…

3. Electric Vehicles

DO YOU SEE YOURSELF DRIVING AN ELECTRIC VEHICLE IN THE NEXT 5 YEARS?

- Yes, as soon as possible
- Yes, but I prefer to wait some months or years
- Maybe
- No, never
- Other…

WHAT IS THE MOST IMPORTANT REASON NOT TO BUY AN ELECTRIC VEHICLE?

- The risk of running out of power
- Vehicle charging takes too much time
- I can not charge an electric vehicle at home (lack of infrastructure)
- I do not want to charge an electric vehicle every day
- Too expensive
- I prefer to drive a gasoline or diesel car
- Other…

WHAT IS THE MOST IMPORTANT REASON TO BUY AN ELECTRIC VEHICLE?

- Friendly for the environment
- Electric vehicles are the future
- I like the technology of electric vehicles
- I pay less/no taxes
- I like the design of electric vehicles
- Other…

ACCORDING YOUR EXPECTATIONS, WHAT IS THE AVERAGE RANGE OF AN ELECTRIC VEHICLE WITH A FULL BATTERY?

- Up to 50 km
- Up to 100 km
- Up to 200 km
- Up to 300 km
- More than 300 km
- I don't know

4. Infrastructure for Electric Vehicles

ARE YOU ABLE TO CHARGE AN ELECTRIC VEHICLE?

- Yes, I know how to charge an electric vehicle
- No, I do not know how to charge an electric vehicle

WHICH FACTORS REGARDING INFRASTRUCTURE ARE OR WOULD BE THE MOST IMPORTANT FOR YOU?

WHICH INCENTIVE (INCENTIVO/ESTÍMULO) WOULD BE THE MOST IMPORTANT FOR YOU?

- Get money back when buying an Electric Car (grant)
- Pay less or no road tax
- Discount Via Verde
- No or less purchase tax
- Other…

Appendix 2: Vehicle comparison

Brand	Model	Price ICE	Price PHEV	Price BEV
Audi	A3 (sportback): 1.0 TSFI 1.6 TDI e-tron	 €28.229,13 €29.223,74	 €45.115,00	X
BMW	3 series (sedan): 330d (diesel) 330i 330e i3	€43.580,00 (basic) €71.390,00 €52.770,00	 €49.960,00	 €38.250,00
Renault	Clio ZOE	€18.560,00	X	 €27.510,00
Smart	ForTwo	€11.220,00	X	€22.500,00
Tesla	Model S Model X	X	X	€88.050,00 €93.350,00
VW	Golf: GTI GTD GTE e-Golf	€25.062,00 (basic) €48.659,00 €46,543,00	 €45.145,00	 €40.879,00

Table 15: Vehicle comparison. Source: www.kbb.pt