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Battery electric vehicle adoption in Portugal and the Netherlands

Boudewijn Samsom

Master in Management

Supervisor:
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iscte BUSINESS SCHOOL

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Resumo

Embora a necessidade de uma redução de emissões seja mais evidente do que nunca, a electrificação da indústria dos transportes não é tão rápida como poderia ser. O que é que impede a adoção em massa de BEV? Uma razão importante é que a adoção de BEV está largamente dependente da aceitação dos consumidores privados, e a sua vontade de adotar este meio de transporte é insuficiente. Os principais obstáculos à limitação do alcance, preço de compra elevado e rede de carregamento insuficiente são importantes para se conseguir a adoção em massa de veículos elétricos. Nesta dissertação a consciência política e de incentivos, a consciência das características tecnológicas, a consciência ambiental, o conhecimento da tecnologia, as características de mobilidade e a demografia são testados para melhor compreender as principais razões para a adoção. É feita uma análise transnacional entre os Países Baixos e Portugal para observar se estas razões podem diferir por país. É realizado um inquérito online para responder às principais questões. São recolhidas e analisadas 400 respostas para compreender quais as variáveis importantes para conseguir a adoção em massa.

Palavras-chave*: intenção de compra BEV, consideração BEV, políticas e incentivos, características tecnológicas percebidas, consciência ambiental, características de mobilidade.*

L91- Transporte: Geral, O33 - Mudança Tecnológica: Escolhas e Consequências, Processos de Difusão

Abstract

Even though the need for an emission reduction is clearer than ever, the electrification of the transport industry is not as rapid as it could be. What is holding back the mass adoption of BEVs? An important reason is that the adoption of BEVs is largely dependent on the acceptance of private consumers, and their willingness to adopt this mode of transport is insufficient. The main barriers of limiting range, high purchase price and insufficient charging network are important to tackle in order to achieve mass adoption of electric vehicles. In this paper, policy and incentive awareness, technological characteristic awareness, environmental awareness, tech savviness, mobility characteristics and demographics are tested to better understand the main reasons for adoption. A cross-country analysis is done between the Netherlands and Portugal to see if these reasons might differ per country. An online survey is conducted to answer the main questions. 400 responses are gathered and analyzed to understand what variables are important to achieve mass adoption.

Keywords*: BEV purchase intention, BEV consideration, policies and incentives, perceived technological characteristics, environmental awareness, mobility characteristics.*

L91- Transportation: General, O33 - Technological Change: Choices and Consequences, Diffusion Processes

Table of Content

Glossary

Term	Explanation
BEV	A battery electric vehicle (BEV) is an electric vehicle that utilizes chemical energy that is stored in rechargeable battery packs
HEV	A hybrid electric vehicle is a type of hybrid vehicle that combines a conventional internal combustion engine (ICE) system powered by fossil fuels with an electric propulsion system.
PHEV	This is a hybrid electric vehicle with rechargeable batteries that can be restored to full charge by connecting a plug to an external electric power source.
ICE	Internal Combustion Engine is an engine which generates motive power by the burning of petrol, oil, or other fuel with air inside the engine, the hot gases produced being used to drive a piston or do other work as they expand.
AC	Alternating Current (AC) is a type of electrical current, in which the direction of the flow of electrons switches back and forth at regular intervals or cycles.
DC	Direct current (DC) is electrical current which flows consistently in one direction.

Chapter 1. Introduction

If humans want to continue to live on this planet, we have to start treating it differently. The United Nations stated that climate change is the defining issue of our time and we are at a defining moment (United Nations, 2019). However, it is difficult to change the way we are living. When analyzing today's industries, it is noticeable that they are structured to focus on efficiency and margin optimization (Barton, 2004). This has been done at the cost of our planet's health and resources (Jowit, 2010). In order to create a future on this planet, industries will have to focus on sustainable solutions. This has several implications, depending on the industry.

The mobility industry is one of the industries that needs to change significantly in order to tackle the challenge of becoming sustainable. In Europe in 2017, 27% of total EU-28 greenhouse gas emissions came from the transport sector and is the main cause of air pollution in cities. These CO2 emissions increased by 2.2% compared with 2016 (European Environment Agency, 2019). These emissions are mainly caused by the use of fossil fuel as energy sources. Since the invention of the first gas powered car in 1886 (37435, 1886), fossil fuels have grown to be the main power source for cars today. However, the use of fossil fuels as main energy source is not a sustainable option for the future (Environmental and Energy Study Institute, 2019). The use of fossil fuels to power vehicles leads to problems such as gas emissions, air pollution and high dependency on countries that supply these fossil fuels (Perera, 2017). In 2016, there were an estimated 1.23 billion vehicles on this planet according to the Wards Intelligence, of which the majority was powered by fossil fuels (Petit, 2017).

There are few alternative energy sources that offer more sustainable mobility solutions. At this moment, the most popular alternative energy source is electricity. In 2018 there were approximately 5.1 million electric powered vehicles on the road (International Energy Agency, 2019). Another alternative energy source is hydrogen power. However, this is a less explored energy source and is only available in a limited number of models. Nevertheless, these models are expected to increase in the near future with brands as Mercedes Benz already introducing models using this technology. In 2019, the GLC F-Cell was introduced. This is a vehicle that combines hydrogen and a battery to create a plug-in hybrid vehicle that uses both sources. This hybrid vehicle offers easy refuel options with hydrogen and charging possibilities for the battery.

Even though the majority of today's car fleet is powered by fossil fuels, the diffusion of electric vehicles has shown exponential increase over the last few years (International

Energy Agency, 2020). This alternative source is increasingly popular due to the problems caused by fossil fuel vehicles such as high emissions, air pollution and high dependency on countries that supply fossil fuels (Perera, 2017). However, not every country has shown the same increase in demand for electric vehicles. Therefore, it is relevant to analyze these differences to fully understand what drives the adoption of electric vehicles and what can be done to increase it. Some governments have shown great interest in increasing the electric mobility fleet in their country. One of these countries is Norway. Currently, Norway is leading the world with the highest ratio of BEV sales with 42.4% of all new vehicle sales in 2019 being BEVs (Opplysningsrådet for Veitrafikken, 2020). This is due to the national goal stated by the Norwegian Parliament that by 2025 all new cars sold have to be zero-emission. Another leading country is the Netherlands. The Netherlands has shown great increase in BEV sales over the last years. The well-developed charging infrastructure and government incentives are suggested to be among the main causes of the higher adoption rate. The Netherlands government has set the date for zero emission new cars sales at 2030. For this reason, the Netherlands will be analyzed in this research.

Another country that has shown progress is Portugal. Even though the deployment of the electric vehicle charging infrastructure has not been a priority for the country for a few years, they are currently expanding the infrastructure to keep up with the increased demand. This, together with attractive incentives, is expected to lead to a growth of the BEV fleet in Portugal. The differences between the Netherlands and Portugal can be caused by a number of factors. The use of different policies and incentives by both governments can be an important factor. Furthermore, the Dutch public charging infrastructure has been shown as the best in Europe (European Alternative Fuels Observatory, 2020). The ban of non-zero emission vehicles together with low emission zones is showcasing the urge to a more sustainable mobility industry.

BEVs offer some advantages compared to a fossil fuel competitor. Even though the purchase cost of BEVs are higher compared to fossil fuel competitors, the lower maintenance and fuel costs make BEVs cheaper than their competitors in the long run. The TNO calculated that the emission break-even point for a medium sized car is reached around 39.000 kilometers (TNO, 2020). It is important for consumers to be aware of these advantages to increase interest for BEVs.

1.1 Thesis objective

Multiple factors have been identified to influence the adoption of battery electric vehicles. This research will focus on identifying these factors and analyzing their importance in today's growing market. Therefore, the question that will be answered in this research is: "*What factors can influence people's consideration and intention to purchase battery electric vehicles?"* To answer this question, the following sub questions will be analyzed and answered accordingly.

1. *What is the effect of Policies & Incentives awareness on people's consideration and intention to purchase battery electric vehicles?*
2. *What is the effect of Perceived Technological Characteristics on people's consideration and intention to purchase battery electric vehicles?*
3. *What is the effect of Environmental Awareness on people's consideration and intention to purchase battery electric vehicles?*
4. *What is the effect of Mobility Characteristics on people's consideration and intention to purchase battery electric vehicles?*
5. *What is the effect of Demographics on people's consideration and intention to purchase battery electric vehicles?*

The research question will be analyzed using a cross-country analysis between the Netherlands and Portugal. It is important to analyze these countries in order to understand the differences in their adoption rates. The answers to these questions will have relevant implications for a variety of individuals and organizations. Firstly, car manufacturers can use this study to better understand what drives customer demand for electric vehicles. They can focus on the factors that are most important to increase the intention to purchase. As emission regulations are becoming stricter, it is important that manufacturers adapt to the electric vehicle trends in order to maintain or even increase their sales. Secondly, governments can use this research to better understand what effectively drives demand and how they can actively assist this transformation. The European Union is aware that the transportation industry has to decrease their emissions drastically in the upcoming years. Governments play a large role in the diffusion of electric vehicles (Hackbartha and Madlener, 2016). It is important to understand how specific policies and incentives drive demand. Lastly, consumers can use this work to understand the changes that are currently happening in the industry. They can learn about the advancements that have been made and the barriers that are currently being tackled by the manufacturers and governments. The thesis analyzes the main barriers for adoption and the ways that brands try to mitigate them.

1.2 Methodology

For this study, data is collected in the Netherlands and Portugal in order to analyze the difference between the variables that are being tested. An online questionnaire was designed to accurately test the different variables of the study. Two versions of the questionnaire were created. One version was created for the Dutch market, using Dutch vehicle statistics, policies and incentives. The other version was created for the Portuguese market, using Portuguese statistics, policies and incentives. The questionnaires were available in English, but also translated into Dutch and Portuguese. Both versions of the questionnaire were divided into different categories in order to engage the respondents as much as possible. The Portuguese and the Dutch questionnaire were distributed using a variety of platforms. LinkedIn, Facebook, Instagram, WhatsApp and e-mail were used to distribute the survey.

The data is collected in order to represent the above mentioned countries as accurate as possible within the limitations of time and budget. The Kruskal- Wallis and Mann-Whitney tests combined with a principal component analysis and a linear regression are done in order to determine the differences in means tested.

1.3 Thesis structure

Chapter 1 introduces the need for an alternative energy source in the mobility industry. Battery electric vehicles are currently seen as one of the best solutions for this industry. In chapter 2 current knowledge on electric vehicle adoption is reviewed and industrial practices and trends are identified. Current literature is analyzed to identify the main factors that drive BEV adaption. In chapter 3 the methodology is discussed. The method of data collection and the analyses are explained in detail. In chapter 4 the survey results and data analyses are elaborated. Lastly, in chapter 5 the overall conclusions of the research are drawn.

Chapter 2: Current knowledge and practices

In this chapter the current market of electric vehicles is analyzed and the main drivers of BEV adoption are discussed. The different electric vehicles are explained. Furthermore, the most important car manufacturers in today's BEV market are discussed, the available models and current sales are examined.

2.1 Industry analyses

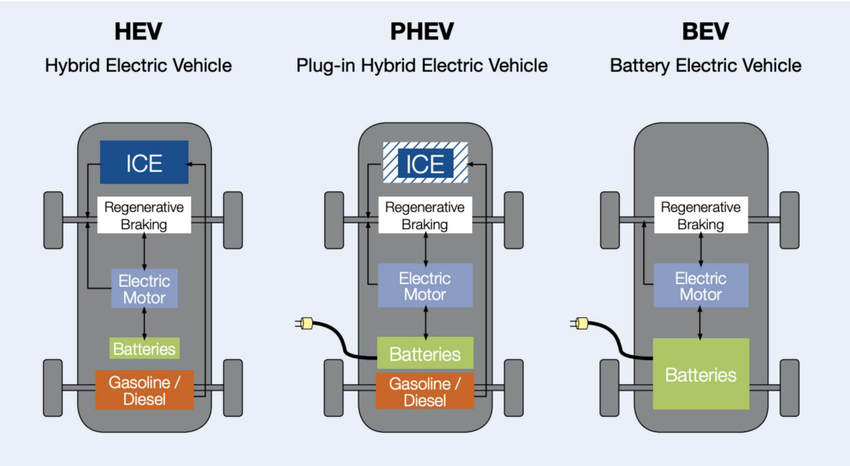
2.1.1 What are electric vehicles?

Vehicles can be powered in many ways. In the beginning of the mobility era, gasoline, steam and electricity were all used to power vehicles. However, due to advancements made in the internal combustion technology, as the electric starter, together with the benefits of greater range, quicker refueling times and the growing petroleum infrastructure led gasoline to become the dominant source of power in cars (Wakefield, 1998). Furthermore, due to the mass production of gasoline vehicles by companies as Ford Motor Company, the price of gasoline cars reduced to less than half of equivalent electric vehicles. Subsequently, this led to a decline in the use of electric engines, effectively removing it from important markets as the United States in the 1930's (The Department of Energy, 2014). However, due to the current global problems occurring from the use of fossil fuels such as gas emissions and air pollution, alternative sources are becoming more attractive. There is a great need for alternative energy sources that mitigate the negative effects caused by the use of fossil fuels. Currently, the most explored alternative energy source is electricity.

Electric vehicles mainly occur in 3 different types: Hybrid electric vehicles (HEV), plug-in hybrid electric vehicles (PHEV) and battery electric vehicles (BEV). A hybrid electric vehicle is a type of hybrid vehicle that combines a conventional internal combustion engine (ICE) system powered by fossil fuels with an electric propulsion system. The first mass-produced hybrid vehicle was the Toyota Prius, launched in Japan in 1997. These systems can offer cleaner transportation than purely fossil fuel vehicles, however, they still cause the same problems as gas emissions and air pollution. Secondly, there are plug-in hybrid electric vehicles (PHEV). A PHEV is a hybrid electric vehicle with rechargeable batteries that can be restored to full charge by connecting a plug to an external electric power source. This type of electric vehicles can offer a cleaner solution than HEVs, however, they still burn fossil fuels to power the internal combustion engine, resulting in emissions and air pollution. Lastly, vehicles can be powered by electricity completely. This type of vehicle is called a battery electric vehicle (BEV). A battery electric vehicle (BEV) is an electric vehicle that utilizes chemical energy that is stored in rechargeable battery packs. Electric vehicles use electric motors instead of internal combustion engines (ICEs). This type of vehicle can offer an end-of-pipe zero-emission solution.

Picture 2.1

Different type of electric vehicles (WWF World Wide Fund for Nature and Kendall, 2008)



Moreover, battery electric vehicles can offer a possible solution to the problems of emission, air pollution and high dependency on countries that supply fossil fuels. According to the International Energy Agency (2020) there are multiple reasons why electric mobility is preferred over the traditional fossil fuel mobility fleet. Firstly, BEVs are more energy efficient. EVs are three-to-five times more energy efficient than conventional internal combustion engine (ICE) vehicles (Global EV Outlook, 2020). This provides unmatched energy efficiency improvement potential for vehicle road transport. Furthermore, electric vehicles offer better energy security. Electric mobility boosts energy security as it transitions the road transport sector from its strong reliance on oil-based fuels. It reduces the dependence on oil imports from foreign countries. Furthermore, electricity can be produced with a variety of resources and fuels, and is often generated domestically. Thirdly, electric mobility causes less air pollution. Because of zero end-of-pipe emissions, EVs are well suited to address air pollution issues, especially in urban areas and along road networks, where a large number of people are exposed to harmful pollutants from road transport vehicles. Furthermore, electric mobility can decrease greenhouse gas emissions (GHG). An increasing electric mobility fleet in association with a progressive increase in low-carbon electricity generation can deliver significant reductions in GHG. In addition, electric vehicles are quieter than ICE vehicles and hence contribute to a reduction in noise pollution. Lastly, EVs are crucially positioned as a possible enabler of significant cost reductions in battery technology, one of the vital value chains of strategic importance for industrial competitiveness, given its relevance for the clean energy transition.

However, there are also some disadvantages that arise when discussing BEVs. As BEVs are a relatively new technology, the purchasing cost are currently higher than an ICE competitor. Secondly, due to the use of battery packs to store energy, the range of BEVs are much lower than their fossil fuel competitors (Schmalfuß *et al.*, 2017). Furthermore, the infrastructure to charge BEVs is not as widely available as gas stations currently are. This, together with higher charging times, creates a boundary for adaption which is discussed later in this chapter.

2.1.2 What battery electric vehicles are currently available?

Due to the benefits ICE vehicles offer at their low cost, it has been difficult for alternative energy sources to compete with them. However, due to the recent urge to find sustainable alternatives, the electric vehicle market has increasingly received attention. One of the most well-known electric vehicle companies is Tesla.

Early pioneer Tesla was founded in 2003 by engineers Martin Eberhard and Marc Tarpenning (Tesla Inc., 2019). The current CEO is Elon Musk, a well-known entrepreneur that joined the company as investor in series A of funding. In 2008, Tesla sparked the public imagination when it launched its first model the 'Roadster', a high-performance sports car (Wells and Weinstock, 2019). The Roadster was the first full electric production vehicle to use lithium batteries and reach a range of over 320 kilometers on a single charge (Shahan, 2015). In 2012, Tesla built their following model, the 'model S'. The model S, being bigger and less expensive, reached a wider target audience compared to Tesla's sportscar. The Model S was the top-selling plug-in electric vehicle worldwide in 2015 and 2016 (Shahan, 2017; Cobb, 2017). The release of Tesla's latest model, the Model 3, has made a significant impact on the electric vehicle market share (Hawkins, 2017). Within a week of unveiling the Model 3 in 2016, Tesla revealed to have received 325,000 reservations for their newest model (Bloomberg, 2016). In the Netherlands and Norway, the Tesla Model 3 became the most sold vehicle in 2019, showing the popularity of the model (Autoweek, 2020; Opplysningsrådet for Veitrafikken, 2020). The model 3 is currently available in the Standard Range Plus version that has an all-electric range of 409 kilometers and the Long Distance version can reach a distance of up to 560 kilometers before needing a charge (Tesla, 2019). This has been a big step forward for the BEV market because of the boundary of limited range BEV have compared to ICE vehicles. Subsequently, the increase of BEV range will decrease the gap between ICE vehicles and BEVs. However, Tesla was not the only pioneer in the battery electric vehicle market. In 2010, Nissan announced the world's first mass-market electric vehicle, the Nissan Leaf. In 2017, the second-generation of the Leaf was introduced. In March 2019, the Leaf became the first BEV model to reach 400,000 units sales (Nissan Motor Corporation, 2019).

As of April 2020, 31 different battery electric vehicles are available for purchase in the Netherlands (EV Database, 2020). Some of these models offer different battery sizes, making a total of 46 different types of BEVs that are available (EV Database, 2020). This number might seem low considering that around 300 different ICE vehicle models were sold in 2019 (Autoweek, 2019). However, leading automakers have announced plans to launch hundreds of new electric vehicle models before 2024 (Wells & Weinstock, 2019). For instance, Volkswagen has revealed that by 2023 they are planning to have invested over 30 billion dollars for their transition from fossil fuel vehicles (Matousek, 2019). By 2030, the company aims electric vehicle sales to be 40% of its global sales. Porsche similarly plans to invest in an electric vehicle future as they released their first electric vehicle, the Porsche Taycan. Together with the release of their new BEV, Porsche has announced plans to invest 6.6 billion euros in the electric vehicle industry by 2022 (Motavalli, 2019). By 2025, the company is predicting that half of the vehicles sold will be at least partly electric. This is necessary because, compared with traditional gasoline vehicles, high prices of EVs are one of the barriers preventing consumers from buying EVs (Larson et al., 2014; Degirmenci and Breitner, 2017; Lin and Wu, 2018).

2.1.3 Electric Vehicle sales

Not only manufacturers have been exploring the electric vehicle market, consumers have similarly shown approval increasingly (International Energy Agency, 2019). In 2018, the total electric vehicle market consisted of 5.2 million units. Close to two million of these electric vehicles were sold in 2018.

The sales of electric vehicles vary significantly depending on the country analyzed. China, for instance, has the biggest battery electric vehicle fleet with over 750,000 BEV sales, 4.5% of total vehicle sales in 2018 (International Energy Agency, 2019). Norway is leading with the highest BEV market share. In 2019, a record high of 42.4% of all new vehicle sales were Battery Electric Vehicles (Opplysningsrådet for Veitrafikken, 2020).

Besides Norway, the Netherlands has also shown increased market shares. In 2019, the overall most sold vehicle was the Tesla Model 3. With close to 30.000 Tesla Model 3 sales, it beat the 2018 most sold vehicle, the Volkswagen Polo, by almost 17.000 units (Autoweek, 2020). According to the Netherlands Enterprise Agency (2020) in 2019, the Dutch Battery Electric Vehicle market share reached 13.7% of total vehicles sales, which is a huge jump from 5.4% in the previous year. In comparison, in Portugal just shy of 7,000 Battery Electric Vehicles were sold in 2019 and a total market share of 3% was reached (Autoforma, 2019). Thus, the electric vehicle market of Portugal is significantly lower compared to the Netherlands. Several reasons can be identified to explain this difference.

2.2 Factors that influence consumer adoption

There are several reasons for people to purchase a battery electric vehicle. These reasons have previously been discussed in literature. Firstly, policies and incentives have been proven to be an important driver of battery electric vehicle adoption. Secondly, technological factors such as vehicle costs, driving range and charging time have been identified to affect battery electric vehicle adoption. Besides that, consumer knowledge is an important driver. This because there is a difference between actual policies and incentives, and technological aspects of the BEVs and the perception of them. Fourthly, since BEVs offer a more sustainable solution to transportation, environmental awareness has been shown to be a driver of BEV sales. Furthermore, mobility characteristics determine whether BEVs can easily fit someone's mobility needs and therefore can determine intention to adopt. Lastly, demographics can impact one's intention to purchase a battery electric vehicle. The above-mentioned factors will be discussed in the following paragraphs.

2.2.1 Policies & incentives

Policies and incentives of governments to support cleaner mobility have been important drivers for the growth of electric vehicles sales. In the early phases of BEV adoption, mass adoption relied heavily on governmental support (Li *et al*., 2017). Current government policies include financial subsidies, preferential tax, free parking and driving privileges (Li, Long, & Chen, 2016). All of these policies have been proven by previous research to have a positive effect on BEV adoption (Sang and Bekhet, 2015; Hackbarth and Madlener, 2013; Zhang *et al*., 2011; Helveston *et al*., 2015). Similarly, the magnitude of the monetary benefits affects the level of market diffusion (Hardman *et al*., 2017). Aasness and Odeck (2015) have argued that, from an economic perspective, BEV adoption is a consequence of economic incentives of current policies, which can help consumers save money. The variety of policies and incentives have different impacts on the market. For instance, the results of Ko and Hahn (2013) showed that consumers who have a high intention to adopt a BEV favor payment of subsidies at once, instead of installment payments. Similarly, Bjerkan *et al.* (2016) suggested that up-front cost decreasing measures, such as exemption or reduction of purchase tax and value-added tax, are the most powerful incentives in promoting BEV adoption. However, some studies suggested that the impact of policies are not as powerful as anticipated. Hoen and Koetse (2014) found in their study in the Netherlands, that policies including road tax exemption and fiscal incentives do lead to higher purchase intention, however, they were less successful in eliminating consumer's doubts about the technological attributes of the BEVs. The policies and incentives used, differ widely per country. For instance, the Norwegian government has been actively promoting BEV's through policies and incentives (Bjerkan et al, 2016). This has led to high levels of BEV adoption in Norway as seen in Figure 2.1.

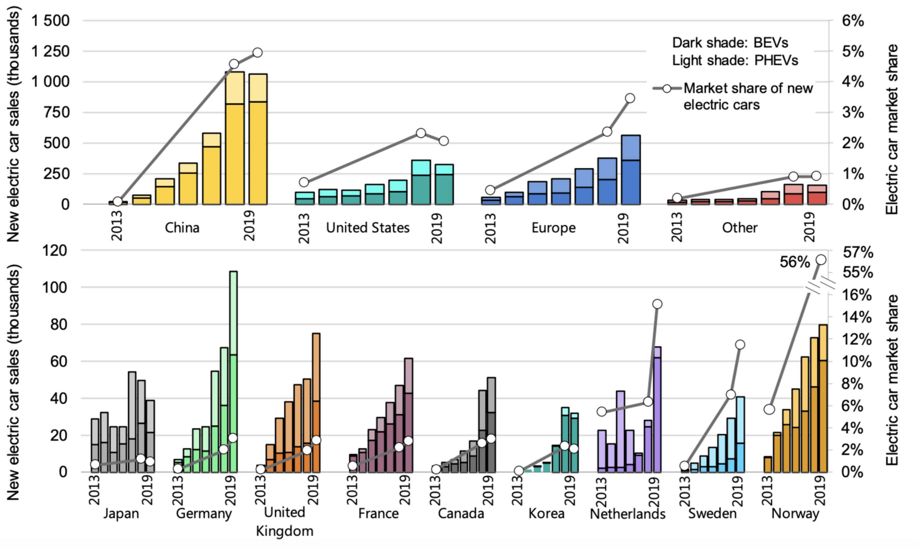


Figure 2.1 *Passenger electric car sales and market share 2013-2019 (EV Outlook, 2019)*

For policies and incentives to influence consumers purchase behavior, consumers must be aware of the policies and incentives provided by their government. Therefore, it is relevant to analyze the current consumer awareness of electric vehicle policies and incentives provided by the government. This study will analyze whether higher policy and incentive awareness will lead to a higher consideration of and intention to adopt BEVs. In the Netherlands the following policies and incentives are currently used:

- Additional charge (bijtelling) for fully electric cars is 8% (up to an amount of €45,000 and 22% for the price above).

- car and motor/motorized vehicle taxes (BPM)
- Vehicle tax exemption until 2025 (ACT)
- Reduced tax rate at charging stations
- The Environmental Investment Allowance (MIA)

In Portugal these policies and incentives are:

- € 2,250 incentive for the purchase of electric vehicles
- Vehicle Tax Exemption (ISV)
- Single Road Tax Exemption
- Autonomous Tax Exemption (0%) for businesses
- Depreciation of Electric Vehicles (EV) for tax purposes for businesses

Additionally, individual policy and incentive awareness is measures to determine the effect of individual policies and incentives on consideration and purchase intention of BEVs.

2.2.2 Technological characteristics

The technological characteristics of BEVs have shown to be important factors for adoption as they can be great enablers or cause boundaries. These characteristics can both enhance or reduce adoption. The technological characteristics that will be discussed comprise of vehicle range, charging and costs. The latter can be further split into purchase costs, fuel costs and maintenance costs. This paragraph will discuss these technological characteristics and their effect on adoption of BEVs.

2.2.2.1 Vehicle driving range

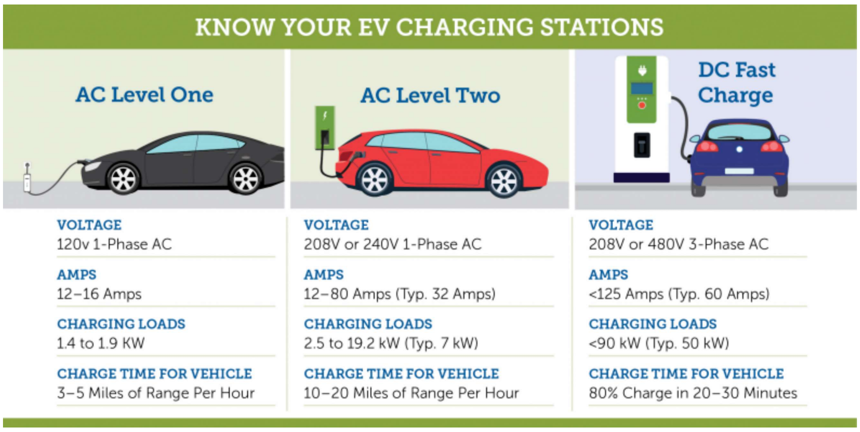
Firstly, vehicle range is an important characteristic that influences purchase behavior (Egbue and Long, 2012; Hackbarth and Madlener, 2016). Vehicle range is determined by the battery size, combined with the driving efficiency of the vehicle. The most commonly used battery type in modern electric vehicles are lithium-ion and lithium polymer, because of their high energy density compared to their weight (Eberhard, 2006). Due to use of batteries to store the fuel of the vehicle, the driving range of BEVs is limited. Therefore, the driving range was found to be one of the main barriers limiting consumer's purchase intention (Egbue and Long, 2012; Hackbarth and Madlener, 2016). Even though the demand for short trips has been met by today's BEVs, consumers still care about the total driving range and the demand for several long trips per month (Tamor *et al.*, 2015; Schneidereit *et al.*, 2015). This happens because consumers have been found to have a particularly high range preference which is found to always exceed their real demand (Franke and Krems, 2013). This can be explained by the high driving range consumers are accustomed to in their traditional fossil fuel cars, which makes consumers produce a similar preference for a battery electric vehicle (Franke and Krems, 2013). Franke and Krems (2013) found that individuals who have driven a BEV for 3 months decreased their range preferences during this period. This indicated that practical experience can play an important role in increasing the intention to adopt a BEV. A reason for this is that when consumers charge their vehicle overnight, they will have a fully charged vehicle if needed the next day. This is something that is different for fossil fuel vehicles. The fear caused by the limited range of BEVs is called *Range anxiety* (Pearre et al, 2011). Furthermore, when consumers have a more planned travel schedule, this reduces the range anxiety (Schmalfuß *et al*., 2017; Ryghaug and Toftaker, 2014). In other studies, it was shown that a timeframe of up to two weeks was sufficient for people to adapt to their range preference (Agerskov and Høj, 2013). Users referred to it as a 'mental blocking' that they need to get passed (Agerskov and Høj, 2013). There is a gap between people's perceived range satisfaction and actual range satisfaction. Furthermore, user's range satisfaction was also higher with more regular and predictable daily mobility patterns (Franke *et al*., 2017). To measure the effect of driving range on respondent consideration and purchase intention of BEVs perceived range is asked. Furthermore, it is important to educate individuals on driving ranges of currently popular BEVs.

2.2.2.2 Charging time

Secondly, vehicle charging is an important characteristic when considering purchasing a BEV. The charging time is determined by both the charging speed and the size of the battery. Other factors such as outside temperature can also affect charging times. However, these factors will not be analyzed in this study. The charging speed is determined by the maximum charging speed of both the vehicle and the charger. As seen in picture 2.2, there are two different types of charging: alternating current (AC) charging and direct current (DC) charging (Liu & Bie, 2019). The power from the grid is AC power. However, the batteries of electric vehicles can only store power as DC. Therefore, electric vehicles use a built-in converter to change the AC power from the grid to DC power. However, this limits the speed of charging to the conversion speed of the build-in converter. DC chargers have already converted the AC power and can therefore be charged at higher speeds. These chargers are called 'Superchargers' and offer a solution to the long charging times of AC chargers.

Picture 2.2

Different types of Electric vehicle charging stations (Brodd, 2017)



Charging stations can be categorised into private, semi-public, and public chargers. Private and semi-public charging refers to the charging points installed at home or workplace. Public chargers are chargers that are installed at public places such as airports, railway stations, shopping malls, traffic hotspots, highways, and parking lots. These charging stations make up the charging network. According to a Mckinsey survey, consumers rank not having enough access to efficient charging stations as one of the biggest barriers to EV uptake (Engel, 2018). Therefore, the charging infrastructure can play an important factor in the uptake of battery electric vehicles. To measure the effect of charging on consumer consideration and purchase intention perceived charging times are measured. Individuals are asked how long they perceive fast and slow charging a BEV will take. Furthermore, it is important to educate individuals on actual charging times of currently popular BEVs.

2.2.2.3 Charging infrastructure

In terms of charging infrastructures, Jensen *et al*. (2013) tested the impact of the ability for someone to charge at their work place, the number and location of charging stations in the public domain are crucial. However, Skippon and Garwood (2011) and Plötz *et al*. (2014) concluded that consumer demand for public charging stations, such as at supermarkets, parks or restaurants, is low. They found that consumers are more willing to charge BEVs at home, indicating that sufficient private charging infrastructure is more important to them. Currently, there is a lack of both sufficient public and private charging infrastructure (ACEA, 2019). Governments can help to mitigate this boundary by providing subsidies for domestic charging stations. Skippon and Garwood (2011) found that consumers who use a BEV are willing to pay a modest investment to upgrade their private charging stations. An increasing amount of companies are interested in playing a part in building this new infrastructure. For instance, a new company called 'IONITY' is building a fast charging station network in Europe. IONITY is a joint venture of BMW Group, Ford Motor Company, Mercedes Benz AG and Volkswagen Group with Audi and Porsche. Their goal is to build a high-power charging network for electric vehicles along major highways in Europe. (Ionity, 2020).

Additionally, the vehicle´s cost influences the consumer´s intention to purchase battery electric vehicle. Compared with ICE vehicles of a similar configuration, BEVs have a higher purchasing cost. This higher purchase cost is often discussed as a barrier to BEVs adoption. The main reason for this is that BEVs are a new technology and therefore cost more to produce. Due to the large investments made in the electric vehicle industry over the recent years, this gap is becoming smaller and the vehicles battery packs can be produced at a more competitive price. Besides that, BEVs have lower operational costs compared to ICE vehicles, enhancing their attractiveness (Lieven *et al.*, 2011; Adepetu and Keshav, 2015; *et al.*, 2013; Barth *et al.*, 2016).

Dumortier et al. (2015) argued the financial benefits from reduced energy consumption and low price of electricity can offset the high purchase cost in the long term. To enhance BEV sales, it is essential to educate consumers of the real savings by showing them how to calculate the total costs over the ownership period. However, although significant money can be saved by the energy conservation of BEVs, consumers with long driving ranges will benefit from it the most (Xu *et al.*, 2010; Plötz *et al.*, 2014). Additionally, consumers value current expenses more than the long-term savings of BEV (Dumortier et al., 2015). Although the benefits of BEV's in terms of cost may attract some consumers, these benefits are not noticeable in the short term. Therefore, short-term measures, such as larger economic incentives, can encourage consumers that are motivated by short term benefits (Dumortier *et al.,* 2015).

The above discussed technological characteristics are constantly evolving. It is therefore increasingly important that potential consumers are aware of these developments. The perceived technological characteristics as range, charging time, charging infrastructure and the involved costs are important to determine the intention to adopt BEV. In this research the perceived technological characteristics will be analyzed to determine how up to date individuals are. Next, these individuals will be given the correct information to test if this will affect their intention to purchase BEVs. To measure the effect of the charging infrastructure, the perceived charging network is measured. Furthermore, it is important to educate individuals on the actual charging infrastructure by showing them the number of charging stations within that country.

2.2.3 Environmental Awareness

An important advantage of electric vehicle mobility is the environmental benefits it offers. According to Noppers *et al*. (2014), environmental protection has become an important factor for attracting BEV consumers. Schuitema *et al*. (2013) suggested that consumers who consider themselves pro-environmental are more likely to be BEV adopters. Therefore, the promotion of BEVs should also emphasize the environmental protection aspect to improve the adoption rate (Peters and Dütschke, 2014). However, the importance of these environmental aspects varies as opposing studies have suggested that environmental protection is not the main concern of consumers (Graham-Rowe *et al.,* 2012). Furthermore, Axsen *et al.* (2012) suggested that some consumers question the ability of BEVs to provide environmental protection. This is due to the fact that environmental benefits of BEVs depend on a variety of factors and are difficult to calculate.

The benefits of driving BEVs include the decrease of air pollution, dependency on oil countries and greenhouse gas emissions. However, the latter is not as straightforward. For instance, the production of BEVs generate on average more emission than a gasoline or diesel competitor. Nevertheless, since electric vehicles are more energy efficient than their ICE competitors, they generate less emission per kilometer. Therefore, BEVs become more environmentally beneficial the more they are driven. The TNO calculated that the emission break-even point for a medium sized car is reached around 39.000 kilometers (TNO, 2018). Since the average lifecycle of cars is around the 220.000 kilometers, the BEV produce on average approximately 35-55% less emission. Furthermore, as the energy generation becomes greener, the emission lifecycle of a BEV will decrease further. These environmental advantages have been stated by various authors as driving factors for BEV adoption intentions (Prakash *et al.*, 2014; Noppers *et al.*, 2014). Egbue and Long (2012) and Carley *et al.* (2013) noted that consumers' awareness of environmental beliefs and environmental issues, values and norms positively affect people's intentions to purchase BEVs. In this study, environmental awareness is tested as a driver for the intention to purchase BEVs.
To measure the environmental awareness the New Ecological Paradigm (NEP) scale is used. Of the published measures that have been designed for the assessment of environmental attitudes, one scale appears to have documented reliability and validity and has gained

general acceptance is the New Ecological Paradigm scale (Dunlap et al. 2000). This scale will assess individual ecological worldview. Therefore, it will enable the assessment of the effect of environmental worldview on individuals consideration and intention to purchase BEVs.

2.2.4 Mobility behaviour

The next important factor to analyze is mobility behavior of consumers. Individuals have different mobility characteristics. These characteristics determine an individual's transportation needs and are important to determine an individual's potential fit for electric vehicle transportation. Due to the current BEVs technological limitations as limited range, long charging times and the charging infrastructure, BEVs are not a feasible option for everyone. Some consumers show better fit than others. It is important to determine these mobility characteristics to enable manufacturers to target the right customers.

Because BEVs have a limited range, individuals with a lower daily distance travelled, fit electric vehicle mobility better. Similarly, due to BEVs using regenerative breaking to re-convert the kinetic energy of the vehicle into electric energy, in stop-and-go traffic electric vehicles are more efficient compared with ICE vehicles. This type of mobility is seen more often in urban areas. Moreover, due to the pollution caused by ICE vehicles, especially cities are welcoming the zero-emission movement (Karathodorou *et al.*, 2010). Cities and local governments around the world continue to develop clean vehicle policies to reduce greenhouse gasses, improve air quality, and increase sustainability. These cities and local governments can create 'Low Emission Zones' (Settey *et al.*, 2019). These zones limit the access to heavy emission vehicles, as certain diesel cars or older vehicles. These zones can tighten their regulation on a yearly basis as for instance Amsterdam is doing (City of Amsterdam, 2020). By 2025, only zero emission vehicles are allowed to enter the city. Furthermore, BEV users are shown to be more satisfied when they have more regular and predictable daily mobility patterns (Franke *et al.*, 2017). Therefore, individuals with a more predictable mobility pattern show better fit to battery electric mobility. It is important to determine the mobility characteristics that best fit BEV mobility to determine the appropriate target audience. Therefore, this research will analyze various mobility characteristics and test the effect on the intention to adopt battery electric vehicles.

Mobility characteristics consist of multiple variables. The travel distance, time and frequency are examples of these characteristics. Since, individuals can travel for both leisure and work, it is important to measure both in order to get the full picture. Transporting other people and dealing with congestion are other important measures.

2.2.5 Demographics

Based on the previous research, young and middle-aged, well-educated male consumers are believed to have higher intentions to adopt BEVs (Hidrue *et al.,* 2011; Hackbarth and Madlener, 2013; Carley *et al.*, 2013; Prakash *et al.*, 2014; Plötz *et al.,* 2014). Multiple studies show that males are more likely to adopt BEV than females (Sovacool *et al.*, 2018; Plötz *et al.*, 2014). According to a McKinsey study (2014) in Norway, the drivers of EVs tend to have higher education than non-adopters, and they report being "highly motivated" by environmental issues (alongside issues of cost). When discussion occupation, Plötz et al. (2014) discovered that consumers who are working in technical professions show a higher preference for BEVs. This is in line with Egbue and Long (2012) and Hackbarth *et al.* (2016) that both suggest BEVs are more likely to be adopted by technology enthusiasts. Even though the purchase cost of a BEV is usually higher, research suggests income does not or has little influence the purchase intention (Hidrue *et al.,* 2011; Zhang *et al.,* 2011). Similarly, Bjerkan *et al.* (2016) found that income is a less prominent indicator when compared with gender, age and education. This research will analyze the effect of gender, age, education, income, tech savviness, geographical location on the intention to adopt BEVs.

To summarize all articles previously mentioned, a table is made to show what has been tested and measured before. This indicates the variables tested and the geographic locations of this research. The Netherlands has been tested previously multiple times, however research about the Portuguese market is limited. Furthermore, cross country analyses are not widely done previously. This indicates the gap in research and the value this research contributes.

Table 2.1

Overview of factors influencing consumers' purchase intention and consideration for battery electric vehicles

Autors	Year	Country	Results	
			Demographics	Other
Aasness and Odeck	2015	Norway		Economic incentives
Adepetu & Keshav	2015	United States		Battery capacity, purchasing cost, driving range
Agerskov & Høj	2013	Denmark		Battery capacity, purchasing cost, driving range, total cost of ownership
Axsen, TyreeHageman, Lentz	2012	United States		Pro-environmental lifestyle, technology oriented lifestyle and openness to change
Barth, Jugert, & Fritsche	2016	Germany		Purchasing cost, driving range, charging infrastructure, charging time, environmental effect, subjective social norm, collective efficacy, experience
Bjerkan, Nørbech and Nordtømme	2016	Norway	Age, gender, education	Purchasing cost, policy incentives
Carley, Krause, Lane, & Graham,	2013	United States	Education, gender, age	Charging time, driving range, charging infrastructure, charging time, fuel economy, purchasing cost, experience, environmental beliefs
Dumortier, Siddiki, Carley, Cisney, Krause, Lane, Rupp, Graham	2015	United States		Battery cost, driving range
Eberhard	2006			
Egbue & Long	2012	United States	Gender, age, education	Technological level, driving range, environment effect, safety, charging infrastructure, purchasing cost, sustainability, attitudes, perception awareness, technology awareness, experience, interest
Engel. Mckinsey	2018	China, Germany, United States		Electric-vehicle infrastructure
Franke & Krems	2013	Germany		Driving range, charging time, charging infrastructure, exemption of road tax, financial incentives
Franke, Günther, Trantow, & Krems	2017	Germany		Range satisfaction, daily travel distance, psychological range
Graham-Rowe et al.,	2012	United Kingdom		Purchasing cost, operation cost, maintenance cost, subsidy policy, environment effect, performance, safety, driving range, battery material, electricity source, charging
Hackbarth & Madlener	2013	Germany	Age, education, accessibility to plug-in vehicles at home	Fuel economy, emission reduction, driving range, charging infrastructure, exemptions of vehicle tax, free parking, bus lane access, environmental concerns
Hackbarth & Madlener	2016	Germany	Age, education	Charging time, driving range, charging infrastructure, environmental effect, fuel cost, policy incentives, environmental concerns
Hardman, Chandan, Tal, & Turrentine	2017			Financial purchase incentives, incentive awareness
Helveston et al.	2015	United States, China		Subsidy policy, driving range
Hidrue, Parsons, Kempton, & Gardner	2011	United States	Age, education	Driving range, purchasing cost, fuel cost, charging time, environmental concerns
Hoen and Koetse	2014	The Netherlands		Purchasing cost, fuel cost, total cost, financial benefit
Jensen et al.	2013			Driving range, top speed, fuel cost, purchasing cost, battery life, charging stations, carbon emission, experience, attitudes, environmental awareness
Karathodorou, Graham, & Noland	2010			Fuel demand, elasticity of demand
Ko and Hahn	2013	Korea		Policy incentives, charging infrastructure, swappable battery
Li, Long, Chen, & Geng	2017			
Lieven, Mühlmeier, Henkel, & Waller	2011	Germany		Purchase price, range, type, performance, social influence
Liu & Bie	2019	China		Public charging stations, AC charging, DC charging
McKinsey study	2014	Europe		Consumer demand, Industry developments, BEV costs, charging infrastructure
Noppers, Keizer, Bolderdijk, & Steg	2014	The Netherlands		Environmental attributes, functional attributes, symbols, social status
Pearre et al	2011	United States		Driving range, driving patterns
Peters & Dütschke	2014	Germany	Gender, age, number of family vehicles	Cost reducing policy, carbon emission, energy efficiency, value, experience, subjective social norm
Plötz, Schneider, Globisch, & Dütschke	2014	Germany	Gender, age, education, occupation, living place, size of family	Fuel economy, driving range, attitudes, experience, environmental beliefs

Prakash, Kapoor, Kapoor, & Malik	2014	India	Gender, age	Fuel economy, environmental effect, safety, vehicle power, reliability and early availability of vehicle in the market
Ryghaug & Toftaker	2014	Norway		user imaginaries, shared expectations, technology developments
Sang & Bekhet	2015	Malaysia	Gender, age, education, marital status, income, living place	Performance attributes, financial benefits, charging infrastructure, social influence, environmental concerns, experience
Schmalfuß, Mühl, & Krems	2017	Germany		BEV experience, range, pleasure, reputation, safety, low noice, satisfaction, usefulness, subjective norm, perceived behavioral control
Schneidereit, Franke, Günther, & Krems	2015	Germany	Gender, age, education, income	Driving range, experience
Schuitema et al.	2013	United Kingdom		Performance, driving range, purchasing cost, hedonic attributes, symbolic attributes, pro-environmental identity
Settey, Gnap, & Beňová	2019	United Kingdom		Low emission zones, regulations, exhaust emission, noice emission
Skippon and Garwood	2011	United Kingdom		Environmental effect, driving range, purchasing cost, charging infrastructure, charging time, acceleration, responsiveness, smoothness, low noise, openness, conscientiousness, agreeableness, symbolic value, environmental concern
Sovacool, Kester, Noel, & de Rubens	2018	Nordics		Energy policies, integration of renewables, intermittency, integration of renewables, electrification of transport and heat, technically managing intermittency, carbon intensity and emissions, reliability of local grids, and ensuring adequate capacity
Tamor, Gearhart, & Soto	2013	United States		Battery cost, driving range
Tamor, Moraal, Reprogle, & Milačić	2015	United States, Germany		Driving range, charging infrastructure
Wei, Bangxi, Zhixue, Dawei, Chuangang	2010	China		
Zhang, Yu, & Zou	2011	China	Number of driver's licenses, number of vehicles	Government policies

Chapter 3: Methodology

3.1 Electromobility in participating countries

Policies and incentives have proven to be an important influencer of BEV adoption (Li *et al.,* 2017). The main goal of these incentives is to cover the cost gap between BEVs and ICE vehicles. However, some governments want to cover more than this gap. The Norwegian government for instance, emphasizes on always making it financially more attractive to choose for the lower emission vehicle, despite this costing the government great amounts of money. Since the latest developments within the BEV industry, the cost gaps are becoming smaller and smaller. Therefore, policies and incentives are constantly evolving. In the Netherlands, driving a BEV is becoming more costly and thus less attractive, due to a decrease in policies & incentives. The additional tax liability that was 0% in 2017 will increase every year until it has reached the same amount of 22% as ICE in 2026. Currently, the additional tax is at 8% and will become 12% for BEVs in 2021.

3.2 Survey design

An internet-based survey was conducted to gather quantitative information about the population of both Portugal and the Netherlands. This survey was carefully designed in order to be ethically correct and measure the appropriate variables. First, the independent variables were analyzed and chosen accordingly. Next, the appropriate scales were gathered to analyze these variables. After gathering the right variables and scales, a first draft of the survey was developed. The survey was pre-tested among 20 master and PhD-students. After reviewing the feedback, the final version of the survey was created.

To start, the respondents were asked about their electric vehicle awareness, if they own a BEV, if have driven a BEV or if they know people that own a BEV (Franke and Krems, 2013). After this, individual tech-savviness was measured (Lavieri and Bhat, 2019; Tsouros, 2018). Furthermore, industry knowledge was tested. This was done by asking individual's perceived industry knowledge, BEV models awareness and the number of BEV models the respondents perceive to be for sale in the respondents country (Egbue and Long, 2012). After this, technology characteristics were measured. The perceived range, slow and fast charging time, and network were analyzed (Franke and Krems, 2013). Next, a Tesla Model 3 was compared with a gasoline powered BMW 3 series. Individuals were asked to compare the cost of, purchase, fuel, maintenance, ownership and lease cost between these vehicles. Another important factor tested was policies and incentive awareness. The perceived awareness together with the awareness of all individual policies used today by governments of the Netherlands and Portugal was tested. After this, individuals were asked what the probability was they would buy any vehicle in the next five years and if they had to purchase a vehicle, what the probability was that they would consider a BEV. Individuals were also asked what the probability is that they would purchase or lease a BEV within the next 5 years.

Following, the respondents were given current information about BEVs. The respondents were informed about the actual range, charging times and charging network within their country. They were also shown a cost comparison of the Tesla Model 3 and a BMW 3 series, the cars they were asked questions about before. Here they found the answers to the previously asked questions regarding vehicle cost. After this information, the respondents were once again asked what the probability was that they would purchase or lease a BEV within the next five years. Next, individual environmental awareness was tested. This was done by using the revised NEP scale proposed by Dunlap *et al.* (2000). Besides this, mobility characteristics were analyzed. This was done by asking the respondents about their transport modes in their most regular trips. Furthermore, mobility characteristics as travel distance, time and frequency for both leisure and business transportation were analyzed. Congestion and transport of other people and parking location and cost were similarly asked. Lastly, sociodemographic such as age, gender, education, income, occupation and area of residence were analyzed.

The survey consisted of two versions. One version was created for the Dutch market, using Dutch vehicle statistics, policies and incentives. The other questionnaire used Portuguese statistics, policies and incentives. The questionnaires were available in English, but also translated into Dutch and Portuguese. This was done to reach a broader audience that could more accurately represent the population. The final version was then tested among a small group of professionals that provided the final feedback. The survey was divided into different categories in order to engage the respondents as much as possible, and was distributed using a variety of platforms. LinkedIn, Facebook, Instagram, WhatsApp and e-mail were used to distribute the survey.

Chapter 4: Survey results and data analysis

4.1 Sample description

For this analyses, 400 complete responses were collected in both countries. In the Netherlands 253 responses were gathered. The Portuguese sample had 147 responses. As seen in figure 4.1, the Dutch sample was composed of 54.9% females and 45.1% males. The Portuguese sample was divided into 41.5% females and 48.5% males. Figure 4.2 depicts the age distribution of the respondents from both countries. Multiple age groups were used to present the distribution of the respondents ages across these groups. As seen in figure 4.3, the highest achieved academic diploma was also divided between multiple levels of degrees in both the Dutch and the Portuguese sample. Furthermore, the income levels are relatively normally distributed for both of the samples as shown in figure 4.4. The survey was distributed in order to represent the population as accurately as possible

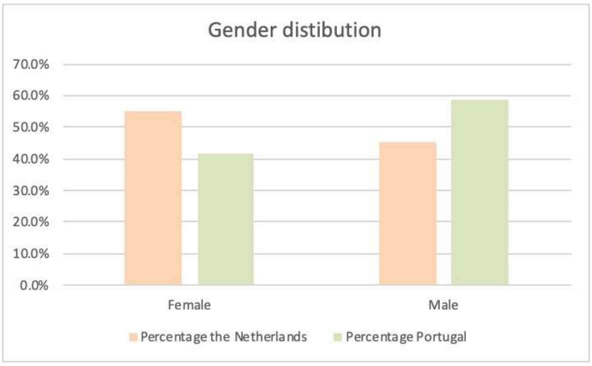


Figure 4.1 Gender distribution

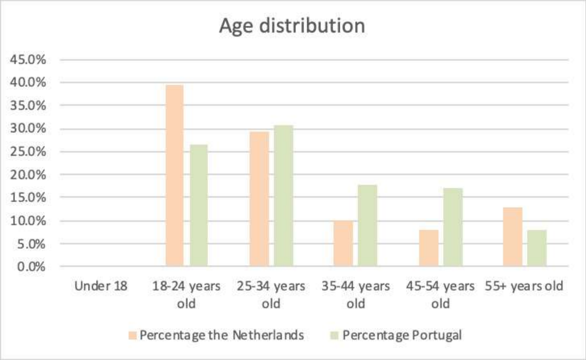


Figure 4.2 Age distribution

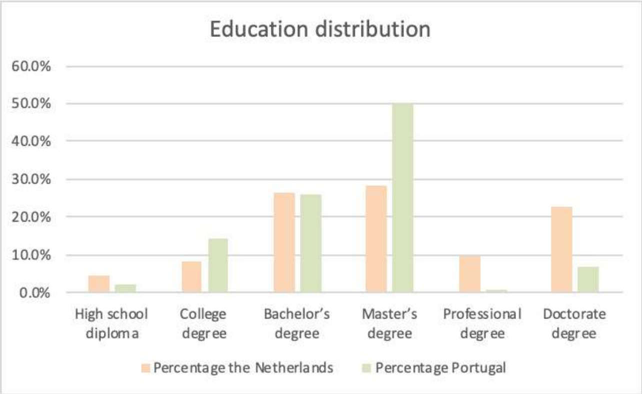


Figure 4.3 Education distribution

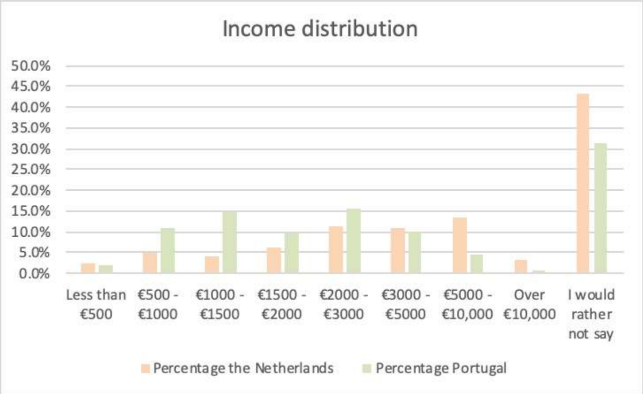


Figure 4.4 Income distribution

Table 4.1

Demographic frequencies the Netherlands and

Descriptor		Percentage the Netherlands	Percentage Portugal
Gender			
	Female	54.9%	41.5%
	Male	45.1%	58.5%
Age			
	Under 18	0.0%	0.0%
	18-24 years old	39.5%	26.5%
	25-34 years old	29.2%	30.6%
	35-44 years old	10.3%	17.7%
	45-54 years old	7.9%	17.0%
	55+ years old	13.0%	8.2%
Education			
	High school diploma	4.3%	2.0%
	College degree	8.3%	14.3%
	Bachelor's degree	26.5%	25.9%
	Master's degree	28.5%	50.3%
	Professional degree	9.5%	0.7%
	Doctorate degree	22.9%	6.8%
Income			
	Less than €500	2.4%	2.0%
	€500 - €1000	5.1%	10.9%
	€1000 - €1500	4.0%	15.0%
	€1500 - €2000	6.3%	9.5%
	€2000 - €3000	11.5%	15.6%
	€3000 - €5000	11.1%	10.2%
	€5000 - €10,000	13.4%	4.8%
	Over €10,000	3.2%	0.7%
	I would rather not say	43.1%	31.3%

Portugal

The demographics of Ashkrof *et al.* (2020) were used in order to check if the Dutch sample was representative of the population. Since the samples' demographics are similar, we justify the sample used in this study. The age and income demographics of the Portuguese sample show a normal distribution. Therefore, we assume a representative sample for the Portuguese sample.

To analyze the data, a few actions were taken to check the sample´s composition. First the samples are tested for normality in the replies of consideration to buy an EV and the intention to purchase an EV. This will determine what kind of analyses will be appropriate to use. Since the sample dimension is $n > 50$ the Kolmogorov-Smirnov's test is appropriate to test normality. The samples are divided into five equal groups of 20 from 0-100. Both samples cannot assume the distribution is normal since the null hypothesis is rejected ($p<0.05$). Since the sample is not normally distributed and there are less than 30 replies in some of the consideration and purchase intention levels, non-parametric tests will be applied to assess if there are statistically significant differences in the replies of the groups according to the tested variables. These non-parametric tests are Kruskal-Wallis and Mann-Whitney tests.

4.2 Cross-country comparisons of perceptions on electric vehicle adoption

In this subchapter, the results of the analyses are illustrated. The results from the Dutch and the Portuguese sample are compared and shown. Firstly, the respondent were asked to what probability they would consider a BEV if they had to buy a vehicle in the next five years. A variety of variables had a significant impact on individual's consideration. Furthermore, some of the variables show to have a significant impact in only one of the countries. After the consideration, the respondents were asked what the probability was that they would purchase a BEV in the next five years. Additionally, multiple variables had a significant impact on individual purchase intention.

Table 4.2

Statistics Portugal

		Consideration of BEVs	Purchase intention of BEVs before information	Purchase intention of BEVs after information
N	Valid	147	147	147
	Missing	0	0	0
Mean		76.5850	58.0068	58.2177
Std. Deviation		24.14592	28.86637	29.35342
Minimum		10.00	0.00	0.00
Maximum		100.00	100.00	100.00

Table 4.3

Statistics the Netherlands

		Consideration of BEVs	Purchase intention of BEVs before information	Purchase intention of BEVs after information
N	Valid	253	253	253
	Missing	0	0	0
Mean		65.9763	45.8577	51.3715
Std. Deviation		26.46545	28.50124	30.17128
Minimum		0.00	0.00	0.00
Maximum		100.00	100.00	100.00

Table 4.4

Consideration for BEVs

	P-value BEV consideration in Netherlands	P-value BEV consideration in Portugal
People who own a BEV	0.000*	0.269
People who have a EV in their household	0.023*	0.195
People that have driven a BEV	0.012*	0.006*
Knowing people that own a BEV	0.013*	0.095
BEV model awareness	0.024*	0.046
Knowledge BEV available for sale	0.025*	0.107
Knowledge slow charging	0.038*	0.350
Perceive charging network as "extremely bad"	0.513	0.030*
Perceive charging network as "somewhat good"	0.046*	0.645
Perceived fuel cost	0.002*	0.663
Perceived maintenance cost	0.036*	0.058
Perceived Total cost of ownership	0.001*	0.100
Perceived lease price	0.899	0.038*
Additional charge (bijtelling) for fully electric cars**	0.009*	-
Amount of transport modes	0.015*	0.179

*The significance level is .050 ** Dutch sample only

In the Netherlands, people who own a BEV show a significantly higher consideration for BEVs. Besides that, the people who have a EV in their household also show a higher consideration in the Netherlands. Furthermore, people who have driven a BEV show a higher consideration in both the Netherlands and Portugal. Besides that, people that have acquaintances that own a BEV show a higher consideration in the Netherlands. Also, people that correctly knew the amount of BEV models for sale at the moment of the survey, show a significantly higher consideration in the Netherlands. Also in the Netherlands, correctly knowing the time it takes to charge a BEV with a slow charger shows to have a significant positive effect on people's consideration for a BEV. In Portugal, the people who perceive the charging network to be 'extremely bad' show a significantly lower consideration for BEVs. In the Netherlands people who perceive the charging network to be "somewhat good" show a significant higher consideration. In the Netherlands, people who perceive "fuel cost", "maintenance cost" and "total cost of ownership" of a BEV to be lower than its fossil fuel competitor show a significantly higher consideration. In Portugal, a lower perceived lease price leads to a higher consideration. People that have knowledge of the Dutch additional charge (bijtelling) for fully electric cars incentive show a higher consideration for BEV's. Lastly, in the Netherlands, people that use more than one transport mode for their "regular trips" show lower BEV consideration.

Table 4.5

Intention to purchase BEVs

Variable	P-value BEV intention to purchase the Netherlands	P-value BEV intention to purchase Portugal
People who own a BEV	0.016*	0.144
Knowing people that own a BEV	0.217	0.014*
Up to date on the automotive industry	0.781	0.040*
Knowledge fast charging time	0.010*	0.202
Perceived charging network	0.035*	0.480
Perceive charging network as "extremely bad"	0.018*	0.205
Perceive charging network as "somewhat bad"	0.049*	0.411
Depreciation policy**	-	0.020*
Autonomous tax exemption**	-	0.008*
Amount of transport modes	0.043*	0.048*
Kind of parking at home	0.271	0.027*

*The significance level is .050 ** Portuguese sample only

In the Netherlands, people who own a BEV have a significant higher intention to purchase BEVs. However, in Portugal, having acquaintances that own a BEV shows a significant positive effect on the intention to purchase a BEV. Furthermore, being up to date on the automotive industry also shows to have a significantly positive effect on the intention to purchase BEVs in Portugal. In the Netherlands, people who have knowledge about the time it takes to charge a BEV using a fast charger show significant higher intention to purchase. Besides that, people who perceive the charging network to be "extremely bad" or "somewhat bad" show significantly lower intention to purchase a BEV in the Netherlands. In Portugal, the knowledge of the "Depreciation policy" and the "Autonomous tax exemption" incentive show a significantly higher intention to purchase BEVs. Furthermore, people who only use one transport mode for their regular trips in both the Netherlands and Portugal show a significant higher intention to purchase BEV's. Lastly, people who have a parking garage at home in Portugal also show a higher intention to purchase.

Table 4.6

Difference in consideration and purchase intention between the Netherlands and Portugal

Variable	P-value BEV consideration	P-value BEV intention to purchase
Country of residence	0.000*	0.020*

*The significance level is .050

The country of residence shows a significant effect in both the consideration and intention to purchase a BEV. People are both more willing to consider a BEV and are more willing to purchase a BEV in Portugal in comparison to the Netherlands.

Table 4.7

Difference in the effect of educating people between the Netherlands and Portugal

A Wilcoxon Signed Ranks Test	Z	Sig.
Intention to purchase a BEV before – after education, *The Netherlands*	-5.853b	0.000*
Intention to purchase a BEV before – after education, *Portugal*	-.905b	0.365

b. Based on negative ranks.

Both the Dutch and the Portuguese sample were asked what the probability was that they would buy a BEV within the next five years. After this question, both samples were educated with current information regarding the electric vehicle infrastructure in their country and a comparison was show between several aspects of the new Tesla Model 3 and its gasoline competitor the BMW 3-series. After this information was shown, the respondents were asked again about their intention to purchase a BEV within the next five years. A Wilcoxon Signed Ranks test was done to determine the difference between the data gathered with these questions. The intention to purchase a BEV significantly increased in the Dutch sample after they were educated about the current electric vehicle infrastructure in their country. However, in the Portuguese sample, the intention did not significantly change.

4.3 Perceptions on electric vehicle adoption at a European level

The following subchapter contains the results of both the Dutch and the Portuguese samples combined. This is done for variables that did not vary on the country being analyzed.

Table 4.8

The effect of policies and incentives on consideration and purchase intention of BEVs

Variable	P-value BEV consideration	P-value BEV intention to purchase
Policy awareness	0.034*	0.030*
Additional charge (bijtelling) for fully electric cars**	0.009*	0.801
Depreciation of Electric Vehicles***	0.467	0.020*
Autonomous Tax Exemption for businesses***	0.648	0.008*

*The significance level is .050 ** Dutch sample only *** Portuguese sample only

The first variable tested is the variable “Policies & Incentives”. Firstly, the effect of the amount of policies people are aware of on their consideration and the intention to buy a BEV was analyzed. Next, the awareness of the individual policies were tested to see if they affect the consideration for and intention to adopt BEVs. The Kruskal-Wallis test shows a significant difference between the different number of policy awareness for both consideration as well as intention to purchase. For the consideration of BEVs, people that are aware of one policy show significantly lower consideration compared to people who aware of all five policies. However, for the intention to adopt BEVs, knowledge of five policies was significantly higher compared to zero, one, two and three.

A few policies showed a significant effect on the consideration and intention to purchase BEVs. Firstly, the only policy that showed significance in the Netherlands was the additional charge for fully electric cars. This policy showed a significant positive effect on people consideration of BEVs. In Portugal, two policies had a positive significance. The “Depreciation of Electric Vehicles”, and the “Autonomous Tax Exemption for businesses” policies both showed a significant effect on the intention to purchase.

Table 4.9

The effect of demographics on consideration and purchase intention of BEVs

Variable	P-value BEV consideration	P-value BEV intention to purchase
People who own a BEV	0.000*	0.006*
People who have a EV in their household	0.050*	0.215
People that have driven a BEV	0.000*	0.268
Knowing people that own a BEV	0.039*	0.020*
Up to date on the automotive industry	0.001*	0.211
BEV model awareness	0.000*	0.096
Knowledge BEV models available for sale	0.007*	0.042*
Knowledge slow charging	0.002*	0.141
Age	0.000*	0.427
Country of residence	0.000*	0.020*

*The significance level is .050

The demographics also had significant effects on the consideration of and intention to purchase a BEV. Firstly, people who own a BEV are both more willing to consider and purchase a BEV. Besides that, having an EV in the household shows to have a significant positive effect on the consideration of BEVs. Furthermore, people that have driven a BEV show a higher consideration of BEVs. Also, having acquaintances that own a BEV has a significant positive effect on both the consideration for and the intention to purchase a BEV. People that are up to date on the automotive industry show a higher consideration for BEVs. Furthermore, the more BEVs people know the higher people’s consideration for BEVs. Additionally, people that correctly know the amount of models that are for sale, show to have a higher consideration and intention to purchase a BEV. Furthermore, knowledge of the time it takes to fully charge a BEV shows to have a positive effect on the consideration of BEVs. Lastly, age shows to have a significant influence on the consideration of BEVs. The age group of “35-44 years old” and “45-54 years old” showed the highest consideration. Both “18-24 years old” and “55+ years old” show a significant lower consideration for BEVs.

Environmental awareness

To analyze the environmental awareness the NEP scale is used. This scale is made up of 15 questions regarding environmental difficulties. To analyze the effect of environmental awareness on peoples consideration and purchase intention of BEVs, the principle component analysis (PCA) is used first. Following, the principle components were used in a linear regression to test their significance.

To start, the correlation matrix is analyzed. Since all values exhibit high correlations, above 0.4, we can continue to the Kaiser-Meyer-Olkin (KMO) test. The KMO is 0.792 indicating a good fit for the PCA for this data sample. Next, the Barlett’s test shows significance of 0.000. Therefore, the correlation matrix (in the population) is not the identity matrix. Question 2, question 6, question 9 and question 12 were taken out of the PCA due to low values in the component matrix of below 0.5. The PCA divided the questionnaire into three components explaining 54,035% of the data. Component 1 can be summarized by the name “Humans integration with the environment”. Component 2 can be summarized as “Natures balance”. Lastly, component 3 can be summarized as “Humans control over nature”.

Table 4.10

KMO and Barlett’s Test for NEP scale

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.792
Bartlett's Test of Sphericity	Approx. Chi-Square	788.696
	df	55
	Sig.	0.000

Table 4.11

Total variance explained for NEP scale

Total Variance Explained

Component	Initial Eigenvalues Total	Initial Eigenvalues % of Variance	Initial Eigenvalues Cumulative %	Extraction Sums of Squared Loadings Total	Extraction Sums of Squared Loadings % of Variance	Extraction Sums of Squared Loadings Cumulative %	Rotation Sums of Squared Loadings Total	Rotation Sums of Squared Loadings % of Variance	Rotation Sums of Squared Loadings Cumulative %
1	3.266	29.693	29.693	3.266	29.693	29.693	2.734	24.857	24.857
2	1.669	15.177	44.870	1.669	15.177	44.870	1.754	15.944	40.801
3	1.008	9.165	54.035	1.008	9.165	54.035	1.456	13.234	54.035
4	0.909	8.261	62.296						
5	0.787	7.150	69.447						
6	0.732	6.653	76.099						
7	0.629	5.716	81.815						
8	0.568	5.161	86.976						
9	0.538	4.887	91.863						
10	0.474	4.308	96.171						
11	0.421	3.829	100.000						

Extraction Method: Principal Component Analysis.

Table 4.12

Rotated Component Matrix for NEP scale

Rotated Component Matrix[a]

	Component 1	Component 2	Component 3
NEP Q1	0.634		
NEP Q3	0.625		
NEP Q4			0.830
NEP Q5	0.630		
NEP Q7	0.591		
NEP Q8		0.840	
NEP Q10		0.728	
NEP Q11	0.632		
NEP Q13	0.663		
NEP Q14			0.777
NEP Q15	0.562		

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 5 iterations.

Tech savviness

To analyze people's tech-savviness two scales are used. These scales are made up of eight questions regarding someone's dependency on technology. To analyze the effect of tech-savviness on peoples consideration and purchase intention of BEV's, first the principle component analysis is used. Thereafter, the principle components are used in a linear regression to test their significance. To start, the correlation matrix is analyzed. Since all values exhibit high correlations, above 0.4, we can continue to the KMO. The KMO is 0.809 indicating a good fit for the PCA for this data sample. Next, the Barlett's test shows significance of 0.000, therefore H_0 is rejected, meaning the correlation matrix (in the population) is not the identity matrix. Question 6 was taken out of the PCA due to a low value in the component matrix of below 0.5. The PCA divided the questionnaire into 2 components explaining 62,94% of the data. Component 1 can be summarized by the name "Use of technology in everyday life". Component 2 can be summarized as "Life without technology".

Table 4.13

KMO and Barlett's Test for Tech-Savviness scale

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.809
Bartlett's Test of Sphericity	Approx. Chi-Square	770.090
	df	21
	Sig.	0.000

Table 4.14

Total variance explained for Tech-Savviness scale

Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.264	46.631	46.631	3.264	46.631	46.631	2.656	37.950	37.950
2	1.142	16.310	62.940	1.142	16.310	62.940	1.749	24.990	62.940
3	0.773	11.038	73.978						
4	0.589	8.418	82.396						
5	0.439	6.275	88.671						
6	0.414	5.917	94.588						
7	0.379	5.412	100.000						

Extraction Method: Principal Component Analysis.

Table 4.15

Rotated Component Matrix for Tech-Savviness scale

Rotated Component Matrix[a]

	Component	
	1	2
Tech-Savviness Q1	0.787	
Tech-Savviness Q2	0.802	
Tech-Savviness Q3	0.746	
Tech-Savviness Q4	0.640	
Tech-Savviness Q5	0.631	
Tech-Savviness Q7		0.799
Tech-Savviness Q8		0.823

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 3 iterations.

Linear regression Environmental awareness and Tech-savviness

The environmental awareness and tech savviness principle component are used in a linear regression to test their effect on the consideration and purchase intention of BEVs. Firstly, regression tested the components effect on consideration of BEVs. The adjusted R^2 for this analysis is 0.043. This indicates that these component have a very low impact on overall consideration of BEVs. The components that show a significant effect on people's consideration of BEVs are component 1 "Humans integration with the environment" and component 2 "Natures balance" of the environmental awareness scale. Besides that, component 2 "Life without technology" of the tech-savviness scale also showed a significant effect on people's consideration of BEVs. All these components had a significant positive impact on consideration. After this, the effect on purchase intention is measured. The adjusted R^2 for this regression is 0.014, indicating a very low effect of the components on the purchase intention. Only component 1 "Humans integration with the environment" had a significant effect on the purchase intention. This is a positive effect.

Table 4.16

Linear regression model summary of the principal components on consideration of BEVs

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.237[a]	0.056	0.043	24.75471

a. Predictors: (Constant), Life without technology, Use of technology in everyday life, Natures balance, Humans control over nature, Humans integration with the environment

Table 4.17

Linear regression Coefficients of the principal components on consideration of BEVs

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	70.240	1.299		54.060	0.000
	Humans integration with the environment	3.106	1.344	0.123	2.311	0.021
	Natures balance	3.073	1.318	0.121	2.332	0.020
	Humans control over nature	0.640	1.327	0.025	0.482	0.630
	Use of technology in everyday life	1.610	1.319	0.064	1.221	0.223
	Life without technology	2.703	1.369	0.107	1.975	0.049

a. Dependent Variable: Consideration

Table 4.18

Linear regression model summary of the principal components on purchase intention of BEVs

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.167[a]	0.028	0.014	27.74175

a. Predictors: (Constant), Life without technology, Use of technology in everyday life, Natures balance, Humans control over nature, Humans integration with the environment

Table 4.19

Linear regression Coefficients of the principal components on purchase intention of BEVs

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	57.113	1.456		39.224	0.000
	Humans integration with the environment	3.195	1.506	0.114	2.121	0.035
	Natures balance	1.906	1.477	0.068	1.291	0.198
	Humans control over nature	-1.386	1.487	-0.050	-0.932	0.352
	Use of technology in everyday life	0.922	1.478	0.033	0.624	0.533
	Life without technology	1.194	1.534	0.043	0.778	0.437

a. Dependent Variable: WillingnessPurchaseBEV

Table 4.20

The effect of Perceived technological characteristics on consideration and purchase intention of BEVs

Variable	P-value BEV consideration	P-value BEV intention to purchase
Perceive charging network as "extremely bad"	0.214	0.022*
Perceived maintenance cost	0.006*	0.181
Perceived Total cost of ownership	0.003*	0.281

*The significance level is .050

The perceived technological characteristics also showed some significant results. For instance, the people who perceive the charging network as “extremely bad” show a significantly lower purchase intention. Individuals who perceived the maintenance cost and total cost of ownership of BEVs to be lower than ICE vehicles, show a significant higher consideration for BEVs.

Table 4.9

The effect of Mobility characteristics on consideration and purchase intention of BEVs

Variable	P-value BEV consideration	P-value BEV intention to purchase
Amount of transport modes	0.000*	0.000*
Congestion to work	0.024*	0.120
Transport other people	0.030*	0.261
Kind of parking at home	0.364	0.038*

*The significance level is .050

Furthermore, individual mobility characteristics showed to have an effect on consideration and purchase intention. People that use one transport mode on their "most regular trips" show a significantly higher consideration and purchase intention for BEVs. Besides that, people who have congestions on their way to work also showed a higher consideration. People who "rarely" transport other people on their way to work show a lower consideration for BEVs than people who "always" transport people on their way to work or people who transport people on their way to work "half of the time". Lastly, people who have a private garage at home show a significantly higher purchase intention.

4.4 Discussion

In this subchapter, the results are discussed. Firstly, the variables that have a significant impact on both the consideration and the purchase intention are discussed. After this, the variables that only have an effect on individuals consideration are discussed. Thirdly, the variables that have a significant impact on purchase intention are discussed. Lastly, the variables that differ between the Netherlands and Portugal are discussed and potential explanations are made.

What has an effect on both Consideration and Intention to Purchase?

A few variables that were tested show a significant effect on both the consideration and the intention to purchase in the next five years. Owning a BEV or knowing someone who owns a BEV are both important factors of influence. BEVs are a new technology, and therefore adoption of BEVs takes time. Diffusion is the process by which an innovation is communicated through certain channels over time among members of a social system

(Rogers, 2003). Rogers (2003) explains the diffusion of innovations. He found that earlier adopters have more social participation, are more highly interconnected in the interpersonal networks of their system, are more cosmopolite, have more contact with change agents, greater exposure to mass media channels, and greater exposure to interpersonal communication channels, engage in more active information seeking, and have greater knowledge of innovations, and a higher degree of opinion leadership.

The knowledge of the amount of BEV models that are available for sale also has a significant effect on both consideration and the intention to purchase a BEV in the next five years. As mentioned by Li et al. (2017) in research on consumer adoption of BEVs, this construct mostly includes knowledge of and practical experience with BEVs. Furthermore, the amount of transport modes used on people's regular trips has a significant effect on both consideration and the intention to purchase a BEV in the next five years. People that only use one transport mode showed a much higher intention and consideration. Lastly, the amount of policies that people are aware of has a positive effect on both the consideration and the intention to purchase a BEV in the next five years. People who are aware of more policies showed a higher consideration and intention. This seems logical since the policies and incentives are developed to enhance adoption. The main goal of these incentives is to accelerate the adoption rate, which shows that the more people are aware of these policies, the more willing they are to consider and purchase BEVs (Bjerkan *et al.,* 2017).

The effect on consideration

Besides variables having an effect on both the consideration and the intention to purchase a BEV within the next five years, the majority of the significant variables had an effect on solely the consideration of BEVs. The individual consideration was measured by asking what people's consideration of a BEV would be if they had to buy a vehicle within the next five years. *This measuring of consideration is something that is lacking in current literature.*

Firstly, people who have an EV in their household are more willing to consider BEVs. This shows that people who have experience with partly electric vehicles are more likely to consider BEVs. This is in line with the result that people who have driven a BEV before also have a higher consideration. The variables that also showed an effect on individuals´ consideration is knowledge. People who are up-to-date on the automotive industry show a higher consideration for BEVs. When asked about the five most popular BEVs of the moment, the people who knew more models also showed a higher consideration. Similarly, people who could correctly answer the time it takes to slow charge a Tesla Model 3 showed higher consideration. These results are in line with the findings of Barth et al. (2016) and Jensen *et al.* (2013). The study of Barth *et al.* (2016) showed a positive relationship between the intention to adopt a BEV and practical experience and BEV-related knowledge. Jensen *et al.* (2013) showed that consumers learn much more about BEVs through practical experience, which changes their preference significantly.

Another factor thas shows a significant effect on people's consideration is age. The age groups "35-44 years old" and "45-54 years old" showed the highest consideration for BEV's. This is in line with Hidrue et al. (2011) who found that people over 56 years old were less EV-orientation. Also, people who perceive both maintenance cost and total cost of ownership of BEV's to be lower than its ICE competitors show higher consideration. This is also in line with the previous discussed BEV knowledge since BEV maintenance and total cost of ownership is indeed lower than comparable ICE vehicles (Barth et al., 2016). Lastly, since BEV's are more efficient in stop and go traffic, it is not surprising that people who have congestion on their most regular trips are more willing to consider BEV's (Raslavičiusa, 2013).

The effect on Intention to purchase

Furthermore, some variables only had a significant effect on the intention to purchase. For example, individuals who perceive the charging network to be extremely bad, had a significant negative effect on the intention to purchase. This can be explained by the result of Yang *et al.* (2016) who found that an insufficient charging infrastructure is regarded as a technical barrier for adoption. Moreover, Pearre *et al.* (2011) found that the negative effect of an insufficient charging network cannot be ignored. Skippon and Garwood (2011) and Plötz *et al.* (2014) found that consumers are more willing to charge BEVs at home, so domestic charging infrastructures are more important to them. This is in line with the effect of a person's parking availabilities that this research showed. People with a private garage showed a significant higher intention to purchase BEV's. Both these variables are related to charging and have an effect on people´s intention to purchase. Even though other variables have a significant positive impact on people´s consideration for BEVs, these practical variables show a boundary for adoption.

During the questionnaire, the respondents were asked about their intention to purchase twice. The first time the respondent was asked how likely they were to purchase a BEV within the next five years, without given any additional information. After this, the respondents were educated on the current status of BEVs and the current charging infrastructure. This showed to have a significant positive effect on the intention to purchase. This further proves the result of Dumortier *et al.* (2015) who found that educating consumers of the real savings of BEVs by showing the cost of the fuel and other costs over the ownership period is a very effective tool to improve the intention to adoption.

What are the differences between the Netherlands and Portugal

In the Netherlands, owning a BEV has a significant positive effect on people's consideration and intention to buy a BEV. In Portugal, this variable does not have a significant effect on people's consideration, nor on their intention to buy a BEV. However, only a small percentage of the total respondents owned a BEV, and especially in Portugal this percentage was low. The effect on people's consideration and intention to buy a BEV might have been significant if the sample size for this research would have been larger.

In the Netherlands, people who have a BEV in their household had a significantly higher consideration to purchase a BEV, while in Portugal, having a BEV in people's household did not significantly change their consideration. A possible explanation for this is that consumers must be sufficiently aware of and familiar with a technology before purchasing it, but individual considerations of what is "sufficient" vary (Silvia and Krause, 2016). Having someone in your household who owns a BEV does not necessarily mean that you are sufficiently aware of and familiar with the technology in a way that it will increase a person's consideration to purchase a BEV. Furthermore, knowledge sharing also plays an important role here. In the process of knowledge sharing on new technologies, there can be cultural differences in the extent to which individuals are likely to influence others and be influenced by others (Zhang & Maruping, 2008). Consequently, a cultural difference between the Netherlands and Portugal could be a possible explanation for the difference in their response to having someone who owns a BEV in their household. This, however, is something that should be investigated in further research.

In the Netherlands, knowing people that own a BEV significantly increased people's consideration to purchase a BEV. In Portugal, this significantly increased people's intention to purchase a BEV. This difference can be explained by the fact that countries vary in terms of people's receptiveness to social influences (Pettifor*et al.*, 2017). Social influence is the process by which consumer attitudes and behaviors towards an innovation are shaped by interactions with others, and differences in social influence between countries are confirmed in studies examining social influence on vehicle purchases (Pettifor *et al.*, 2017).

In the Netherlands, people that have knowledge about the amount of BEVs that are available for sale and knowledge about charging times, showed significant higher consideration to purchase a BEV. Besides that, in the Netherlands, knowledge about fast charging time significantly increased people's intention to buy a BEV. In Portugal, these three factors were not significant. This difference can be caused by the different ways people obtain information and to what degree they trust this information source. A customer can obtain information from several sources: personal sources, family and friends, commercial sources, advertising and retailers, and public sources, for instance newspapers, magazines, radio, television or the internet. The usefulness and degree of influence of each of these sources of information will vary by product and by the consumer (Łatuszyńska *et al.*, 2012). Consumer behaviour is generally influenced by factors that can be classified into five groups: cultural factors, social factors, physical factors, personal factors and the marketing mix (Łatuszyńska *et al.*, 2012). Since cultural factors can influence consumer behavior, this could be a possible explanation for this different result.

Other factors that have a different effect on people's consideration to buy a BEV in the Netherlands compared to Portugal are perceived fuel cost, maintenance costs and costs of total ownership. In the Netherlands, people that perceived the fuel costs, maintenance costs and total costs of ownership of a BEV to be lower than its ICE vehicle competitor showed significant higher consideration for BEV's. An explanation for this could be that the role of money is culturally different between Portugal and the Netherlands. For example, Merchant *et al.,* (2017) found that some cultures emphasize on the importance of spending for enjoyment and the dangers of excessive saving, while other cultures can universally endorse saving (Merchant *et al.,* 2017).

In Portugal the kind of parking has a significant effect on people's BEV purchase intention. Namely, people who have a private garage have a higher purchase intention in Portugal. This can be explained by the lack of infrastructure in Portugal. Charging of BEV's is one of the main barriers for adoption (Hackbarth and Madlener, 2013). To mitigate this barrier, companies and governments emphasize the construction of sufficient charging infrastructure. The Netherlands is one of the leading countries when it comes to charging infrastructure (European Alternative Fuels Observatory, 2020). In October 2020, in the Netherlands almost 60.000 (semi) public charging stations and almost 1.500 fast chargers are available (RVO, 2020). Portugal, however, has a little over 5.000 charging points (Electromaps, 2020). Consequently, to charge your BEV in Portugal, it is more important to have a BEV charger at home. To enable domestic charging, a private garage is beneficial. In the Netherlands however, domestic charging is less essential since public chargers are widely available.

Chapter 5: Conclusion

5.1 Conclusion

There is a large need for a more sustainable future. In order to fulfil this need, one of the industries that needs to change significantly is the transportation industry, as this industry causes a lot of emission. One of the sustainability movements we see in this industry is the electrification of vehicles. Battery electric vehicles are becoming more popular. Since Tesla and Nissan pioneered the electric vehicle industry years ago, other well-known vehicle brands are now joining them in the move to a more sustainable energy source. However, to stimulate consumers to move to this more sustainable energy source and to consider and purchase BEVs, it is important to understand what drives their consideration and purchase intention.

There are multiple variables that have a significant impact on both the consideration of BEVs and the BEV purchase intention. This research identified and clarified which different variables have an impact on consideration and purchase intention of BEVs. To test these variables a survey was designed. Firstly, the awareness of policies and incentives was measured. After this, perceived technological characteristic, tech-savviness, environmental awareness, mobility characteristics and demographics were tested to measure the impact of these factors on both consideration and purchase intention of BEVs. Furthermore, two versions of the survey were designed, one for Portugal and one for the Netherlands. These two versions were made with adjusted figures to accurately demonstrate the current situation in those specific countries. In total, 400 respondents were gathered of which 253 in the Netherlands and 147 in Portugal. Both samples accurately represented the population of the measured country.

The results of the survey were analyzed to give a better understanding of the importance of the tested variables and to measure whether there were any significant differences between the two countries. The results showed multiple significant variables. Policies and incentives awareness showed to have a significant impact on a few of the tested policies. Showing that the more informed people are about the policies in their country, the higher their consideration for and intention to purchase a BEV is. Perceived technological characteristics of BEVs showed to have some significant points as well. People who consider the charging infrastructure to be extremely bad, had as expected a lower purchase intention. Additionally, lower perceived costs lead to higher consideration for BEVs. Additionally, tech-savviness had a significant effect on the consideration of BEVs. The more tech-savvy individuals are, the higher their consideration for BEVs is. Furthermore, environmental awareness had a significant effect on both consideration and purchase intention. The higher the individual environmental awareness, the more likely they are to consider or have intention to purchase a BEV. Besides that, mobility characteristics also has influence on the consideration and purchase intention of BEV's. The amount of transport modes, congestion to work and the transportation of other people all lead to a difference in the consideration of BEVs. Furthermore, individuals who own a private garage showed higher intention to purchase a BEV. This is due to the high need for domestic charging. Similarly, demographics showed significant results. Lastly, these results were analyzed and explained with additional literature.

There were a few differences to be analyzed between the impact of certain variables in the Netherlands and Portugal. These differences are also discussed. For instance, the different ways people obtain information and to what degree they trust this source, or the perception of money and cost savings or the charging infrastructure are all possible explanations of the differences. These insights can be useful to car manufacturers to better understand what drives consumer demand. Besides that, understanding the differences between countries and their consumer demand of BEVs can help to design a more local approach to reach potential customers. Even though both the consideration for and intention to purchase BEVs in Portugal is higher than in the Netherlands, the sales of BEVs in the Netherlands are still much higher, indicating there are still boundaries obstructing potential consumers that have not yet been tackled accordingly. In order to increase the diffusion of BEVs and to move towards a more sustainable transportation industry, it is essential to improve the charging infrastructure and technological characteristics, and educate people on current BEVs specifications and availability. Moreover, we need to acknowledge the importance of local markets and their differences in consumer preferences.

5.2 Limitations and future work

This research has a few limitations. First of all, due to limited time and resources, the research targeted a limited sample size. With a larger sample size for both countries, it would have better represented the population. Furthermore, due to the global pandemic caused by COVID-19, the answers of the survey might not be as consistent as possible. This because the data was gathered before and during the pandemic. Respondent mobility characteristics and use of internet might have been influenced by the pandemic. For future research, the differences between countries can be analyses further. This research indicates multiple differences that could be explained by a number of factors as, culture, gross domestic product (GDP) or other factors.

References

Aasness, M. A., & Odeck, J. (2015). The increase of electric vehicle usage in Norway incentives and adverse effects. *European Transport Research Review*, 7(4), 1–8.

Adepetu, A., & Keshav, S. (2015). The relative importance of price and driving range on electric vehicle adoption: Los Angeles case study. *Transportation*, 44(2), 353–373.

Agerskov, M. L., & Hoj, J. C. L. (2013). Lessons learned from the Danish EV living lab. *2013 World Electric Vehicle Symposium and Exhibition (EVS27)*, 1–7.

Axsen, J., TyreeHageman, J., & Lentz, A. (2012). Lifestyle practices and pro-environmental technology. *Ecological Economics*, 82, 64–74.

Barth, M., Jugert, P., & Fritsche, I. (2016). Still underdetected – Social norms and collective efficacy predict the acceptance of electric vehicles in Germany. *Transportation Research Part F: Traffic Psychology and Behaviour*, 37, 64–77.

Bjerkan, K. Y., Nørbech, T. E., & Nordtømme, M. E. (2016). Incentives for promoting Battery Electric Vehicle (BEV) adoption in Norway. *Transportation Research Part D: Transport and Environment*, 43, 169–180.

Carley, S., Krause, R. M., Lane, B. W., & Graham, J. D. (2013). Intent to purchase a plug-in electric vehicle: A survey of early impressions in large US cites. *Transportation Research Part D: Transport and Environment*, 18, 39–45.

Dumortier, J., Siddiki, S., Carley, S., Cisney, J., Krause, R. M., Lane, B. W., … Graham, J. D. (2015). Effects of providing total cost of ownership information on consumers' intent to purchase a hybrid or plug-in electric vehicle. *Transportation Research Part A: Policy and Practice*, 72, 71–86.

Eberhard, M. (2010, September 15). A Bit About Batteries. Retrieved from https://www.tesla.com/nl_NL/blog/bit-about-batteries?redirect=no

Egbue, O., & Long, S. (2012). Barriers to widespread adoption of electric vehicles: An analysis of consumer attitudes and perceptions. *Energy Policy*, 48, 717–729.

Engel, H. (2019, March 11). Charging ahead: Electric-vehicle infrastructure demand. Retrieved from https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/charging-ahead-electric-vehicle-infrastructure-demand

EV Database. (2020, April 1). EV Database. Retrieved from https://ev-database.nl/

Franke, T., Günther, M., Trantow, M., & Krems, J. F. (2017). Does this range suit me? Range satisfaction of battery electric vehicle users. *Applied Ergonomics*, 65, 191–199.

Franke, T., & Krems, J. F. (2013). What drives range preferences in electric vehicle users? *Transport Policy*, 30, 56–62.

Graham-Rowe, E., Gardner, B., Abraham, C., Skippon, S., Dittmar, H., Hutchins, R., & Stannard, J. (2012). Mainstream consumers driving plug-in battery-electric and plug-in hybrid electric cars: A qualitative analysis of responses and evaluations. *Transportation Research Part A: Policy and Practice*, 46(1), 140–153.

Hackbarth, A., & Madlener, R. (2013). Consumer preferences for alternative fuel vehicles: A discrete choice analysis. *Transportation Research Part D: Transport and Environment*, 25, 5–17.

Hackbarth, A., & Madlener, R. (2016). Willingness-to-pay for alternative fuel vehicle characteristics: A stated choice study for Germany. *Transportation Research Part A: Policy and Practice*, 85, 89–111.

Hardman, S., Chandan, A., Tal, G., & Turrentine, T. (2017). The effectiveness of financial purchase incentives for battery electric vehicles – A review of the evidence. *Renewable and Sustainable Energy Reviews*, 80, 1100–1111.

Hawkins, A. J. (2017, July 28). How Tesla changed the auto industry forever. Retrieved from https://www.theverge.com/2017/7/28/16059954/tesla-model-3-2017-auto-industry-influence-elon-musk

Helveston, J. P., Liu, Y., Feit, E. M., Fuchs, E., Klampfl, E., & Michalek, J. J. (2015). Will subsidies drive electric vehicle adoption? Measuring consumer preferences in the U.S. and China. *Transportation Research Part A: Policy and Practice*, 73, 96–112.

Hidrue, M. K., Parsons, G. R., Kempton, W., & Gardner, M. P. (2011). Willingness to pay for electric vehicles and their attributes. *Resource and Energy Economics*, 33(3), 686–705.

Hoen, A., & Koetse, M. J. (2014). A choice experiment on alternative fuel vehicle preferences of private car owners in the Netherlands. *Transportation Research Part A: Policy and Practice*, 61, 199–215.

Hull, D. (2016). Tesla Says It Received More Than 325,000 Model 3 Reservations. Retrieved from https://www.bloomberg.com/news/articles/2016-04-07/tesla-says-model-3-pre-orders-surge-to-325-000-in-first-week

Jensen, A. F., Cherchi, E., & Mabit, S. L. (2013). On the stability of preferences and attitudes before and after experiencing an electric vehicle. *Transportation Research Part D: Transport and Environment*, 25, 24–32.

Karathodorou, N., Graham, D. J., & Noland, R. B. (2010). Estimating the effect of urban density on fuel demand. *Energy Economics*, 32(1), 86–92.

Ko, W., & Hahn, T.-K. (2013). Analysis of Consumer Preferences for Electric Vehicles. *IEEE Transactions on Smart Grid*, 4(1), 437–442.

Li, W., Long, R., Chen, H., & Geng, J. (2017). A review of factors influencing consumer intentions to adopt battery electric vehicles. *Renewable and Sustainable Energy Reviews*, 78, 318–328.

Lieven, T., Mühlmeier, S., Henkel, S., & Waller, J. F. (2011). Who will buy electric cars? An empirical study in Germany. *Transportation Research Part D: Transport and Environment*, 16(3), 236–243.

Liu, X., & Bie, Z. (2019). Optimal Allocation Planning for Public EV Charging Station Considering AC and DC Integrated Chargers. *Energy Procedia*, 159, 382–387.

McKinsey. (2014, April). *Electric vehicles in Europe: gearing up for a new phase?* Retrieved from https://www.mckinsey.com/~/media/McKinsey/Locations/Europe%20and%20Middle%20East/Netherlands/Our%20Insights/Electric%20vehicles%20in%20Europe%20Gearing%20up%20for%20a%20new%20phase/Electric%20vehicles%20in%20Europe%20Gearing%20up%20for%20a%20new%20phase.ashx

Noppers, E. H., Keizer, K., Bolderdijk, J. W., & Steg, L. (2014). The adoption of sustainable innovations: Driven by symbolic and environmental motives. *Global Environmental Change*, 25, 52–62.

Pearre, N. S., Kempton, W., Guensler, R. L., & Elango, V. V. (2011). Electric vehicles: How much range is required for a day's driving? *Transportation Research Part C: Emerging Technologies*, 19(6), 1171–1184.

Peters, A., & Dütschke, E. (2014). How do Consumers Perceive Electric Vehicles? A Comparison of German Consumer Groups. *Journal of Environmental Policy & Planning*, 16(3), 359–377.

Plötz, P., Schneider, U., Globisch, J., & Dütschke, E. (2014). Who will buy electric vehicles? Identifying early adopters in Germany. *Transportation Research Part A: Policy and Practice*, 67, 96–109.

Prakash, N., Kapoor, R., Kapoor, A., & Malik, Y. (2014). Gender preferences for alternative energy transport with focus on electric vehicle. *Journal of Social Sciences*, 10(3), 114–122.

Rogers, E.M. (2003). Diffusion of innovations (5th ed.). New York: Free Press.
Ryghaug, M., & Toftaker, M. (2016). Creating transitions to electric road transport in Norway: The role of user imaginaries. *Energy Research & Social Science*, 17, 119–126.
Sang, Y.-N., & Bekhet, H. A. (2015). Modelling electric vehicle usage intentions: an empirical study in Malaysia. *Journal of Cleaner Production, 92*, 75–83.
Schmalfuß, F., Mühl, K., & Krems, J. F. (2017). Direct experience with battery electric vehicles (BEVs) matters when evaluating vehicle attributes, attitude and purchase intention. *Transportation Research Part F: Traffic Psychology and Behaviour*, 46, 47–69.
Schneidereit, T., Franke, T., Günther, M., & Krems, J. F. (2015). Does range matter? Exploring perceptions of electric vehicles with and without a range extender among potential early adopters in Germany. *Energy Research & Social Science*, 8, 198–206.
Schuitema, G., Anable, J., Skippon, S., & Kinnear, N. (2013). The role of instrumental, hedonic and symbolic attributes in the intention to adopt electric vehicles. *Transportation Research Part A: Policy and Practice*, 48, 39–49.
Settey, T., Gnap, J., & Beňová, D. (2019). Examining the impact of the deployment of low emission zones in Europe on the technological readiness of road freight transport. *Transportation Research Procedia*, 40, 481–488.
Skippon, S., & Garwood, M. (2011). Responses to battery electric vehicles: UK consumer attitudes and attributions of symbolic meaning following direct experience to reduce psychological distance. *Transportation Research Part D: Transport and Environment*, 16(7), 525–531.
Sovacool, B. K., Kester, J., de Rubens, G. Z., & Noel, L. (2018). Expert perceptions of low-carbon transitions: Investigating the challenges of electricity decarbonisation in the Nordic region. *Energy*, 148, 1162–1172.
Tamor, M. A., Gearhart, C., & Soto, C. (2013). A statistical approach to estimating acceptance of electric vehicles and electrification of personal transportation. *Transportation Research Part C: Emerging Technologies*, 26, 125–134.
Tamor, M. A., Moraal, P. E., Reprogle, B., & Milačić, M. (2015). Rapid estimation of electric vehicle acceptance using a general description of driving patterns. *Transportation Research Part C: Emerging Technologies*, 51, 136–148.
Tushman, M., Smith, W., & Binns, A. (2011). The ambidextrous CEO. *Harvard Business Review*.
Xu, W., Xiong, B., Cheng, Z., Wang, D., & Ying, C. (2010a). Growth and Fecundity of Megalobrama skolkovii in the Xujiahe Reservoir of Hubei, China*. *Chinese Journal of Appplied Environmental Biology*, 16(1), 91–95.
Xu, W., Xiong, B., Cheng, Z., Wang, D., & Ying, C. (2010b). Growth and Fecundity of Megalobrama skolkovii in the Xujiahe Reservoir of Hubei, China * : Growth and Fecundity of Megalobrama skolkovii in the Xujiahe Reservoir of Hubei, China. *Chinese Journal of Appplied Environmental Biology*, 16(1), 91–95.
Zhang, X., & Maruping, L. M. (2008). Household technology adoption in a global marketplace: Incorporating the role of espoused cultural values. *Information systems frontiers*, *10*(4), 403-413.
Zhang, Y., Yu, Y., & Zou, B. (2011). Analyzing public awareness and acceptance of alternative fuel vehicles in China: The case of EV. *Energy Policy*, 39(11), 7015–7024.

Annexes

Annex A

Survey

Awareness

Are you aware of what Battery Electric Vehicle's (BEV) are?

Do you have a driver's license?

Do you own a Battery Electric Vehicle?

Have you ever driven a Battery Electric Vehicle?

Do you know people that own a Battery Electric Vehicle?

Tech-Savviness

I frequently use online banking services

I frequently purchase products online

Learning how to use new smartphone apps is easy for me

I rely on technology to get things done

Internet is a big part of my everyday life

I own many gadgets

Our civilization stops when there is no electricity

My life would be extremely hard without technology

Industry awareness

I consider myself up-to-date on the automotive industry.

Which of these models do you know?

How many Battery Electric Vehicles models do you think are available for sale in your country?

Technological characteristics

What do you think the range/distance of this vehicle (Tesla Model 3) is?

How long do you think it will take to charge this vehicle 100% using a domestic charger (7kW)?

How long do you think it will take to charge this vehicle from 10% to 80% using a fast charger? (150kW)

How would you describe the charging network in your area?

When comparing the Tesla to this BMW, do you think the following costs will be higher or lower?

- Purchase costs
- Fuel costs
- Maintenance costs
- Total Cost of Ownership
- Lease price (60 months/ 10.000km per year)

Policies & incentive awareness

I am aware of the Battery Electric Vehicle 'Policies & Incentives' in my country.

What policies are you aware of?

Ranking aspects

What do you consider to be the 3 **most** important aspects when considering the purchase of a BEV?

Rank the 3 **most** important factors from most important to less important.

Consideration & purchase intention

What is the probability that you will **purchase** a vehicle in the next 5 years?

If you would buy a vehicle in the next 5 years, what would be the probability that you will **consider** a **Battery Electric Vehicle**?

What is the probability that you will **purchase** a **Battery Electric Vehicle** in the next 5 years?

What is the probability that you will **lease** a **Battery Electric Vehicle** in the next 5 years?

Education part

Current Tesla model 3 specifications

Current charging infrastructure statistics

Consideration & purchase intention after education

After this information, what is the probability that you will purchase a Battery Electric Vehicle in the next 5 years?

After this information, what is the probability that you will lease a Battery Electric Vehicle in the next 5 years?

NEP Scale

We are approaching the limit of the number of people the earth can support.
Humans have the right to modify the natural environment to suit their needs.
When humans interfere with nature it often produces disastrous consequences.
Human ingenuity will insure that we do NOT make the earth unlivable.
Humans are severely abusing the environment.
The earth has plenty of natural resources if we just learn how to develop them.
Plants and animals have as much right as humans to exist.
The balance of nature is strong enough to cope with the impacts of modern industrial nations.
Despite our special abilities humans are still subject to the laws of nature.
The so-called "ecological crisis" facing humankind has been greatly exaggerated.
The earth is like a spaceship with very limited room and resources.
Humans were meant to rule over the rest of nature.
The balance of nature is very delicate and easily upset.
Humans will eventually learn enough about how nature works to be able to control it.
If things continue on their present course, we will soon experience a major ecological catastrophe.

Mobility characteristics

When you make your regular trips, for instance "home-work" or "home-school", do you usually walk?
In these regular trips, do you use only one transport mode or more than one transport mode?
What transport mode(s) do you use in your regular trips?
Do you have a job?
Does your company pay for your commute?
How many days a week do you travel to your workplace?
Besides traveling to your workplace, how many round trips do you make on average per day for work?

What distance do you travel on average per day for work?

How long do you travel on average per day for work?

On your daily work commute, do you face congestion?

How much congestion do you face on your daily commute?

How often do you transport any other people on your trip to your workplace?

How many **non-work** round trips do you make on average per week?

What distance do you travel on average per week for your non-work trips?

Do you transport any other people on your non-work trips?

Do you have access to free parking?

Where do you have access to free parking?

How many cars are available in your household?

Is/are there electric vehicle(s) available in your household?

Has there ever been an electric vehicle available in your household?

Demographics

What is your age?

What is your gender?

What is your highest achieved education diploma?

What is your home postal code?

What kind of parking space do you have at your house?

What is your household monthly net income?

My income allows me to live:

What is your occupation?