POLITECNICO
MILANO 1863

SCUOLA DI INGEGNERIA INDUSTRIALE
E DELL'INFORMAZIONE

EXECUTIVE SUMMARY OF THE THESIS

# Drivers and Barriers Affecting the Diffusion of Electric Vehicles in Italy: an Empirical Investigation on Private Users and Corporate Fleets

MASTER OF SCIENCE IN MANAGEMENT ENGINEERING – INGEGNERIA GESTIONALE

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## 1. Introduction

The environmental pressure linked to global warming and increasing levels of pollution in atmosphere require the adoption of new solutions for mobility of people. Low impact possibilities are Electric vehicles (EVs), among which there are *Plug-in Hybrid Electric Vehicles* (PHEVs, coupling thermal and electric engine) and *Battery Electric Vehicles* (BEVs, with just electric engines) (Plananska, 2020). Despite the great developments of these technologies along years (Della Valle & Zubaryeva, 2019), their diffusion is too low because of barriers which hindering their uptake. This thesis wants to analyse the drivers and barriers currently affecting this world, both on the view of private users and corporate fleets.

The work starts with a literature review to discover drivers and barriers suggested by the literature. Anyway, literature is not fully exhaustive about the theme, neglecting some aspects – namely literature gaps – which can be interesting to deepen the phenomenon, as for example the role of emotions in purchasing cars process (Moons & De Pelsmacker, 2012), and the role of non-economic factors in the process (Hackbarth & Madlener, 2013). The study proceeds with a survey-based empirical investigation on the Italian context to address drivers and barriers in this domain. Italy is the core of the work since there are very few studies about it and there is lack of research about the entire nation, since majority of existing contributions analyse limited zones of the territory. The analysis is based on different questionnaires proposed to private users and fleet managers in companies, to understand their points of view on this theme and assess possible new insights.

Thanks to this empirical analysis, it is possible to understand interesting trends which are present in the purchasing process for EVs, and so determine from "real world" experience driver and barriers for users and companies.

In addition to this discussion, an important result which can be obtained by the analysis carried out regards the implications which can be extracted. Indeed, theoretical implications can be obtained, to deepen the existing knowledge on EVs and their drivers and barriers, along with recommendations

for policy makers and car makers, to boost the diffusion of electric vehicles worldwide.

## 2. Literature Review

The literature about the theme of EVs is very wide, so the analysis carried out just focuses on the contributions related to the managerial context, neglecting the most technical ones. In addition, only contributions analysing private cars and company cars have been considered, neglecting the ones related to car sharing or other mobility modalities. Among the studies analysed, it is possible to define different classes of drivers and barriers, namely *economic*, *environmental*, *image*, *comfort of usage*, *personal* and *governmental*.

Among the contributions researched on Scopus, the major drivers for the purchase of EVs are the economical ones (Plananska, 2020) with a total cost of ownership (TCO) for EVs lower than the *internal combustion engine* counterparts. Indeed, the expenses all across the entire life of the vehicle (e.g., lower fuel costs, lower insurance costs and tax exemptions) decrease dramatically the total expense related to the ownership and usage of the vehicle. The purchase is also driven by the strong economic incentives promoted by governments, by the environmental benefits associated to their usage and by the presence of enough public charging points. The other classes of drivers are less perceived as fundamental by practitioners, who do not perceive image and personal drivers as important as the economic and environmental ones. The only exception is attributed to corporate fleets, for which the adoption of EVs can improve the overall image of the firm towards the public and stakeholders.

Among the barriers, the highest one is the high cost of EVs (Lieven, Mühlmeier, Henkel, & Waller, 2011), which is a severe hurdle especially for private users. The high cost is in many cases due to the insufficient state incentives put in place, and this can prevent the purchase of an electric car. Along with that, environmental impact associated to the production of batteries is seen as a very important barrier (Tabuchi & Plumer, 2021), making the adoption on large scale of EVs hard to be accepted by people, because of the bad perception associated to the production and dismantle of batteries. Another crucial barrier is related to the comfort of usage, and more in detail to the low autonomy of EVs and the low diffusion of public charging points, two aspects which make the usage of EVs difficult in case of long journeys. These barriers tend to be stackable for private users and companies, apart from the high cost of purchase, since firms tend to avoid the purchase of the vehicle, preferring rental or leasing solutions.

Literature also addresses the importance of socio-demographic mediators as influencers of the choice of buying an EVs. These factors – among which the most important are age, gender, degree of education and area of residence – explain trends relate to the purchasing process of cars and EVs in detail: for example, younger generations tend to be more sensitive about the environment than elder ones, so they may have higher tendency in buying EVs (Formánek & Tahal, 2020).

Despite the abundance of information, the analysed contributions show some gaps of knowledge which should be covered by further analysis:

- Too high focus on economic factors to analyse the purchasing process, neglecting other dimensions of drivers and barriers (e.g., personal, environmental).
- Too low importance given to the integration of other factors apart from the cost of the car itself, which is perceived as the most important factor.
- No differentiation of BEV owners, as they are seen as a unique category, without focusing on their typology (high-end, low-end) and their sensitivities towards drivers and barriers.
- No segmentation of the studies on the basis of the type of car acquired (segment A, B, SUV, …).
- Absence of differentiation between owners and non-owners when surveys are proposed.
- Lack of studies covering the theme of corporate fleets, especially in Italy.
- Lack of studies covering Italy as a whole, with existing studies analysing just limited regions of the nation.

## 3. Research Design

To satisfy the literature gaps presented, a *survey-based methodology* has been adopted. This methodology has been based on the definition of two surveys, one for private users and one for fleet managers, through the usage of the *Google Modules*

platform. For both questionnaires, three main types of questions have been proposed:

- *Open questions*
- *Likert Scales*
- *Multiple choice questions*

The two questionnaires show some differences, with the one for private users made of 6 sections, and the one for companies by 5 sections, with distinct questions for each. The questions range on different areas of the leitmotif regarding EVs, analysing themes ranging from the usage of the electric car to the exploitation of private and public charging points, investigating also the knowledge of users and managers on the themes related to electric mobility, such as availability of incentives, technical knowledge and other aspect related

The data obtained from the surveys are analysed through the usage of *Google Modules* (which was useful for a preliminary reordering of the answers) and through the help of *MS Excel*. It has been useful to evaluate average answers and standard deviations, but also to create summary graphs and to analyse trends between socio-demographic mediators and variables, drivers and barriers through the exploitation of *Pivot Tables*.

## 4. Results

The survey for private users and fleet managers recorded, respectively, 895 and 34 answers. After a brief sampling of the respondents, to assess socio-demographic mediators (age, gender, …) and data for companies, the presentation of the results begins, with a specific focus on drivers and barriers and on the role of socio-demographic mediators.

### 4.1. Private Users

After a first clustering of the respondents based on age, gender, region of residence and degree of education, the most interesting results are related to the perceived barriers by the non-owners which represent the 58.3% of the sample. The percentage of non-owners represent little more than the half of the entire population of answerers, allowing an even presence of responses from EV owners and non-EV owners, as desired at the beginning.

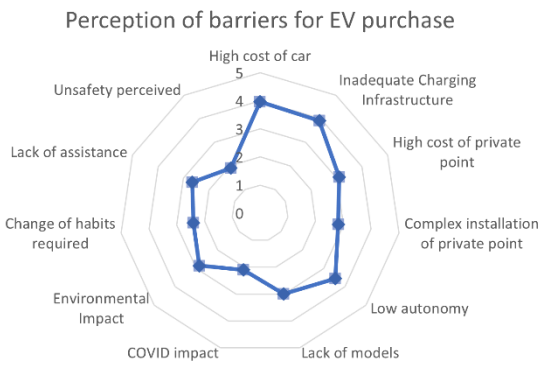


Figure 1: Perception of barriers for EV purchase

As in Figure 1, the survey confirms how the most important barrier is represented by the high cost of the vehicle, followed by the inadequacy of the public charging infrastructure. This, coupled with the low autonomy of vehicles, becomes a significant hurdle to overcome for the expansion of the market for EVs. The environmental impact of battery production is an important barrier, too, but less impacting than the previously mentioned, thanks to the actions undertaken by producers to limit the usage of raw materials and to reduce the damages related to the management of exhausted batteries. Analysing the propensity in the adoption of EVs, the sample splits, with 55.4% of the answerers who are in favour of them; the tendency shows a higher propensity for 30-50 years old people and, analysing the answers of EV-owners, the major driver of choice is the lower TCO in comparison to ICE cars, coupled with the positive environmental effects associated to their usage. It goes in pair with the possibility of better exploiting renewable sources of energy (e.g., PV plants installed at home), to reduce environmental impact and cost of recharge.

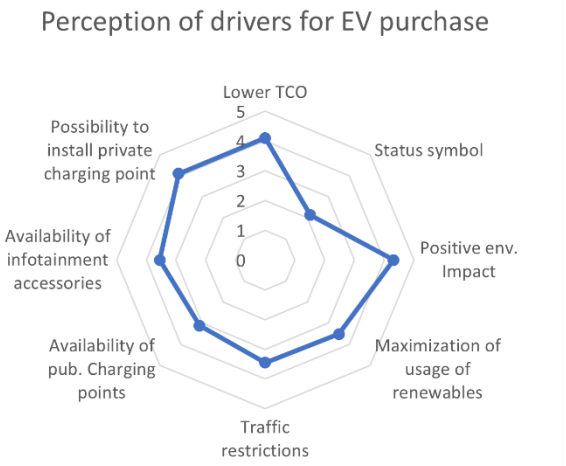


Figure 2: Perception of drivers for EV purchase

In accordance with what said before, Figure 2 also confirms that the possibility of having a private charging point (and so overcome the issues of public charging infrastructure) are an important driver of choice for EVs, while traffic restrictions and status symbol do not appear as crucial drivers.

## 4.2. Company Fleets

Also in this case, the analysis considers first a clustering phase to analyse the typologies of respondents, and then it goes in detail of the answers.
Analysing the drivers for the choice of EVs, companies are attracted first of all by the sustainability aspects related to the usage of electric cars. Their adoption can indeed help companies in reaching sustainability goals through reduction of emission, also creating a green image for the firm. These three drivers are strongly bonded together, while the fourth most perceived one is the possibility of installing a private point at company sites, as confirmed by Figure 3.

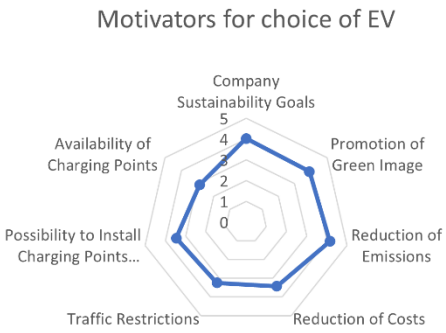


Figure 3: Motivators for choice of EV by fleets

Another important driver is the possibility to cut mobility costs for the company, thanks to lower expense for maintenance of vehicles and fuel.
Shifting on the barriers (Figure 4) for the adoption of EVs by companies, the most important ones are related to the range anxiety for EVs. Indeed, the most critical ones are the low autonomy of vehicles which, coupled with the inadequacy of the public charging infrastructure, make EVs still not compatible with the necessities of employees covering high kilometrages each day. Another important barrier is the change of habits required to use these vehicles effectively, which consider, for example, the necessity to plug the car everyday overnight in order to have a vehicle ready for the next day (indeed the charging times of EVs are not comparable to the refuelling times of ICE cars, so if a car has no charge in the morning, it will take hours to be ready for use).

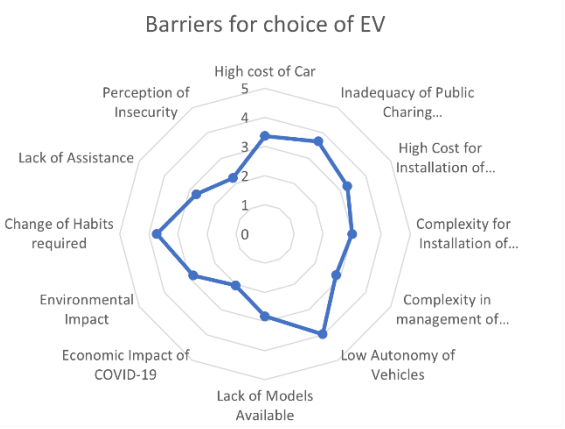


Figure 4: Motivators for choice of EV by fleets

The environmental impact associated to electric vehicles, seen as an important barrier by literature, is not perceived as so high, just like for the private users. The same holds for the cost of the car, since companies tend to rent or lease cars, and not buy them, while the high cost of the private charging point in company sites can be a significant barrier for the choice of EVs in the firm.

# 5. Discussion

The surveys reveal a general accordance with the literature on the theme, not differentiating too much from what practitioners analysed in their contributions.
For private users, the most important barriers are the economic ones and the ones related to the inadequacy of the public charging infrastructure. The issues of costs and complexity of management arise also for private charging points, which are still "luxury" items for a limited part of the owners of EVs: the high expense for the installation and the difficulties in using and managing them become barriers for a wide diffusion of electric vehicles. In discordance with the literature there is the environmental impact of EVs: Italian respondents are less scared of the dangers determined by their production and tend to believe more in car makers and in the industrial processes under development to reduce the impact of production.
Shifting on drivers, the economic ones are once again the most important, followed, surprisingly, by the possibility to install a private charging point at home, which would allow users to overcome the inadequacy of the public infrastructure. This driver

has the same importance of the reduction of ownership costs associated to EVs.
Analysing companies, instead, literature is quite poor about the theme of adoption of EVs. The survey allowed to discover that the major motivators for their adoption are the environmental ones. Indeed, the environmental benefits due to EVs allow companies to pursue sustainability objectives and create a better image. The economic drivers have less power in the case of firms both in positive and negative terms, while the low autonomy, coupled with the lack of charging points publicly available become important barriers.

## 6. Implications

In the end, the entire work of thesis allows to find implications which can be directed to different actors, namely literature (*theoretical implications*), car makers (*managerial implications*) and public administrators (*policy implications*).
Starting with the theoretical implications, the survey reveals how the purchasing process of EVs is not just based on economic criteria, but also on other ones as environmental concerns or emotional aspects in the individual. This determines that the final choice of a vehicle is not always the cheapest one. Relating to this, the lack of appealing models of EVs becomes an important consideration for users, who sometimes go for an ICE car instead of an EV because they cannot find the model they like. In addition, once again socio-demographic factors acquire an important role in explaining specific trends between EVs adoption and EV world and personal factors as age and gender, with different propensity in approaching this world basing on personal characteristics.
Along with these implications, there is also the fact that the study allowed to enlarge the knowledge about EVs adoption in Italy, focalizing on the entire nation and not on specific areas only. The same holds for the knowledge about fleet vehicles: the thesis allows to enlarge the low knowledge about drivers and barriers for the adoption of electric car in the context of Italian companies.
Analysing the managerial implications, the major recommendations for car makers regard the necessity to work hard on improving the performance of EVs in terms of autonomy and pleasure of driving. Iindeed, the low autonomy is seen as a crucial barrier both by private users and companies, thus improvements should be done in this direction. At the same time, they should also propose more EV models to better fit the necessities and tastes of the audience, and so to enlarge the purchase of EVs. In addition, they should work a lot on improving the production and recycling process of batteries, to reduce the environmental impact for the extraction of virgin materials and related to the mismanagement of exhausted batteries. As a last remark for car makers, they should invest also in the formation of the car dealers, to increase their knowledge about EVs and so to help them in proposing the best vehicles for the necessities of the buyers; in this way they can also clarify doubts and perplexities of customers, and so increase the possibilities of purchase of electric vehicles. Car dealers should also promote test drives of EVs, to get potential buyers acquainted with the technology, sometimes discarded because of the lack of experience with it.
Referring to manufacturers of points of charge, they should develop points with lower costs and easier to be installed and operated by final users, since the cost and complexity of usage of charging points is perceived as a barrier for the adoption of EVs both by private owners and companies.
Analysing the last category of implications – the policy ones – governments should first invest in the development of the public charging infrastructure, which is seen as inadequate by users and companies and whose role in the spread of EVs is reputed as fundamental. This should be done in cooperation with mobility service providers in a joint way, with attention also on superchargers, crucial to encourage the usage of electric cars on long routes. Public administration should also enlarge the amount of incentives to buy the car and to install a private charging point: their high cost is perceived as an important barrier, and the survey demonstrated how the economic incentives can have a great influence on private users and, for charging points, also companies. As a last remark, governments should also increase the knowledge of buyers and managers about EVs: this can be done by providing informative materials and through seminars to explain the advantages about owning an EV and to get people more acquainted with the technology. The provision of information in a comprehensive online portal can be a great tool to help citizens and managers in finding all the information they need.

## 7. Conclusions

Environmental pressures and issues are imposing to mankind a rethink of the way people move on the planet, in order to reduce harmful emissions and damages towards the Earth. EVs (BEVs and PHEVs especially) can be a good option to accomplish this goal, but their diffusion is still too limited because of barriers which make their adoption difficult for citizens and companies. Literature analyses how the most important drivers for the adoption are related to the economic and environmental spheres, while the most important barriers are the high cost of the car and the inadequacy of the charging infrastructure. These evidences are partially confirmed by the study carried out on the Italian context for citizens and companies, a study which allowed also to evaluate the impact of socio-demographic mediators in the purchasing process of such vehicles and to enlarge the knowledge about the world of company fleets and their approach towards EVs. Along with that, the work also allows to see if the "real world experience" is in accordance or not with literature: there is a general concordance between those two dimensions, with just some new trend or topics which emerge from the survey and which are highlighted in the work. Along with that, the thesis allows also to draft several recommendations for car makers and governments to favour the diffusion of EVs: joint and strong actions should be put in place, to create suitable vehicles for the necessities of users and firms and at the same time support the diffusion of EVs with a good recharging network. Only a joint effort by all the actors involved in this world can enlarge the spread of electric vehicles worldwide, and making them the everyday normal and not just an exception for very few individuals.

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# DRIVERS AND BARRIERS AFFECTING THE DIFFUSION OF ELECTRIC VEHICLES IN ITALY: AN EMPIRICAL INVESTIGATION ON PRIVATE USERS AND CORPORATE FLEETS

MASTER OF SCIENCE FINAL THESIS IN MANAGEMENT ENGINEERING

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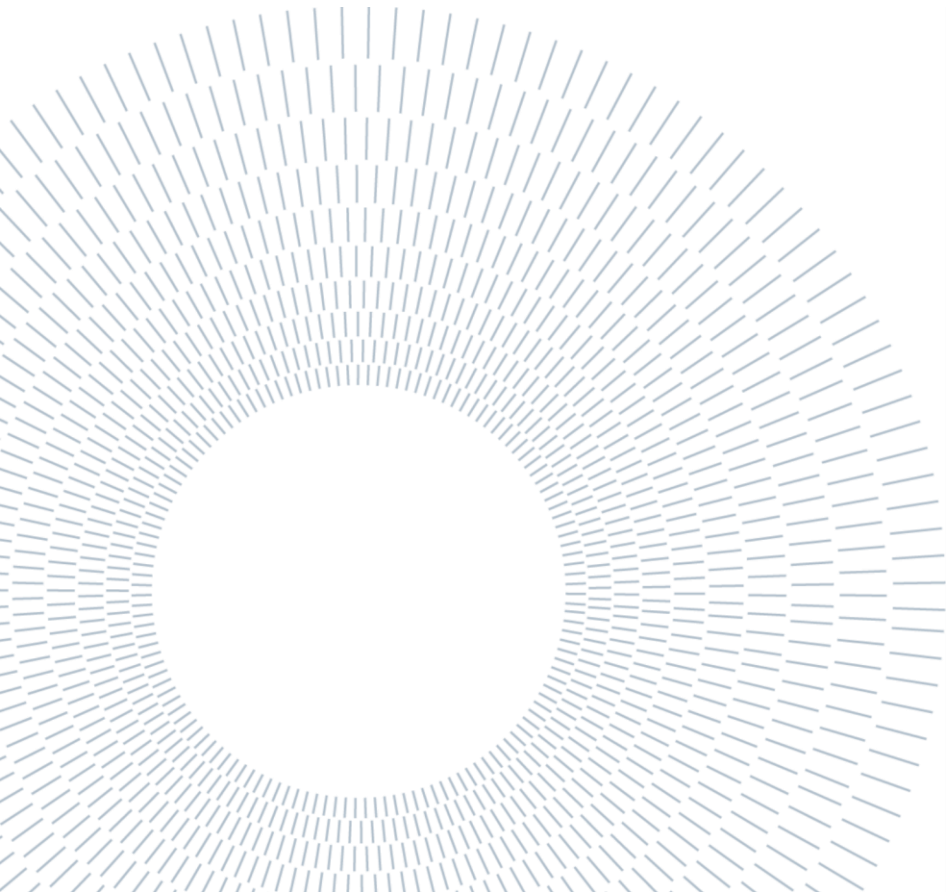


# Abstract

The necessities of adopting novel solutions for transportation sector are becoming more and more important nowadays, to put in place actions to mitigate climate change. This can be done by choosing low impact vehicles. Electric vehicles (EVs) are an option capable of putting together necessities of transportation with lower emissions. The most important technologies are *Plug-in Hybrid Electric Vehicles* (PHEVs, coupling thermal and electric engine) and *Battery Electric Vehicles* (BEVs, with just electric engines).

Despite the benefits they can introduce, their diffusion is still too low because of barriers which are hindering their uptake. This thesis aims at discovering the drivers and barriers which can foster or obstruct the diffusion of electric cars, adopting a dual perspective. First, an extensive literature review is carried out to identify drivers and barriers suggested by the literature. Then, a survey-based empirical investigation is carried out in the Italian context to address drivers and barriers in this domain. The country has been chosen as focus since there are very few studies analysing this nation; in addition, there is lack of studies considering drivers and barriers in the country, with available contributions analysing only some areas of the nation, neglecting an organic analysis of the country in its entirety.

For private users the most critical barrier is the economic one, with the high cost of vehicles seen as the major; on the other hand, lower environmental impact related to usage is the most important driver, along with the possibility of installing a private charging point at home. For companies the most critical barriers are related to the inadequate public charging infrastructure and to the low autonomy of EVs, incompatible with necessities of companies; lower TCO and environmental impact can be good drivers for the adoption of EVs in firms, as they are seen as the most important ones among the proposed.

The work brings out a series of recommendations for policy and car makers, aimed at developing collaborations to better satisfy the demand for mobility from public and companies and at the same time support them with an adequate network for recharge.

**Key-words:** electric vehicles; drivers; barriers; Italy; private users; company fleets

# Abstract in lingua italiana

Oggigiorno la necessità di sviluppare e adottare nuove soluzioni di mobilità per privati e aziende sta diventando sempre più importante e cruciale. Infatti, il settore dei trasporti risulta essere una delle principali fonti generatrici di gas serra; essi sono responsabili di cambiamenti climatici quali incremento delle temperature e conseguenti eventi climatici estremi, come siccità prolungate e piogge torrenziali, anche in zone che non erano mai state soggette ad essi finora.

I veicoli elettrici possono essere una valida opzione per coniugare le richieste di mobilità della popolazione e delle aziende con l'attenzione per l'ambiente, grazie all'assenza, o almeno alla riduzione, di emissioni direttamente legate all'utilizzo dell'automobile. Allo stato attuale, le tecnologie più diffuse risultano essere i *Plug-in Hybrid Electric Vehicles* (PHEVs) e i *Battery Electric Vehicles* (BEVs). I primi vedono l'accoppiamento di un motore termico tradizionale con uno o più motori elettrici, alimentati da batterie che possono essere ricaricate tramite presa elettrica o durante l'utilizzo del veicolo stesso, grazie a sistemi di recupero dell'energia in fase di frenata o tramite il motore termico stesso, che può fungere da generatore elettrico. La seconda tipologia di veicolo è caratterizzata dalla sola presenza di un motore elettrico – o più di uno, a seconda del modello di automobile – alimentato da batterie, che possono essere solamente ricaricate tramite presa elettrica, e in maniera marginale da sistemi di recupero dell'energia durante le fasi di frenata dell'automobile. Ovviamente, i veicoli BEV sono caratterizzati dall'assenza di emissioni durante il loro esercizio, mentre i PHEV generano emissioni a causa della presenza del motore termico, anche se in maniera molto minore rispetto a tradizionali veicoli a benzina o Diesel grazie al supporto del motore elettrico che, specialmente a basse velocità, permette addirittura lo spegnimento del motore a combustione interna.

Nonostante gli indubbi benefici introdotti da queste nuove tecnologie, la diffusione di tali veicoli è ancora scarsa a livello globale a causa di diversi tipi di barriere che spaventano privati e aziende nell'adottarle.

Per questa ragione, lo scopo di questa tesi è quello di capire quali siano i driver e le barriere che caratterizzano il mondo degli EV e che possono favorire o scoraggiare la scelta di auto elettriche, sia per i cittadini che per le imprese nelle loro flotte.

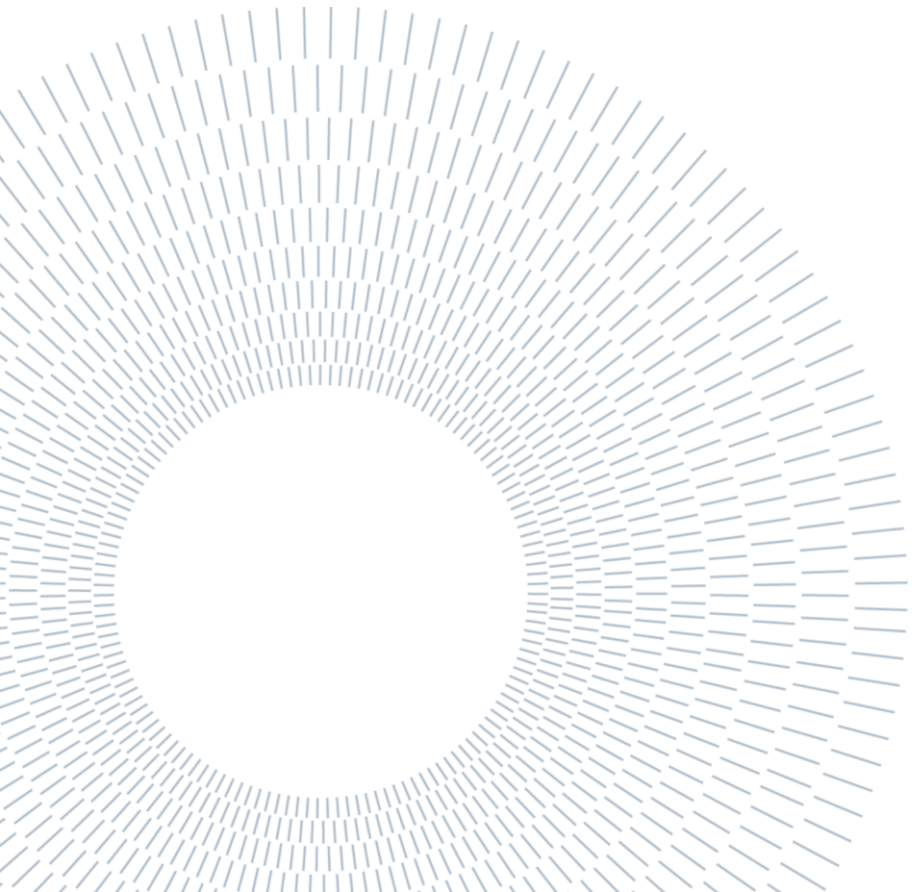
Per fare ciò, il primo passo da svolgere è un'attenta analisi della letteratura accademica a livello globale, per comprendere a fondo quale sia il punto di vista di ricercatori e studiosi sul tema, confrontando articoli scientifici redatti considerando diverse aree del pianeta. Sulla base di questa rassegna della letteratura esistente si innesta il lavoro

sperimentale, nel quale dei sondaggi creati *ad hoc* per privati cittadini e aziende sono sottoposti ad un campione di soggetti: nel primo caso qualunque cittadino può essere un buon soggetto per ottenere una risposta, mentre nel caso di società il sondaggio viene sottoposto alle figure che all'interno delle compagnie stesse si occupano della gestione delle flotte aziendali. Da questi sondaggi è possibile ottenere il punto di vista di cittadini e aziende riguardo le auto elettriche in Italia, e capire così quali sono i driver e le barriere che favoriscono o ostacolano la loro diffusione.
Il focus dell'intera analisi è l'Italia, per le seguenti ragioni: innanzitutto, l'Italia è una nazione in cui il mercato automobilistico ha una grande importanza a livello economico e storico, essendo un paese di grande tradizione nel settore e sede di grandi gruppi e marchi automobilistici. Oltre a questa ragione, c'è un motivo più legato alla letteratura esistente: esistono pochi studi e analisi che considerano i driver e le barriere per la diffusione dei veicoli elettrici in Italia; inoltre, i pochi studi presenti vanno ad analizzare soprattutto regioni specifiche del paese, e non la nazione nella sua interezza, andando quindi ad ottenere risultati che non possono essere estesi all'intero territorio nazionale.

Tali risultati variano a seconda delle due categorie sopra citate. I cittadini, infatti, riportano come barriera principale l'alto costo d'acquisto dei veicoli, accoppiato con la scarsa diffusione e capillarità della rete di ricarica pubblica. Motivatori della scelta risultano invece essere in primis il minor impatto ambientale derivante dall'utilizzo rispetto ai veicoli tradizionali, assieme alla possibilità di installare un punto di ricarica privato nell'abitazione. Tra le aziende, invece, le barriere principali sono legate alla ridotta autonomia dei veicoli – specialmente BEV – e l'inadeguatezza delle infrastrutture di ricarica pubbliche, che rendono così inadatte le auto elettriche pure per lunghe trasferte. I driver principali per le compagnie risultano invece essere i minori costi di gestione del veicolo e la riduzione delle emissioni associate all'utilizzo, che permettono alle società di perseguire i propri obiettivi legati alla sostenibilità aziendale.

Da questo lavoro di tesi emerge come, per favorire la diffusione dei veicoli elettrici, sia necessario agire su più dimensioni contemporaneamente: per incoraggiare gli utilizzatori ad acquistare auto elettriche è necessario che i costruttori sviluppino veicoli capaci di soddisfare maggiormente le richieste del pubblico (per esempio auto con maggior autonomia, migliori performance, …). Tuttavia, allo stesso tempo, il settore pubblico deve lavorare sull'infrastrutture di ricarica, collaborando con aziende private per sviluppare un adeguato network di punti di ricarica.

**Parole chiave:** veicoli elettrici; drivers; barriere; Italia; privati; flotte aziendali



# Contents

# Introduction

A lot of research has been done on internal combustion engines, with strong research and development aimed at reducing the direct emissions generated by fuel combustion, like $CO_2$ and also other pollutants, such as nitrous oxides or carbon oxides. Anyway, this is not sufficient: in order to maintain global warming under control and respect the international norms on temperature increases, a radical innovation is required to finally shift from the usage of fossil fuels towards new and cleaner alternatives. In this perspective, hydrogen cars appear as a good solution, but they are still far from commercial maturity (Ala, et al., 2020), so the real game changer in this current era of automotive is represented by battery vehicles (BEVs) and hybrid vehicles, in particular by plug-in hybrid vehicles (PHEVs). For them there has been an enormous development and evolution across years (Della Valle & Zubaryeva, 2019).

These technologies can be very advantageous for a wide variety of reasons, which can range from the economic ones to the environmental ones, comprising also some related to personal and corporate image (Hackbarth & Madlener, 2013). All factors that are identified as "drivers" (or "enablers") within the extant literature (Plananska, 2020). Anyway, there are still various reluctance and uncertainties by potential EV buyers regarding this kind of vehicles which can slow down the substitution process of vehicles, retarding the switch towards clean mobility (Berkeley, Jarvis, & Jones, 2018). All factors that are identified as "barriers" within the extant literature. Interestingly, existing literature brings into light different peculiarities characterizing the different categories of potential EV buyers, such as private users (Haddadian, Khodayar, & Shahidehpour, 2015) and fleet managers (Di Foggia, 2021).

However, literature is not fully exhaustive regarding this theme: indeed, one of the main criticalities is the fact that, when assessing drivers and barriers, only economical aspects are considered, neglecting others as environmental ones or emotional ones which can have a significant role in the purchasing process (Moons & De Pelsmacker, 2012). In addition, another aspect which is marginally present in literature is the consideration of socio-demographic aspects as moderators and mediators for purchase: gender, education, age and other personal factors determine different approaches to the world of EVs (Formánek & Tahal, 2020), but literature still lacks deep studies on this thematic. Socio-economic mediators are personal factors which modify and influence individual propension towards EVs and hybrid cars (Formánek & Tahal, 2020). Great importance is attribute in literature to gender and age-based differences, but along with them great importance is given also to socio-economic and lifestyle factors, along with the provenience of the individual (Formánek & Tahal,

2020). Few contributions analyse their impact on the purchasing process of EVs, especially in Italy, where they are not analysed at all.

Literature also lacks a focus on the segments of vehicles the users are interested in: studies introduce no differentiation based on the different sizes and characteristics of models currently on the market (segment B, C, …), aspects which may underline different propensity towards EVs by private users and companies. In addition, majority of researches and surveys carried out in literature do not focus on EV users, considering a "casual" sample of respondents or without even analysing the opinion of EV owners; in this work both EV owners and non-owners are consulted in order to have a broader view of the phenomenon. Another gap from literature is the lack of questions regarding the intention of EV users to acquire again an EV after the experience they had: this crucial question allows to have a simple and comprehensive overview of the overall perception of the vehicles by those people who already tried them, giving their opinion about them. Another gap regards the fact that the wide majority of contributions analyses the theme of drivers and barriers regarding EVs just from the perspective of private users, without analysing the point of view of companies for their fleets; a study which entails also the latter is important to analyse the situation of EVs diffusion in all its facets. As a last remark, another gap is the scarcity of studies analysing drivers and barriers for the diffusion of EVs in Italy: this makes the necessity of analysing this geographical area crucial, and it is one of the aims of this work.

These motivations require a deep investigation, with the aim of understanding which are the success factors for electric vehicles on which institutions and car makers should insist to drive the change, and which are the major critical points which impede it. This should be done analysing two different perspectives: the point of view of citizens (private users) and the one of companies (commercial fleets). This dual analysis is required since the two categories identified have different necessities and issues to solve, so they may perceive different advantages and disadvantages in the adoption of EVs.

Starting from these premises, the thesis aims at assessing the drivers and barriers affecting the diffusion of EVs, by first providing a comprehensive picture of such factors leveraging extant literature and then assessing their relative importance through a broad empirical investigation (survey) that involved around 900 respondents among private users and companies fleet managers.

The work starts indeed with a literature review, providing a broad overview of scientific contributions on the topic. The documents, which are retrieved from Scopus database (Scopus.com, 2021) cover different geographical scopes, ranging from worldwide reviews (Shao, Taisch, & Ortega-Mier, 2016) to region specific analyses

(Tomasi, Alyona, Pizzirani, Dal Col, & Balest, 2021), with also documents analysing specific countries and nations (Berkeley, Jarvis, & Jones, 2018; Meszaros, Shatanawi, & Ogunkunbi, 2021). In addition, the different contributions focus on different perspectives, to analyse both the situation of private owners (Unal & Shao, 2019) and fleet managers (Di Foggia, 2021). This allowed the recognition of recurring drivers and barriers across literature, themes which have been clustered basing on the typology of their nature, like economic ones, environmental ones and other clusters which will be presented afterwards.

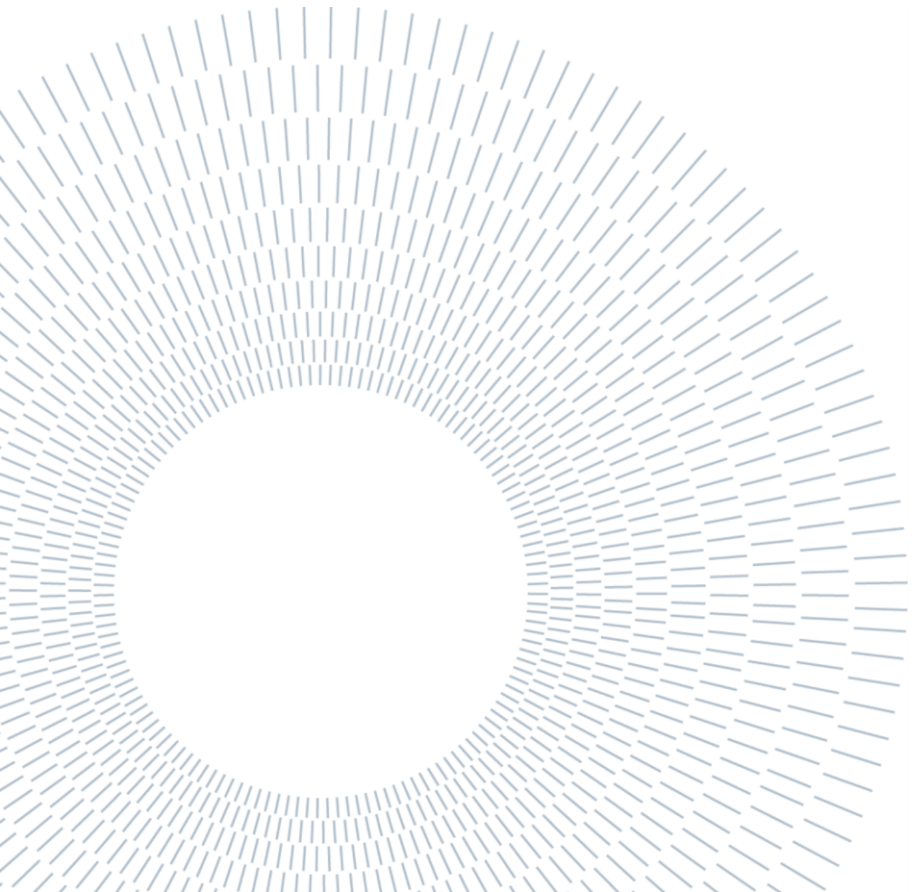
After the first phase of literature review, the work goes on with an extensive empirical investigation, i.e., a survey-based analysis. Two surveys have been developed, one to analyse the perception of driver and barriers by Italian consumers, while the other one to accomplish the same goal analysis fleet managers. Of course, the two questionnaires contained different questions and assessments. In the end the surveys recorded answers from 895 respondents for private users, and 34 for fleet managers.

Italy has been chosen as the empirical setting of our analysis since there is still a lack of comprehensive studies analysing drivers and barriers for the diffusion of EVs in the country. Indeed, despite the high value of the automotive market in the country there are still very few studies analysing the penetration of EVs in the local market, a fact which can be partially explained by the low diffusion of such vehicles in comparison to other European countries. In addition, Italy sees a high utilization of renewable sources for electricity generation: this can be a very important booster for the decrease of GHG emission, thanks to the usage of such sources to produce the electricity required to feed EVs, reducing the utilization of fossil-based products for electricity generation and to fuel vehicles. As a last remark, the country has been chosen as focus of the analysis since the very few studies which analyse drivers and barriers for EV adoption in the nation focus on very narrow areas of the country, for example Alpine areas as Verbano-Cusio-Ossola (Tomasi, Alyona, Pizzirani, Dal Col, & Balest, 2021) or South Tyrol (Della Valle & Zubaryeva, 2019), or in specific urban areas as Milan (Pucci, 2021).

After the presentation of the results of the two surveys proposed, discussion about drivers and barriers emerging from them starts. In this phase the aim is to understand if the evidences obtained from the research are in accordance or discordance with what is reported in literature, or if there are novel elements which have never been considered. After this discussion phase, the related implications are proposed, focusing on three layers: the theoretical implications (so the possible contributions given to literature by the work), the managerial implications (those for the companies working in this world, for example car makers) and finally the implications directed

to policy makers (local and national governments), to propose possible actions to put in place in order to favor the diffusion of EVs on wide scale.

Finally the work terminates with the possible suggestions for future research on the theme, namely those aspects which was not possible to investigate in detail in this thesis but which are worthy a further analysis to obtain further insights.



# 1. Chapter one: Literature Review

## 1.1 Methodology

The first step of the entire analysis was pointed at finding useful contributions which could help the understanding and the obtaining of a broad overview of the drivers and the barriers affecting the diffusion of electric vehicles worldwide. In addition, this preliminary phase was crucial to highlight gaps of the literature to be further investigated.

The main source of information has been Scopus (Scopus.com, 2021), an online database which groups together documents and academic contributions from Universities and research groups worldwide. On Scopus the search has been carried out manually by using specific keywords which could be helpful to perform a first filtering phase of the entirety of the documents available.

First, the research has been aimed at sorting out just the articles which included the thematic of electric vehicles in the area of Business, Management and Accounting (i.e., BUSI), considering the keywords of "drivers" and "barriers", and including also the keywords "fleet" and "green" as extra-filters, to circumscribe the areas of analysis.

To do so, manual advanced research has been performed, by using a specific string of text to include the keywords I was interested in and to go through the database:

TITLE-ABS-KEY (*electric vehicle** AND ((*driver**) OR (*enabler**) OR (*barrier**) ) ) AND (LIMIT-TO (SUBJAREA, *"BUSI"*)) AND (LIMIT-TO (LANGUAGE, *"English"*))

This allowed to obtain just the articles and contributions which considered battery powered vehicles (BEVs) and hybrid vehicles (HEVs), not considering the ones dealing just with thermal engine; in addition, using that filters the technical contributions related to the technological foundations of batteries have been discarded as well as other articles analysing technical aspects out of scope. With this string also contributions focusing on commercial and company fleets are considered.

This first phase gave a pool of 240 documents from which it was possible to deepen the analysis: this collection contained not just academic contributions, but also articles from reviews, journals, and chapters from books.

Then the analysis was mainly aimed at excluding the older contributions: indeed, since the EV theme is undergoing fast and radical improvements year by year, it would be pointless to analyse documents from more than 10 years ago; for this reason, the research has been reduced to the articles after 2011, to have an up-to-date overview of the criticalities concerning the theme. This first filtering phase allowed excluding 3 documents from the results obtained.

Once saved all the documents resulting from these searches, different levels of analysis have been carried out to consider just the most interesting and useful documents:

*TITLE ANALYSIS:* Only the documents whose title was clearly fitting our scope of work were maintained, excluding the ones which did not seem useful, or which covered thematic areas which we were not interested in. This first filtering excluded 113 documents from the analysis:

- Some of them were clearly out of scope, dealing with arguments not under the interest of this work (e.g., some analysed decarbonisation in residential sector, others in the airline field); this first category of excluded documents encompasses 49 contributions.
- Other documents (37) were instead discarded because they were related to the most technical aspects of EVs, namely evolutions in the technology for batteries, with the aim of analysing in deep detail the technological foundations, or technological aspects related to the generation of power to feed EVs.
- Contributions whose focus was on a very narrow aspect of the phenomenon (for example political actions put in place by states, …) have been discarded, since the major focus is the theme of drivers and barriers on the perspective of final users and fleet managers. This last elimination reduced the total amount of contributions of 27.

*ABSTRACT ANALYSIS:* before reading documents in their entirety, the abstract of each contribution was read, to have an overview of its content. This allowed to discard the documents which went in detail of themes not under our interest, without the necessity of reading all of them. This second filtering process allowed the discarding of other 68 documents:

- Some contributions have been ignored due to the fact that they mainly focus on technical aspects of the world of EVs (37 contributions).
- Other documents have been eliminated since they mainly focused on very narrow areas of the argument (e.g., range anxiety, or feelings related to the ownership) and the possible implications have been discarded, with 31 eliminations.

*FULL TEXT ANALYSIS:* the documents which were considered interesting were finally read in their entirety, to obtain the information needed for the work and, in case, to discard documents which seemed suitable at the first steps of analysis, but which turned out as useless. This allowed the finest refining of the literature documents considered, discarding other 29 documents, and getting to the final total of 27 contributions which are the foundation of the next literature review. Some contributions have been discarded since they mainly focus on just one aspect, not giving a broad overview of drivers and barriers for EVs diffusion. Some documents just focused on actions required to improve charging infrastructure or to reduce the charging times of vehicles: they focused just on the solutions to the problems, without

deepening the knowledge about the foundational barriers which required those corrective actions.

The final pool of documents used for the literature review of this thesis counted a total of 27 contributions. In addition, by exploring the references cited by the 27 documents, it was possible to identified 10 contributions to be added to the previous pool. Table 1 provides an overview of the identified contributions.

| Author(s) & Year | Source | Vehicle Type | Geographical Area | End User Type | Scope | Survey sample |
|---|---|---|---|---|---|---|
| (Biresselioglu, Kaplan, & Yilmaz, Electric mobility in Europe: A comprehensive review of motivators and barriers in decision making processes, 2018) | Transportation Research | EVs (BEV, PHEV) | Europe | Private | Drivers | N.A. |
| (Della Valle & Zubaryeva, 2019) | Energy Research & Social Science | EVs (BEV, PHEV) | Italy | Private, public | Barriers | 591 |
| (Formánek & Tahal, 2020) | Central European Business Review | ICE, EVs (BEV, PHEV) | Czech Republic | Private | Drivers, barriers | 452 |
| (Di Foggia, 2021) | Research in Transportation Business & Management | EVs (BEV, PHEV) | Italy | Fleet | Drivers, barriers | 93 |
| (Wikström, Hansson, & Alvfors, 2016) | Transportation Research | ICE, EVs (BEV, PHEV) | Sweden | Fleets | Barriers | 40 |
| (Unal & Shao, 2019) | Journal of Cleaner Production | EVs (BEV, PHEV) | Europe | Private | Drivers | 582 |

| | | | | | | |
|---|---|---|---|---|---|---|
| (Adhikari, Ghimire, Kim, Aryal, & Khadka, 2020) | Sustainability | ICE, EVs (BEV, PHEV) | Nepal | Private | Barriers | 53 |
| (Noussan & Tagliapietra, 2020) | Journal of Cleaner Production | ICE, EVs (BEV, PHEV, FCEV) | Europe | Private, fleets | Barriers | N.A. |
| (Shao, Taisch, & Ortega-Mier, 2016) | Journal of Cleaner Production | EVs (PHEV) | Europe | Private | Barriers | N.A. |
| (Müller, 2019) | Sustainability | ICE, EVs (BEV, PHEV) | Europe, China, North America | Private | Drivers, barriers | 1,177 |
| (Jelti, Saadani, & Rahmoune, 2020) | 2020 IEEE 13th International Colloquium of Logistics and Supply Chain Management (LOGISTIQUA) | ICE, EVs (BEV, PHEV) | Morocco | Private | Drivers, barriers | N.A. |
| (Meszaros, Shatanawi, & Ogunkunbi, 2021) | Periodica Polytechnica Transportation Engineering | EVs (BEV, PHEV) | Developing countries, Asia, Africa, Middle East | Private, fleets | Drivers, barriers | N.A. |
| (Tomasi, Alyona, Pizzirani, Dal Col, & Balest, 2021) | Sustainability | EVs (BEV, PHEV) | Italy, Switzerland, Austria, France | Private | Drivers, barriers | 1,000 |
| (Berkeley, Jarvis, & Jones, 2018) | Transportation Research | ICE, EVs (BEV, PHEV) | United Kingdom | Private | Barriers | 26,195 |

| | | | | | | |
|---|---|---|---|---|---|---|
| (Bhosale, Gholap, Mastud, & Bhosale, 2019) | International Journal of Recent Technology and Engineering | EVs (BEV, PHEV) | India | Private, fleets | Drivers, barriers | N.A. |
| (Hrudkay & Jaroš, 2019) | Acta logistica - International Scientific Journal about Logistics | EVs (BEV, PHEV) | Slovakia | Private, fleets | Barriers | N.A. |
| (Om Bansal & Goyal, 2020) | 2020 IEEE International Symposium on Sustainable Energy, Signal Processing and Cyber Security (iSSSC) | EVs (BEV, PHEV) | India | Private | Drivers, barriers | N.A. |
| (Plananska, 2020) | Energy Research & Social Science | ICE, EVs (BEV, PHEV) | Switzerland | Private | Drivers, barriers | 553 |
| (Ala, et al., 2020) | Sustainability | ICE, EVs (BEV, PHEV, FCEV) | Italy | Private, fleets | Barriers | N.A. |
| (Guglielmetti Mugion, Toni, Di Pietro, Giovina Pasca, & Renzi, 2019) | International Journal of Quality and Service Sciences | ICE | Italy | Private, fleets | Drivers, barriers | 230 |
| (Pucci, 2021) | Cities | ICE, EVs (BEV, PHEV) | Italy | Private | Drivers, barriers | N.A. |

| | | | | | | |
|---|---|---|---|---|---|---|
| (Secinaro, Brescia, Calandra, & Biancone, 2020) | Journal of Cleaner Production | EVs (BEV, PHEV) | Italy, Europe, World | Private | Drivers | N.A. |
| (Cherubini, Iasevoli, & Michelini, 2015) | Journal of Cleaner Production | EVs (BEV, PHEV) | Italy | Private | Barriers | N.A. |
| (Mahdavian, et al., 2021) | IEEE Access | EVs (BEV, PHEV) | World | Private | Drivers, barriers | N.A. |
| (Marletto, 2014) | Technological Forecasting and Social Change | EVs (PHEV) | Italy | Private | Drivers, barriers | N.A. |
| (Turton & Moura, 2008) | Technological Forecasting and Social Change | EVs (BEV) | Italy, Europe, developing countries | Private | Drivers, barriers | N.A. |
| (Rezvani, Jansson, & Bodin, 2015) | Transportation Research Part D: Transport and Environment | EVs (BEV, PHEV, HEV) | World | Private | Drivers, barriers | N.A. |
| (Axsen & Sovacool, The roles of users in electric, shared and automated mobility transitions, 2019) | Transportation Research Part D: Transport and Environment | EVs (BEV. PHEV, HEV) | World | Private | Drivers, barriers | N.A. |
| (Axsen, Goldberg, & Bailey, How might | Transportation Research Part D: Transport | EVs (BEV, PHEV) | Canada | Private | Drivers | 1,754 |

| | | | | | | |
|---|---|---|---|---|---|---|
| potential future plug-in electric vehicle buyers differ from current "Pioneer" owners?, 2016) | and Environment | | | | | |
| (Dumortier, et al., 2015) | Transportation Research Part A: Policy and Practice | ICE, EVs (BEV, PHEV) | USA | Private | Drivers | 2,759 |
| (Hackbarth & Madlener, 2013) | Transportation Research Part D: Transport and Environment | ICE, EVs (BEV, PHEV, HEV), NGV | Germany | Private | Drivers, barriers | 711 |
| (Higgins, Mohamed, & Ferguson, 2017) | Transportation Research Part A: Policy and Practice | ICE, EVs (BEV, PHEV, HEV) | Canada | Private | Drivers | 20,520 |
| (Huang & Ge, 2019) | Journal of Cleaner Production | ICE, EVs (BEV) | China | Private, fleets | Drivers, barriers | 204 |
| (Jansson, Pettersson, Mannberg, Bränlund, & Lindgren, 2017) | Transportation Research Part D: Transport and Environment | ICE, AFV, EVs (PHEV, BEV) | Sweden | Private | Drivers | N.A. |
| (Junquera, Moreno, & Alvarez, 2016) | Technological Forecasting and Social Change | ICE, EVs (BEV, PHEV) | Spain | Private | Drivers, barriers | 1,245 |
| (Laberteaux & Hamza, 2018) | Transportation Research | ICE, EVs (BEV, | USA | Fleets | Drivers | N.A. |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Part D: Transport and Environment | PHEV, HEV) | | | | |
| (Moons & De Pelsmacker, 2012) | Journal of Marketing Management | ICE, EVs (PHEV, BEV, HEV) | Belgium | Private | Drivers, barriers | 1,202 |

Table 1: Overview of the identified contributions

As far as vehicle type addressed is concerned, the contributions reported do not just focus on one type of vehicle. Indeed, they analyse different types of drivetrains present on models on the market, with a special attention for electric vehicles. This since some of them report – like (Junquera, Moreno, & Alvarez, 2016) – drivers and barriers for the adoption of EVs making a comparison against traditional ICE cars. Going in detail to explain the acronyms present in the table, we have:

- *ICE* stands for Internal Combustion Engine vehicles; among them there are:
  - *NGV*, which are *Natural Gas Vehicles,* powered by natural gas
  - *AFV*, which are Alternative Fuel Vehicles, powered by alternative fuels as biodiesel, synthetic gasoline, ethanol
- *EV* stands generically for Electric Vehicles, among which there are:
  - *HEV*, which are *Hybrid Electric Vehicles*, those which can not be recharged plugging the car to an electric socket.
  - *PHEV*, which are *Plug-in Hybrid Electric Vehicles*, which can be recharged both by the internal combustion engine on-board and through the electric grid.
  - *BEV*, *Battery Electric Vehicles*, which can just be recharged via electric grid, since they have only electric engines and batteries onboard.
  - *FCEV*, *Fuel Cell Electric Vehicles*, which are electric vehicles powered by hydrogen through the usage of fuel cells.

Focusing on the geographical areas covered by the contributions, there is an even distribution of geographical areas covered: one third of the contributions is centred on Italy only, with another third focused on other European nations or the entire continent and another third of the total which analyses extra-UE scenarios. Anyway, the issue with the contributions regarding Italy is that very few of them cover the territory in its entirety: most of the contributions presented analyse specific areas of the country (e.g., Alpine regions, urban area near Milan), analysing the drivers and barriers specific for those territories. Due to major differences among different Italian regions (in terms of development of infrastructures, salaries of inhabitants, …) they

are only partial studies which require an approach considering all the areas of the nation, making this a significant gap for literature.

For what regards the end user type, the wide majority of the contributions under analysis (nearly 90%) covers private users' cars, while a minor part considers commercial fleets for companies; this is a confirmation of the lack of literature analysing the latter theme.

Finally, as far as the scope of analysis is concerned, the majority of contributions discuss both drivers and barriers for the diffusion of EVs (57.14%), while the remaining ones cover just one of the two thematic here presented (respectively 22.86% barriers only, and 20.00% drivers only).

Apart from the geographical focus of the contributions, the documents face the theme of electric vehicles upon different perspectives: indeed, some of them present specific case studies (Della Valle & Zubaryeva, 2019; Guglielmetti Mugion, Toni, Di Pietro, Giovina Pasca, & Renzi, 2019; Pucci, 2021), while others reach the goal by providing an overview of the available literature (Biresselioglu, Kaplan, & Yilmaz, Electric mobility in Europe: A comprehensive review of motivators and barriers in decision making processes, 2018; Shao, Taisch, & Ortega-Mier, 2016; Secinaro, Brescia, Calandra, & Biancone, 2020). In Table 1, those contributions based on case studies and surveys are the ones with specified the size of the sample of answerers, while those which do not report that information are based on literature reviews or studies not based on the proposition of surveys.

## 1.2 State of Art

In this section the focus is the definition of the current state of art for what regards the uptake of EVs, both at private level and at corporate level, in fleets. The paragraph is divided in two macro areas – namely drivers and barriers – in which the different motivations fostering or discouraging the purchase of an electric vehicle are divided, based on their nature in 6 categories:

1. Economic factors
2. Environmental factors
3. Image factors
4. Comfort of usage factors
5. Personal factors
6. Governance factors

### 1.2.1 Drivers

Drivers can be defined as factors which influence the choice of a specific investment which otherwise would not have been undertaken; they act as motivators and triggers for the purchase (Haddadian, Khodayar, & Shahidehpour, 2015). In this case, they are all the factors which may influence the individual or the company to buy or lease an electric vehicle instead of a "traditional" one.

#### *Economic drivers*

Economic drivers are all those drivers which are related to a projected money saving for the entity which buys, or uses in general, an electric vehicle instead of a one with an internal combustion engine (ICE) (Biresselioglu, Kaplan, & Yilmaz, Electric mobility in Europe: A comprehensive review of motivators and barriers in decision making processes, 2018).

- *Lower Total Cost of Ownership*

Total Cost of Ownership can be defined as an estimation of the costs deriving from the purchase and usage of a product – in this case cars – along the entire lifecycle (Formánek & Tahal, 2020). This is a key theme since it is considered by literature a crucial success factor to promote and favour the diffusion of EVs, since they have lower operating costs than ICE cars (Cherubini, Iasevoli, & Michelini, 2015). The theme is analysed also by (Ala, et al., 2020), and it is gaining more and more importance since TCO is strongly influenced by national and local taxes, which are way lower for electric vehicles. TCO is a crucial aspect especially for developing and poorer countries: according to (Mahdavian, et al., 2021) the analysis of TCO, if favourable, can boost the

sales of electric automobiles in areas of the world with by low economic availability (Meszaros, Shatanawi, & Ogunkunbi, 2021).

TCO is made by costs which emerge in 4 phases of life of the car: purchase, usage, maintenance, end of life (Junquera, Moreno, & Alvarez, 2016). In each of these phases there can be 4 categories of costs: costs associated to the vehicle, related to charging infrastructure, linked to fiscality and related to emissions. Since it is clear how the cost of a vehicle is not limited to the purchasing phase, it is important for users to understand the total cost of the different phases of the useful life of the car, to make a comprehensive evaluation to compare EVs to ICE vehicles.

Analysing together those aspects, it is possible to identify all the possible voices of cost which emerge during the life of a vehicle, which are summed up in Table 2:

| | | PHASES OF LIFE OF VEHICLE | | | |
|---|---|---|---|---|---|
| | | *PURCHASE* | *USAGE* | *MAINTENANCE* | *END OF LIFE* |
| CATEGORIES OF COST | *VEHICLE* | Cost of purchase | Cost for fuel and energy<br><br>Insurance cost | Cost for vehicle maintenance<br><br>Cost for battery maintenance | Costs for dismantlement of vehicle |
| | *CHARGING INFRASTRUCTURE* | Cost of purchase of infrastructure | Impact of V2G services | Costs for maintenance of charging infrastructure | |
| | *FISCALITY* | Incentives at purchase | Incentives for parking, access to limited traffic areas | Costs for annual revision of vehicle | |
| | *EMISSIONS* | | Costs associated to emissions | | |

Table 2: TCO breakdown

Despite higher purchasing price (Plötz, Schneider, Globisch, & Dütschke, 2014), the TCO of electric vehicles result to be lower than the one of ICE cars, making them more convenient (Adnan, Nordin, Rahman, & Rasli, 2017; Dumortier, et al., 2015). This is due to lower expenses for recharging instead of refuelling (Biresselioglu, Kaplan, & Yilmaz, Electric mobility in Europe: A comprehensive review of motivators and barriers in decision making processes, 2018) with savings which offset the higher cost of the car (Junquera, Moreno, & Alvarez, 2016). Expense for fuel is a consistent burden for private owners and companies, so the switch to electricity can be a relief: to cover 100 km with a middle-sized car the expense with a gasoline engine is about € 12.5, while with an EV it is just €4[1] (EnelX, 2020).

This comes from the fact that:

- Gasoline and diesel fuel have a higher production cost than electricity.
- Gasoline and diesel fuel are subject to heavy taxation, which can reach up to 65% of the total cost for the final user (Ecologica, 2021) based on the country.

On the other hand, cost of electricity is lower, with final tariff of approximately 25 c€/kWh (in Italy), and lower taxation on final price (ARERA, 2021). This mismatch is more evident in regions with low costs for electricity production, thanks to abundance of natural resources as in regions like Trentino Alto-Adige and South Tirol (Della Valle & Zubaryeva, 2019). This is a trend visible also in other EU nations (Formánek & Tahal, 2020; Hrudkay & Jaroš, 2019; Wikström, Hansson, & Alvfors, 2016) and in developing countries as Brazil (Meszaros, Shatanawi, & Ogunkunbi, 2021).

EVs also imply lower maintenance costs: in case of BEVs, vehicles are simpler than ICE ones, so there are less parts which may break down and lower risk of failures, reducing the expense for repairing (Plananska, 2020). This advantage is limited to pure BEVs, since hybrid vehicles are fitted with an ICE which present the criticalities cited before.

TCO is reduced thanks to favourable taxation in many countries: nearly in all Europe there are tax exemptions for EVs, reducing yearly expense for owners and companies (Biresselioglu, Kaplan, & Yilmaz, Electric mobility in Europe: A comprehensive review of motivators and barriers in decision making processes, 2018; Plananska, 2020). TCO is lowered by savings for parking places and access to restricted traffic zones: in Europe (Hrudkay & Jaroš, 2019; Plananska, 2020; Pucci, 2021) and other areas of the world (Meszaros, Shatanawi, & Ogunkunbi, 2021; Huang & Ge, 2019) local administrations apply restrictive norms against polluting vehicles in city centres (Formánek & Tahal, 2020), to improve quality of air and to reduce traffic; the access to restricted traffic areas is subject to payment, from which hybrid and electric cars are

[1] This test has been performed in Italy with the Italian tariffs for electricity and gasoline, but it reflects the fact that fuels present a higher cost than electricity.

partially or totally exempted. These advantages are in some cases extended to toll roads or to bus and taxi lanes (Hrudkay & Jaroš, 2019; Plananska, 2020; Pucci, 2021). Also insurance costs are in many cases favourable for EVs (Elliott, 2020).

For what regards incentives at purchase the situation is more fragmented; if additional funds to support the acquisition of a vehicle are provided, the TCO decreases.

- *Economic incentives at purchase*

One of the main criticalities which is limiting the diffusion of electric vehicles on large scale is the higher price in comparison to traditional ICE vehicles (Plananska, 2020). Indeed, electric counterparts of gasoline models can cost up to two times the model with internal combustion engine (Plananska, 2020). This makes extremely important the adoption of policies to support the purchase of EVs, to make them competitive in the market against the traditional ones, at least until the prices of electric models decrease. These are fundamental drivers since literature sees the implementation of public incentives to promote the purchase of EVs the most important driver to favour the transition towards low or zero emission vehicles (Junquera, Moreno, & Alvarez, 2016), even in areas with high availability of capital for private owners, like South Tirol (Della Valle & Zubaryeva, 2019). To make an example, areas like Norway, California and Netherlands have very high market shares for EVs thanks to strong support schemes by the governments (Sierzchula, Bakker, Maatab, & van Wee, 2014; Melton, Axsen, & Goldberg, 2017). This is a driver is cited among many documents and contributions which come from all around the globe, as the literature reviews analysed confirm (Shao, Taisch, & Ortega-Mier, 2016): the provision of funds to support the purchasing of electric vehicles can be a boost for the flourishing of the EV market. This is true for all the possible markets: consumers are more than pleased to be offered discounts of any kind – promoted by the car dealer or by the state – when it comes to buy a new vehicle, irrespectively from the fact that we are in more developed areas like Europe (Shao, Taisch, & Ortega-Mier, 2016; Tomasi, Alyona, Pizzirani, Dal Col, & Balest, 2021; Hrudkay & Jaroš, 2019) and America or developing areas, like Africa (Jelti, Saadani, & Rahmoune, 2020; Meszaros, Shatanawi, & Ogunkunbi, 2021) or Asia, Middle East (Meszaros, Shatanawi, & Ogunkunbi, 2021) and South America (Meszaros, Shatanawi, & Ogunkunbi, 2021). Even in the wealthiest areas of the world – like Switzerland – the availability of state incentives is a crucial driver for the decision of buying a vehicle (Plananska, 2020).

This is true also for corporate car fleets: costs related to purchase or rental can be a barrier towards the adoption of EVs; statal financial support can have significant effects to drive the choices of fleet managers in favour of EVs (Di Foggia, 2021). A clear example is Sweden (Wikström, Hansson, & Alvfors, 2016), where fleets constitute a large share of new car sales (approximately 60%). The deployment of strong financial

support to buy low emitting vehicles (plug-in hybrid[2] vehicles or battery[3] vehicles), and their wide adoption by public administrations allowed reaching huge results, with fleets operating 85% of total PHEVs in the country (Wikström, Hansson, & Alvfors, 2016).

- *Tax deductions/exemptions*

This driver strongly relates with the total cost of ownership. I refer to this driver as the weight of taxation which can be avoided thanks to the usage of an EV instead of an ICE one (Ala, et al., 2020). Indeed, the usage of a car is subject to the payment of different kinds of taxes. Among them there are ownership tax, sales and registration taxes and taxes on fuels (excises). In many countries governments offer exemption or reduction for ownership tax, and in some cases for even part of sales and registration taxes, but the situation is still fragmented across different nations (Biresselioglu, Kaplan, & Yilmaz, Electric mobility in Europe: A comprehensive review of motivators and barriers in decision making processes, 2018), with the single countries which provide different schemes and tax reliefs. This is a significant driver no matter the "prosperity" of a region: in all cases tax exemption is seen as a great driver to promote the adoption of EVs. As analysed in (Della Valle & Zubaryeva, 2019) and (Tomasi, Alyona, Pizzirani, Dal Col, & Balest, 2021), even in alpine regions like Switzerland (Plananska, 2020), South Tirol and Verbanio-Cusio-Ossola – which are characterized by high GDP per capita – the tax exemption is as a boost for possible EV sales.

The same influential power of tax deductions can be found also in other parts of Europe: it can be registered in Czech Republic (Formánek & Tahal, 2020), Slovakia (Hrudkay & Jaroš, 2019) and in the entire European Union (Biresselioglu, Kaplan, & Yilmaz, Electric mobility in Europe: A comprehensive review of motivators and barriers in decision making processes, 2018). They are present also in China, North America (Müller, 2019) and emerging economies countries, where they can be a game changer to boost the diffusion of EVs (Meszaros, Shatanawi, & Ogunkunbi, 2021; Jelti, Saadani, & Rahmoune, 2020; Meszaros, Shatanawi, & Ogunkunbi, 2021).

For corporate fleets, also in this case tax exemptions have a significant effect on the decisions of company to buy an EV. Savings from taxes allow a significant reduction of TCO for the vehicle, allowing quicker recovery of the investment and reducing the payback time of the vehicle (Di Foggia, 2021); this is important since the PBT parameter is, in many industrial cases, seen as a severe hurdle to overcome when we deal with electric vehicles, due to their higher purchasing cost, which may limit their diffusion. The presence of incentives can be a boost for companies to go for electric vehicles. This

[2] In short, PHEVs
[3] In short, BEVs

has been demonstrated true in countries whose financial support is stronger, like Sweden (Wikström, Hansson, & Alvfors, 2016), where the strong support by the state allowed a huge diffusion of BEVs and PHEVs also in commercial fleets.

### *Environmental drivers*

Environmental drivers are drivers linked to reduction of emissions and harm to environment, allowing for a lower impact of the transportation sector (Beck, Rose, & Hensher, 2013). Electric vehicles – BEVs and PHEVs – can allow for this scope, reducing the usage of fossil fuels in favour of electric energy, which can be obtained also from renewable sources. This section lists the drivers related to this dimension of analysis, specifically addressing the environmental reasons for which a consumer or a company may be positively influenced in buying or using an EV instead of a vehicle equipped with an ICE.

- *Environmental benefits*

One of the main drivers which can determine a shift towards electric vehicles is the positive environmental effect they can have (Egbue & Long, 2012). BEVs are responsible of no direct emissions from usage thanks to the fact that there are no internal combustion engines on them. PHEVs do present an ICE onboard, but with the support of batteries to improve performance and reduce emissions; this is even more evident in urban areas, where these vehicles can run just on batteries, with no release of $CO_2$ or pollutants. These features allow to reduce Greenhouse Gases (GHG) (Laberteaux & Hamza, 2018), and consumption of energy to feed vehicles (Axsen, Goldberg, & Bailey, How might potential future plug-in electric vehicle buyers differ from current "Pioneer" owners?, 2016; Degirmenci & Breitner, 2017; Hackbarth & Madlener, 2013).

This driver can be found in documents from all over the globe (Secinaro, Brescia, Calandra, & Biancone, 2020), but also in site specific studies focalised on European countries and institutions (Della Valle & Zubaryeva, 2019; Formánek & Tahal, 2020; Noussan & Tagliapietra, 2020; Müller, 2019; Tomasi, Alyona, Pizzirani, Dal Col, & Balest, 2021; Hrudkay & Jaroš, 2019; Plananska, 2020), North America (Müller, 2019), China (Müller, 2019), Africa (Jelti, Saadani, & Rahmoune, 2020), India (Bhosale, Gholap, Mastud, & Bhosale, 2019; Om Bansal & Goyal, 2020) and many countries also from emerging economies (Meszaros, Shatanawi, & Ogunkunbi, 2021).

When a vehicle burns fuel, as gasoline or Diesel, exhaust gases contain many gaseous compounds. These emissions can be ranked as (Natural Resources Canada, 2014):

  - *Criteria Air Contaminants (CAC):* toxic compounds which pollute the environment and can be harmful if inhaled or if there is contact. They

comprehend carbon monoxide (CO), sulphur oxides ($SO_X$), nitrogen oxides ($NO_X$), particulate matter[4] ($PM_X$), ammonia ($NH_3$) and Volatile Organic Compounds[5] (VOC).

- *Greenhouse Gases (GHGs):* non-toxic gases responsible of greenhouse effect, which leads to an increase of the temperatures of the planet. Among them the most important ones are carbon dioxide ($CO_2$), nitrous oxide ($N_2O$) and methane ($CH_4$).

The perception of this driver can differ between countries, basing on differences on socio-economic dimensions: environmental pressure seems to be more perceived in wealthier countries than in the poorer ones. This is justified also by the presence of specific political actions by entities like the European Union (Biresselioglu, Kaplan, & Yilmaz, Electric mobility in Europe: A comprehensive review of motivators and barriers in decision making processes, 2018; Formánek & Tahal, 2020), USA, the UK (Berkeley, Jarvis, & Jones, 2018) which are setting ambitious environmental goals for the next future to boost the diffusion of EVs. Actions form emerging – like China and India (Bhosale, Gholap, Mastud, & Bhosale, 2019; Om Bansal & Goyal, 2020) – or poorer countries (Meszaros, Shatanawi, & Ogunkunbi, 2021) seem insufficient for the scope, since the main goal of local governments satisfy the basic needs of population.

Companies are getting more and more environmental sensitive, too, understanding that a rethink of their operations is required. This green trend is more evident in wealthier countries like Sweden, where there is a huge diffusion of electric vehicles also for commercial scopes (Wikström, Hansson, & Alvfors, 2016). Anyway, also in the Italian context the scenario is improving, with projected presence of EVs in fleets which are increasing in next years thanks to more demand for sustainability coupled with all the economic benefits analysed before (Di Foggia, 2021).

In addition to these aspects, electric engines are characterized by a higher efficiency in comparison to ICEs: while the latter can reach levels of efficiency of about 40% (for very efficient Diesel engines), electric ones can achieve even 85% (Boloor, Valderrama, Statler, & Garcia, 2019). Electric engines are still undergoing R&D phases, so in the future their performances and their efficiency and can furtherly improve, unlike for ICEs, which are almost a mature technology with limited room for improvement.

As a last remark, one of the major criticalities regarding EVs is linked to the batteries of the cars themselves: their production is cited as polluting and not respectful for the

[4] PM is solid or liquid particles in the atmosphere. Soot or smoke is made up of particles that are large or dark enough to be visible. Vehicle particulate emissions consist mainly of fine PM that is generally not visible. This PM is also known as PM2.5 because the particles are less than 2.5 microns in diameter (Natural Resources Canada, 2014).

[5] VOCs are carbon-containing gases and vapours such as gasoline fumes but exclude $CO_2$, CO, $CH_4$ and chlorofluorocarbons. Reactive VOCs can combine with NOX in the presence of sunlight to form ground-level ozone ($O_3$) (Natural Resources Canada, 2014).

conditions of workers: batteries require the extraction of materials like lithium, lead, cobalt and other metals through energy intensive processes. These procedures take place in countries where the working conditions of miners are in many cases neglected (Zhang, Yu, & Zou, 2011). In addition, the mismanagement of batteries at their end of life is very dangerous (Biresselioglu, Kaplan, & Yilmaz, Electric mobility in Europe: A comprehensive review of motivators and barriers in decision making processes, 2018). For this reason, the definition of procedures and technologies to try to reduce the impact of batteries throughout the entire lifecycle gets more and more important, becoming a driver for the uptake of EVs. Many efforts have been already put in place by the players with different solutions:

- *Reusage of batteries:* batteries no more suitable for the usage on vehicles can be re-used for stationary applications. After a loss of capacity of approximately 30% (about 8 years of usage) batteries are no more usable for vehicles, so they must be substituted. Instead of dismantling them, they can be re-used to create big accumulators in stationary applications, where there are less stressful cycles of charge/discharge. Car makers are investing resources to develop those technologies and extend the life of batteries as much as possible (Daimler, 2017; Volkswagen AG, 2019).
- *Development of novel recycling techniques and plants:* companies are trying to develop recycling techniques to reobtain as much raw materials as possible, to use them again in the production cycle for new batteries. Current processes cannot recycle the entirety of the materials present in accumulators, so still action is required. Promising pilot projects from companies like Volkswagen and Tesla should be able to recover up to 97% of the materials in batteries, way higher compared to the current 53% cited by the German company (Volkswagen AG, 2019; Cao, 2020).

The breakthroughs to reduce the impact of batteries can be an important driver to promote the purchase and usage of electric vehicles, convincing the most sceptic individuals regarding the environmental side of EVs.

- *Better exploitation of renewable energy sources*

This driver is related to the possibility to couple EVs with the generation of electricity with renewable sources to reduce the energy usage and the GHG/polluting emissions in atmosphere (Hofmann, Guan, Chalvatzis, & Huo, 2016).

Electric vehicles can indeed create synergies with the renewable plants for the electricity generation, determining a successful combination of those two technologies. EVs can indeed be recharged by exploiting the PV panels which can be installed at residences of private owners in company sites, decreasing the cost of recharge and increasing the environmental benefits associated to EV usage. This is crucial for the development of future environmental agendas by states and federations, like the

European Union (Biresselioglu, Kaplan, & Yilmaz, Electric mobility in Europe: A comprehensive review of motivators and barriers in decision making processes, 2018; Turton & Moura, 2008) and UK (Berkeley, Jarvis, & Jones, 2018) and US.

### *Image drivers*

Image drivers are drivers related to the idea that a person has about another person or company, namely the image of a specific entity (Hardman, Shiu, & Steinberger-Wilckens, 2016). It can be modified by actions or choices, as the uptake of EVs (Moons & De Pelsmacker, 2012).

- *Increase personal/company image by purchasing EVs*

Nowadays environmental awareness is becoming a more and more popular trend, thus the choice of low impact alternatives is welcomed and applauded as a conscious and cool choice and as a sign that the person cares about the environment and its protection. Indeed, in literature this is a common driver which can boost the adoption of electric vehicles and which can be applied both to individuals and companies (Hackbarth & Madlener, 2013; Helveston, et al., 2015).

In addition, as electric vehicles are still characterized by higher prices in comparison to traditional vehicles, their possession is seen as a status symbol, since they are exclusive vehicles (Biresselioglu, Kaplan, & Yilmaz, Electric mobility in Europe: A comprehensive review of motivators and barriers in decision making processes, 2018; Schuitema, Anable, Skippon, & Kinnear, 2013). Car owners can give the impression of caring about the environment (Mohd Suki & Mohd Suki, 2019) by acquiring an EV, or having power by purchasing premium big sized EVs (Rezvani, Jansson, & Bodin, 2015).

The same can be said for company fleets: if a company purchases and uses EVs it gives to the public a good image of themselves, with possible good effects on their sales or economic results. This can be possible thanks to the fact that a person can be influenced by the green image that the company gives, so individuals may choose a company's product over another one because of the green perception (Di Foggia, 2021; Mohd Suki & Mohd Suki, 2019). This is a very common driver for the adoption of EVs in fleets, cited at Italian (Di Foggia, 2021) and international level (Biresselioglu, Kaplan, & Yilmaz, Electric mobility in Europe: A comprehensive review of motivators and barriers in decision making processes, 2018; Rezvani, Jansson, & Bodin, 2015), which can be also applied to companies operating in car sharing (Guglielmetti Mugion, Toni, Di Pietro, Giovina Pasca, & Renzi, 2019): a person may choose a car sharing platform instead of another basing on the adoption of EVs.

- *Sense of belonging to a group*

This other driver relates to the fact that there is a strong sense of community which links together the owners of EVs (Mohd Suki & Mohd Suki, 2019). Since this is still a new technology, only early adopters already purchased an electric vehicle, probably the most concerned about environment characterized by the highest enthusiasm. For this reason, there are many groups on social medias uniting EV owners loyal to just one brand (e.g., Tesla fans) or to the concept of EVs. This is a recurring theme which already was present for ICE vehicles, with fan groups of specific models or brands creating communities based on the same interest for automobiles. In last years, thanks to the development of electric models, the phenomenon reappeared, now dealing with EVs (Biresselioglu, Kaplan, & Yilmaz, Electric mobility in Europe: A comprehensive review of motivators and barriers in decision making processes, 2018; Rezvani, Jansson, & Bodin, 2015; Mohd Suki & Mohd Suki, 2019).

- *Sustainability consciousness*

This driver is related to the personal preferences about a certain product, and the willingness to ask for a "sustainable" product instead of a "traditional" one (Mohd Suki & Mohd Suki, 2019). Especially in last years, the growing concerns about global warming increased the awareness about the theme, determining an increase of demand for sustainable products, making this a very important aspect (Mohd Suki & Mohd Suki, 2019). The automotive industry followed this trend, with a huge increase of the availability of EV models in the range of each manufacturer. Care for environment is increasing a lot in people both in traditionally attentive countries and areas (e.g. South Tirol (Della Valle & Zubaryeva, 2019), Sweden (Wikström, Hansson, & Alvfors, 2016), Switzerland (Plananska, 2020)) but also in developing countries, sometimes cited as less conscious about environment (Meszaros, Shatanawi, & Ogunkunbi, 2021). Strong correlation between this driver and the effective choice of an electric car instead of a traditional one has been highlighted by literature (Axsen, Goldberg, & Bailey, How might potential future plug-in electric vehicle buyers differ from current "Pioneer" owners?, 2016; Moons & De Pelsmacker, 2012; Huang & Ge, 2019). The same holds for company fleets: demand for green vehicles is increasing over years, thanks to the related economic and image advantages (Wikström, Hansson, & Alvfors, 2016) and pressures and expectations of stakeholders (Di Foggia, 2021).

### *Comfort of usage drivers*

These drivers refer to the everyday usage of the vehicle, which can be experienced by the EV owner. Indeed, there can be some differences in the usage of an electric vehicle in comparison to a traditional internal combustion engine vehicle, which in many cases

translate into advantages which can determine higher propensity in purchasing them instead of others.

- *Access to bus lanes, reserved parking, and other restricted areas*

This is an issue already seen in the economic section of drivers. Indeed, electric vehicles and plug-in hybrids are subject to some advantages, especially in cities. They can be free of accessing specific lanes as the bus lanes or taxi lanes, to dedicated parking spots and the possibility to access restricted traffic zones (Formánek & Tahal, 2020). These are found in literature as *non-economic incentives* (Huang & Ge, 2019), and they are not seen as the major drivers which can change dramatically the perception of EVs. They are important, of course, since they can improve a little bit the driving experience, but according to (Hackbarth & Madlener, 2013; Huang & Ge, 2019) there is no positive correlation between these incentives and a change in the adoption intention, so these benefits from the government appear insufficient to accelerate the diffusion of EVs.

- *Ease of use of vehicle and ease of maintenance*

Pure electric vehicles are characterized by an easier experience of usage and an easier maintenance routine than traditional ones. Pure BEVs, indeed, are characterized by a simpler architecture than ICEs, so there are less components which risk to break down; in addition, there is less stress when driving BEVs, since transmissions are automatic. This translates in a more relaxed driving experience and in less expenses for maintenance (Noussan & Tagliapietra, 2020; Jelti, Saadani, & Rahmoune, 2020), making it a significant driver for both private owners and companies. The simple structure of these vehicles, and the lower maintenance costs and needs, can be a significant game changer especially in developing countries, where the economic availability of users is not so high, along with the relative scarcity of mechanic shops in which repair the car (Om Bansal & Goyal, 2020). As a last remark, the lower maintenance needs can be very good as drivers for a wide adoption of EVs also in car sharing and company fleets, determining easier management of the fleet in comparison to traditional ones, along with lower expenses for reparations and periodic check-ups (Cherubini, Iasevoli, & Michelini, 2015; Mahdavian, et al., 2021). In addition, electric vehicles, thanks to the characteristics of electric engines, permit having great experiences in terms of driving performances (acceleration and maximum speed). Indeed, these can be important motivations which can drive a potential buyer to choose an EV instead of an ICE vehicle, thanks to the fact that – for equal type of vehicle – the performances of the electric one are higher (Beck, Rose, & Hensher, 2013; Hess, Fowler, Adler, & Bahreinian, 2011; Sovacool, Kester, Noel, & de Rubens, 2018).

- *Diffusion of public charging points*

This is one of the main concerns when it comes to the usage of electric vehicles, so the presence and distribution of charging points (Berkeley, Jarvis, & Jones, 2018). One of the main problems and fears affecting the diffusion of EVs (BEVs in this case, since PHEVs can run also relying on the ICE engine) is the so-called "range anxiety", so the fear of not having enough autonomy to reach the prefixed destination, along with the lack of enough charging points to recharge the car when needed. A wide presence of charging points can boost the uptake of EVs.

It is cited as a driver in contributions analysing ambitious emerging countries (e.g., Thailand, China (Meszaros, Shatanawi, & Ogunkunbi, 2021) and Morocco (Jelti, Saadani, & Rahmoune, 2020)), European nations (Slovakia (Hrudkay & Jaroš, 2019), Italy (Pucci, 2021) and analysing in general terms the potential success factors which may increase the diffusion of electric vehicles, saying that the wide presence of charging stations across countries can be a significant factor which can determine the choice of an electric vehicle, eliminating the already cited "range anxiety" (Secinaro, Brescia, Calandra, & Biancone, 2020; Cherubini, Iasevoli, & Michelini, 2015).

The installation of charging stations can be performed by public sector per se, or in collaboration with private companies or by possessors of public activities (e.g., private charging points for public use in restaurants, malls, …) or by private users in houses (wall boxes). An increase in their number and capillarity can encourage more drivers to adopt an EV thanks to the security of having a point in which recharge the car close to them, diminishing the perceived anxiety of remaining without charge. The statal intervention in the development of the charging point infrastructure becomes fundamental to facilitate the diffusion of the charging network, thus it is crucial to convince more drivers in adopting an EVs (Formánek & Tahal, 2020). Statal support can be found also in documents analysing emerging countries (Jelti, Saadani, & Rahmoune, 2020; Meszaros, Shatanawi, & Ogunkunbi, 2021; Om Bansal & Goyal, 2020) and in worldwide literature (Secinaro, Brescia, Calandra, & Biancone, 2020) as a crucial point to have a sufficient recharging network. This is not enough: to spread even more EVs, the state should support private entities in installing charging points in private spaces (houses and workplaces) and public places as malls or restaurants.

- *Specific vehicle characteristics and accessories onboard*

The electric vehicles which are now present on the market are in many cases fitted with specific optional features and tools which are not present in ICE vehicles, or some elements which can improve the overall experience onboard during the journey (Mahdavian, et al., 2021). The presence of these features can be a significant influencer in the choices, with the most technological customers which may choose the vehicle basing on them.

This driver, cited in (Secinaro, Brescia, Calandra, & Biancone, 2020) and (Cherubini, Iasevoli, & Michelini, 2015), covers for example automation devices which may lead to automated vehicle, with levels of automation which can differ among countries and kind of actions which can be performed by the vehicle itself (Mahdavian, et al., 2021). The stress on automation is even more present in electric vehicles since they are the future: if a car manufacturer has to develop novel and revolutionary technologies it does that on revolutionary vehicles such as EVs. This is a great driver for the diffusion of EVs (Mahdavian, et al., 2021). In addition, EVs are now fitted with programs and tools which improve the driving experience and overcome inhibitors which may discourage their purchase. For example, to overcome range anxiety, models have in navigation systems options to plan stopovers to recharge the car basing on driving habits of users, predicting also the time spent to recharge the vehicle (Secinaro, Brescia, Calandra, & Biancone, 2020).

### *Personal drivers*

These drivers are related to the personal feelings and beliefs which influence the choice of a product instead of another. As for the image drivers, they are not directly related to economic or performance aspects, but they are more related to the subjective sphere of tastes and emotions that an individual experiences when purchasing a product. Anyway, they differentiate from image ones since here I refer not to what external people think about an EV owner, but I intend to focus on the personal emotions and feelings felt by the individual while using the electric car, without any external influence. Indeed, (Huang & Ge, 2019; Moons & De Pelsmacker, 2012) analysed how there is a strong link between the emotions that a vehicle generates in the potential customer and the actual purchase of the vehicle, making emotions a catalyst for the transaction. This link highlighted by literature makes them worthy of an analysis.

- *Peer influence*

Peer influence is the influence that a group of peers (family, friends, colleagues, …) can exert on individuals, influencing their choices when buying a product (Mohd Suki & Mohd Suki, 2019). The word of mouth can help the individual in obtaining more knowledge about the product, increasing awareness and unravelling doubts and worries. This has been analysed as one of the driving forces which can influence the choices of the individuals (Plananska, 2020; Guglielmetti Mugion, Toni, Di Pietro, Giovina Pasca, & Renzi, 2019; Mohd Suki & Mohd Suki, 2019). Indeed, (Mohd Suki & Mohd Suki, 2019) say that purchases are influenced by peer influence more than advertisements: people trust people they know more than companies or someone they don't know personally. This is confirmed by (Axsen & Sovacool, The roles of users in electric, shared and automated mobility transitions, 2019; Zhang, Yu, & Zou, 2011;

Moons & De Pelsmacker, 2012), which report how peer pressure has greater influence on personal choices in comparison to media pressure. Studies like (Jansson, Pettersson, Mannberg, Brännlund, & Lindgren, 2017; Axsen, Orlebar, & Skippon, Social influence and consumer preference formation for pro-environmental technology: The case of a U.K. workplace electric-vehicle study, 2013) confirm this, with neighbours exerting the strongest influence, followed by co-workers and finally by relatives. The mutual exchange of impressions and thoughts about EVs and their usage can positively influence their purchase from individuals.

- *Degree of innovativeness*

According to (He, Zhan, & Hu, 2018), passion and interest of an individual in innovative objects and themes, like EVs, have strong influence on purchases, inducing their acquisition. Other studies (Axsen, Goldberg, & Bailey, How might potential future plug-in electric vehicle buyers differ from current "Pioneer" owners?, 2016) demonstrated that users with high "personal level of innovativeness" are more interested in evaluating environmental impacts of such items, tending towards the purchase of EVs.

### *Governance drivers*

The last category of drivers which are analysed are referred to the actions put in place by local authorities and governments in order to promote the diffusion of electric mobility in the different countries (Biresselioglu, Kaplan, & Yilmaz, Electric mobility in Europe: A comprehensive review of motivators and barriers in decision making processes, 2018). Indeed, economic driver and the usage ones are strongly affected by what governments do and plan to do to incentivize the purchase and usage of EVs.

- *Adoption of EVs in public fleets (public transport, state fleets, car sharing)*

In this case the driver is directly related to the example given by the administration in adopting and using electric vehicles. The adoption of electric vehicles by public sector can be explained by all the economic and environmental drivers seen, but in this case there is also a novel meaning: it has been cited as a booster for the adoption by the public, thanks to the fact that in this way they give the example by effectively embracing them, and not just telling people that they should do so (Biresselioglu, Kaplan, & Yilmaz, Electric mobility in Europe: A comprehensive review of motivators and barriers in decision making processes, 2018). The wide usage of EVs by governments may increase the curiosity and the awareness about EVs (Meszaros, Shatanawi, & Ogunkunbi, 2021), along with the possibility to assess the advantages from their usage (Bhosale, Gholap, Mastud, & Bhosale, 2019).

Another important aspect relates to the usage of EVs in car sharing schemes: their adoption allows people to get in touch with them, and gain experience, increasing the possibility that they may buy an EV (Guglielmetti Mugion, Toni, Di Pietro, Giovina Pasca, & Renzi, 2019; Pucci, 2021; Cherubini, Iasevoli, & Michelini, 2015; Mattia, Guglielmetti Mugion, & Principato, 2019).

- *Government actions to better inform drivers about advantages of EVs*

One of the main criticalities for the adoption of electric vehicles is the knowledge about them (Plananska, 2020). EVs are still affected by many prejudices, which may exist for many reasons: for example, people may still think that their autonomy is still too low because of bad experiences in the past or may imagine that the overall cost of owning an EV is higher than for ICE cars. This is cited as one important driver by (Biresselioglu, Kaplan, & Yilmaz, Electric mobility in Europe: A comprehensive review of motivators and barriers in decision making processes, 2018), which tells us the importance of acting in providing information to people, for example with seminaries or conferences to make people aware of the advantages coming from the usage of EVs (Rezvani, Jansson, & Bodin, 2015), as well as the payback times for EVs in company fleets overestimated in many cases by managers (Di Foggia, 2021). Sometimes people and companies are not aware of the fiscal incentives provided by states (Della Valle & Zubaryeva, 2019; Berkeley, Jarvis, & Jones, 2018) for EVs purchase, so administrations should better inform them. Over the economic knowledge, also the technical one is too low, with individuals and managers who do not have idea of the technological development that EVs have faced in the years (Shao, Taisch, & Ortega-Mier, 2016; Plananska, 2020); governments and car dealers should better inform audience about the potential that this technology has (Di Foggia, 2021). This is also linked to the necessity of companies to opportunely train employees when EVs are introduced in fleets: (Wikström, Hansson, & Alvfors, 2016) reveals that in some cases companies give EVs to their workers without sufficient training, thus they may fear this new technology, preferring traditional ICE vehicles.

As seen, information and communication of different aspects of EVs can help their adoption and diffusion, with states and companies which should invest funds and efforts in promoting informative actions (Shao, Taisch, & Ortega-Mier, 2016).

The different drivers found in literature are summarized in Table 3: in that table there is not only a sum up of the drivers analysed until now and their typology (e.g., economic, image, …) and category upon which they act, but there is also a specific column to describe their nature, which can be exogenous, endogenous or both. In this sense, an exogenous driver is a driver on which the final user – or companies seeking for fleet vehicles – have no room of manoeuvre, meaning that they depend only on third party entities, like the public administration for example. On the opposite, endogenous drivers are the ones on which the user or the company has the possibility to act on, since they depend directly on them.

| | DRIVERS | | |
|---|---|---|---|
| | NAME | CATEGORY | NATURE |
| ECONOMIC | Lower Total Cost of Ownership | Private/fleet | Endogenous & Exogenous |
| | Economic incentives | Private/fleet | Exogenous |
| | Tax deductions | Private/fleet | Exogenous |
| ENVIRONMENTAL | Environmental benefits | Private/fleet | Endogenous & exogenous |
| | Better exploitation of renewables | Private/fleet | Endogenous |
| IMAGE | Increase of image by purchasing EVs | Private/fleet | Endogenous |
| | Sense of belonging to a group | Private | Endogenous |
| | Sustainability consciousness | Private/fleet | Endogenous |
| COMFORT OF USAGE | Access to bus lanes and restricted areas | Private/fleet | Exogenous |
| | Ease of use and maintenance | Private/fleet | Exogenous |
| | Diffusion of public charging points | Private/fleet | Exogenous |
| | Specific vehicle characteristics and accessories onboard | Private | Exogenous |
| PERSONAL | Peer influence | Private | Endogenous |
| | Degree of innovativeness | Private | Endogenous |
| GOVERNANCE | Adoption of EVs in public fleets | Private | Exogenous |
| | Better information of drivers about EVs | Private/fleet | Endogenous & exogenous |

Table 3: Recap table for drivers and their nature

### 1.2.2 Barriers

Barriers are characterized as factors which inhibits an investment or a purchase of a product, moving away the investor from that specific alternative under analysis (Haddadian, Khodayar, & Shahidehpour, 2015). They can be of different nature and, in this context, they are related to all those factors which impede and avoid that an individual or a company buy or rent an electric vehicle, or at least those issues which can slow down the entire purchasing process. The identified barriers are divided in six categories, which will be analysed case per case.

#### *Economic barriers*

Economic barriers are the barriers related to financial expenses which may result higher than the ones which may be faced in purchasing and using an internal combustion engine vehicle. They can be also in this case *direct* (e.g., higher purchasing cost) or *indirect* (e.g., too low incentives).

- *High cost of purchase of EV and too high rental costs*

The first barrier which can be identified is related to the high EVs cost. Indeed, this is the biggest problem which can be found (Lieven, Mühlmeier, Henkel, & Waller, 2011): the cost of an electric version of a model is currently from 50% to 100% higher than the ICE counterpart. PHEV versions are less expensive than the BEV ones, but in comparison to ICE models they are 40% more expensive (Lieven, Mühlmeier, Henkel, & Waller, 2011). This determines reluctances in potential customers, so literature addresses this as a crucial problem (Plötz, Schneider, Globisch, & Dütschke, 2014). This is cited as the main worldwide barrier which slows down the adoption of electric vehicles, (Shao, Taisch, & Ortega-Mier, 2016; Secinaro, Brescia, Calandra, & Biancone, 2020) and it is found in contributions analysing Europe (Biresselioglu, Kaplan, & Yilmaz, Electric mobility in Europe: A comprehensive review of motivators and barriers in decision making processes, 2018) and specific countries (Della Valle & Zubaryeva, 2019; Formánek & Tahal, 2020; Hrudkay & Jaroš, 2019; Om Bansal & Goyal, 2020; Plananska, 2020). The problem of high cost exists even in rich areas like Switzerland (Plananska, 2020), alpine regions (Tomasi, Alyona, Pizzirani, Dal Col, & Balest, 2021; Della Valle & Zubaryeva, 2019), and USA (Müller, 2019); in these countries the situation can be mitigated by relatively high GDP per capita and by the presence of local EV industries which allow to reduce or eliminate import taxes. In developing countries, the situation is widely different (Meszaros, Shatanawi, & Ogunkunbi, 2021): in many of them population lives on very low salaries, with difficulties of accessing food and water. In these countries the possibility to buy an electric vehicle becomes pretty much null, apart from very few wealthy individuals who can afford them.

Analysing commercial fleets, the problem of price follows what already said for privates: companies would adopt EVs willingly, but they are scared by price (Di Foggia, 2021; Wikström, Hansson, & Alvfors, 2016). In case of fleets, this problem is accompanied by the perception that payback time for vehicles is too high: for private vehicles the tendency is to keep them for more than 5 years, but in firms vehicles are changed every 3 or maximum 4 years (Di Foggia, 2021). This is a problem, since savings from the usage of EVs appear in the long term; if vehicles are changed too fast, the higher price of EVs is not offset by the savings from the usage (Di Foggia, 2021).

The economic barrier represented by purchasing price is one of the main concerns regarding the diffusion of EVs, both for fleets and private owners. The severity of the problem becomes even higher in poorer countries, where there are the highest economic difficulties in adopting those new technologies.

- *Reduction or insufficient state incentives*

Another barrier cited and very present in the literature is represented by the insufficient state incentives put in place by governments to help people in buying electric vehicles. This is a criticality observed worldwide (Shao, Taisch, & Ortega-Mier, 2016; Secinaro, Brescia, Calandra, & Biancone, 2020; Turton & Moura, 2008), no matter the wealth of the country under analysis.

Despite the increasing awareness and actions by government, incentives are still not sufficient in many countries, ranging from European ones like Czech Republic (Formánek & Tahal, 2020) and Italy (Della Valle & Zubaryeva, 2019), passing through Switzerland (Plananska, 2020). In emerging countries, the situation is even worse: apart from China, which is heavily investing in EV spread (Müller, 2019), other countries report difficulties in offering enough incentives. In India (Bhosale, Gholap, Mastud, & Bhosale, 2019; Om Bansal & Goyal, 2020), for example, the ambitious plans to develop electric mobility in the nation still lack sufficient economic resources to be effective on large scale, due to the enormous audience of possible requestors and the limited resources available.

This is a problem also for fleets (Laberteaux & Hamza, 2018): (Di Foggia, 2021) reports how the little number of vehicles present in Italian fleets is due mainly to the high costs of purchase, which is not enough reduced by statal incentives. In states providing sufficient economic support like Sweden (Wikström, Hansson, & Alvfors, 2016), the presence of electric vehicles in fleets is higher, with commercial fleets operating about 85% of new registered PHEVs in the country in 2015.

- *High ownership costs*

In some countries the ownership costs for an EV may be higher than the ones for a traditional one, making the usage of ICE vehicles more convenient. This becomes a

huge problem to pursue the objectives of a wide diffusion of EVs, since, if costs are higher than for ICEs, economic benefits disappear, making their adoption antieconomic (Adhikari, Ghimire, Kim, Aryal, & Khadka, 2020).

To make an example, in Italy people report as a barrier for EV usage the high cost for recharging them in public charging points, where fast recharge is still seen too expensive. This is more evident in emerging countries, since the electricity grid is in many cases not sufficiently reliable and the costs of generating electricity and transmitting it is high; (Adhikari, Ghimire, Kim, Aryal, & Khadka, 2020) reports how one of the main economic barriers is the high cost for electricity at charging points, making difficult the adoption of EVs. The same source reports how in poorer countries there is also a problem of heavy variations of price, making difficult possible estimations to understand payback times and assessments of savings. Also (Meszaros, Shatanawi, & Ogunkunbi, 2021) stress a lot this concept, with a focus on emerging economies: in those nations there are still low incentives for the purchase; this, coupled with inadequate grid and high charging costs, makes the ownership costs of EVs too high compared to ICE cars. The same problems are registered in India (Bhosale, Gholap, Mastud, & Bhosale, 2019), where initially EVs were well welcomed by the population as a good solution to reduce expense for transport and emissions; gradually this perception changed, due to the high purchasing costs of the vehicles and the high costs of recharging.

As a last remark, it is important to cite another problem which determines high cost for EV ownership: (Rezvani, Jansson, & Bodin, 2015) reports that in countries as China, USA and nations from Middle East the cost for fossil fuels like oil and its derivates is very low, because they extract those resources or states apply low taxes on them. This makes the usage of ICEs very convenient, and the adoption of EVs antieconomic.

All these issues are hardly ever in the hands of the consumers and the companies who want to adopt EVs, apart the minimal possibility to change electricity provider or choose the least expensive charging points.

- *High costs for private charging points*

Continuing the discussion about the recharge of vehicles, another problem is the high cost of the private charging points for domestic use. They are fundamental to charge the vehicles at an acceptable speed. Majority of domestic meters support at maximum 3 kW of power delivered, with also other domestic appliances connected, while wall boxes, with modifications of meters, allow to deliver more power and significantly

reduce the time to recharge[6]: different technologies are available, with powers of 3.7 kW, 7.4 kW, 11 kW and 22 kW. The main problem is related to the cost for their installation: focusing on an Italian case (Mirra, 2021), costs of purchase and installation of a 3.7 kW point range between € 900 and € 1,500, a significant investment. In some cases, wall boxes may be offered at discounted fares – or even for free – by car dealers (Mirra, 2021) or there are specific statal incentives for their purchase (Mirra, 2021).

These are very specific cases, and in normal conditions without subsidies the purchase and installation of a wallbox becomes a hurdle, so literature addresses it. This is remarked by (Adhikari, Ghimire, Kim, Aryal, & Khadka, 2020) saying that the high costs for charging – including the cost for the charging point – are significant barriers faced by possible users, barriers which are cited both in developed countries (like Italy (Ala, et al., 2020; Mirra, 2021), Slovakia (Hrudkay & Jaroš, 2019), Switzerland (Plananska, 2020)) and in poorer ones, like India (Om Bansal & Goyal, 2020) and others (Meszaros, Shatanawi, & Ogunkunbi, 2021). In these latter cases the problem is even more serious, since people have low salaries and low financial resources.

### *Environmental barriers*

These barriers are related to the impact which derives from the production and usage of electric vehicles. They are not totally carbon free, since emissions are generated during the production phases and the end-of-life treatment of car and batteries (Abdul-Manan, 2015). This is one of the major themes which drive the debate about EVs, along with the economic concerns and which can represent an inhibitor for the choice of these vehicles, so great attention should be put when analysing them.

- *Negative environmental impact caused by electric vehicles*

The major environmental barrier regarding the wide adoption of EVs is represented by the issues regarding batteries. On these vehicles the most adopted technology for batteries is the one based on lithium ions (Li-Ion battery technology), thanks to their high energy density (approximately 170-180 Wh/kg (Zago, 2020)) and their duration (6/8 years or 100,000/160,000 km (Zago, 2020)). They contain lithium and other chemical elements whose extraction takes place in Africa and South America with significant impact on the environment: in many cases the extraction and refining of those materials require chemicals which may release toxic gases (Tabuchi & Plumer,

[6] Using the domestic plug (maximum 3 kW) the average time required to charge a vehicle with a 50-kWh battery capacity would be of 15-17 hours, while with a 3.7 kW wallbox it would be 12/14 hours. With a 7.4 kW box the time would decrease to 6/7 hours (LeasePlan, 2021).

2021); in other cases the processes may cause leakages of polluted water, with risk of contamination of water reservoirs and poisoning of entire communities (Tabuchi & Plumer, 2021). In addition, extraction of these elements is energy and water intensive, with production of EVs which is reported to be nearly 50% more water intensive than for of ICEs, mainly due to the extraction of materials for batteries (Tabuchi & Plumer, 2021). Impact for battery production is also social: since reservoirs of precious elements are in countries with low control on working conditions, miners are provided with inadequate protections while working in extreme conditions, in contact with toxic chemicals and contaminated waters (Tabuchi & Plumer, 2021).

Along the production phase, there are problems also for the disposal phase: once batteries are exhaust, they can be re-used for stationary energy storage as some car makers are doing (like Renault, Nissan, Volkswagen, Daimler) (EDF Energy, 2021), but then they need to be recycled to recover materials. Major issues perceived by users are related to the recycling phase: (Biresselioglu, Kaplan, & Yilmaz, Electric mobility in Europe: A comprehensive review of motivators and barriers in decision making processes, 2018) says that drivers perceive the dismantle of batteries harmful for the environment, an aspect which may discourage people from buying an EV. The same doubts from consumers are reported by (Berkeley, Jarvis, & Jones, 2018), saying that durability and environmental impact of batteries in their lifecycle phases is among the major barriers in UK. This leads to the necessity of the establishment of a reverse supply chain to collect batteries from car dealers and deliver them to recycling centres. This is also a sign of the increasing environmental awareness by the public, which is increasing the demand for "real" green products, more than in the past.

Car makers are investing lots of resources to develop new usages of exhausted batteries and to recycle them: batteries no more suitable for automotive applications are collected and sent back to manufacturer, then checked and, if suitable, used in stationary energy accumulators (EDF Energy, 2021). When they are really exhausted, they are recycled. Recycling processes are evolving, with goals to recover 95%-97% of the materials in batteries, and reduce the usage of raw resources (Volkswagen AG, 2019; Tabuchi & Plumer, 2021). In addition, breakthroughs to enlarge life of batteries and reduce their cost are required, to remove the barriers related to expense and duration of these components (Jensen, Cherchi, & Lindhard Mabit, 2013).

Another critique made on electric vehicles regards the primary energy sources used to produce electricity. Not always it is possible to use renewables, so also EVs are – at least indirectly – responsible of polluting emissions (Beck, Rose, & Hensher, 2013; Hofmann, Guan, Chalvatzis, & Huo, 2016; Laberteaux & Hamza, 2018). This is an issue which is related to the energy mixes used in each country, which depends strongly on the resources available and on the single specific contracts stipulated by user with their energy providers. In addition, (Biresselioglu, Kaplan, & Yilmaz, Electric mobility in Europe: A comprehensive review of motivators and barriers in decision making processes, 2018) reports how in case of demand peaks for electricity it is necessary to

rely on conventional plants, the only ones which can work "on demand", to balance the unpredictability of renewables. This is an issue in countries like China (Hofmann, Guan, Chalvatzis, & Huo, 2016) and India, which use mainly coal for electricity production (BP, 2019): in these cases, emissions coming from energy production, coupled with the ones for the realization of the vehicle, generate a total amount of GHG during the lifetime of the car higher than the one of an ICE (Hofmann, Guan, Chalvatzis, & Huo, 2016). This, confirmed also by (Abdul-Manan, 2015), can be a significant obstacle slowing down the diffusion of EVs (Nichols, Kockelman, & Reiter, 2015; Zhao & Heywood, 2017). Indeed, some users are attracted by EVs thanks to their expected lower impact on the planet in terms of emissions and usage of resources. If such impact becomes higher than the one of ICEs environmental sensitive buyers will shift their choice on the latter category of cars. This is an issue discussed by (Berkeley, Jarvis, & Jones, 2018) analysing the British context, in which nearly half of the energy is still obtained by fossil resources, setting the debate on whether EVs can allow a reduction of emissions. It is important to say, as a last remark, that also the construction of renewable plants is a source of emissions, from the extraction of materials to the final installation, so it is incorrect to say that EVs relying on renewables produce zero emissions in their life.

### *Image barriers*

These barriers are related to the perceived image of a driver coming from the usage of electric vehicles, which may slow down the process adoption of such vehicles. They are not concrete nor objective barriers, but they act on the psychological level of people, influencing their judgements and choices.

- *Bad perception of EVs from people*

In some cases the perception of electric vehicles by people sees EVs as an uncool choice, a vehicle which is not interesting and whose scope is just to spend less in comparison to ICE ones. In these cases, detractors perceive the performances of EVs as the ones of electric vehicles of twenty or thirty years ago, characterized by insufficient battery capacity, low performances and inexistent pleasure of driving, along with unattractive design (Moons & De Pelsmacker, 2012). This is a barrier which is mainly perceived in developing countries like Morocco (Jelti, Saadani, & Rahmoune, 2020) and areas like Turkey, Middle East, South America and Asia (Meszaros, Shatanawi, & Ogunkunbi, 2021). This because people still see as a status symbol the ownership of powerful ICE cars, so EVs are not well perceived. This bad perception can be defied by the possibility to try feel the performances of EVs: people tend to change their mind, after direct experience with the vehicles (Axsen, Goldberg, & Bailey, How might potential future plug-in electric vehicle buyers differ from current "Pioneer" owners?, 2016).

Another explanation for this bad perception is due to the issues deriving from the wide adoption of EVs: (Bhosale, Gholap, Mastud, & Bhosale, 2019; Om Bansal & Goyal, 2020) reports how in India electric vehicles were at first welcomed, but then people started thinking about the huge requirements of materials and infrastructure necessary for their functioning, changing their mind and perceiving EVs in a bad way. This problem is present also in other countries, like Slovakia (Hrudkay & Jaroš, 2019), and in worldwide literature reviews like (Mahdavian, et al., 2021; Turton & Moura, 2008): that is the proof that the bad perception is not always linkable to the wealth of a country, but it can be linked to the poor informative action put in place by states and car makers in order to clarify the doubts and the bad perceptions that people may have about those vehicles.

### *Comfort of usage barriers*

This category of barriers is linked to the overall driving experience for the user when choosing an EV instead of an ICE car. The different barriers can range from the effective driving phase to the phases of charging, along with the post-sale support and service in case of problems with the vehicle.

- *Long charging times*

The first and most important issue which slows down the diffusion of EVs regards the charging times for the vehicles. This is cited in literature as the major barrier when it is time to use a vehicle, no matter of the geographical location analysed (Axsen, Goldberg, & Bailey, How might potential future plug-in electric vehicle buyers differ from current "Pioneer" owners?, 2016). With a normal 3 kW meter at home, between 16 and 18 hours are required to charge a 50-kWh battery vehicle; with boxes of 3.7 kW the situation improves to 14-16 hours, while with a 7.4 kW the time decreases to 6-8 hours, definitely too many. The situation improves with more powerful boxes (11 kW or 22kW), which can reduce the time to 1 or 2 hours, still too much. Superchargers, with powers of recharge up to 250 kW (Tesla, 2021), allow to charge up to 80% of the battery in just 15 minutes, but they are still too few, especially outside the US: majority of EV users need to recharge vehicles with station at lower power, with longer durations. (Biresselioglu, Kaplan, & Yilmaz, Electric mobility in Europe: A comprehensive review of motivators and barriers in decision making processes, 2018; Cherubini, Iasevoli, & Michelini, 2015; Mahdavian, et al., 2021) cite this problem in the category of technical restrictions which currently slow down the uptake of EVs in the EU. This barrier is recorded also by (Pucci, 2021; Axsen, Goldberg, & Bailey, How might potential future plug-in electric vehicle buyers differ from current "Pioneer" owners?, 2016), which report it as one of the major barriers for the spread of EVs, along with the costs of fast charge. The same issue is present in developing countries, where

it is aggravated by the lack of investments and economical availabilities to develop a network: (Meszaros, Shatanawi, & Ogunkunbi, 2021) cites the problem of charging times as one of the main concerns for the difficulties in adoption of EVs in areas like Brazil, Turkey, Lebanon. The only exception is represented by China, where there is an efficient network of charging points thanks to the enormous public funds put in place (McKerracher, 2021).

The problem is critical also for commercial fleets: thinking to cars for representants, they cannot wait hours to recharge them, otherwise time would be lost. Analysing vans and other vehicles to transport goods the situation is even worse (Wikström, Hansson, & Alvfors, 2016): transportation of perishable goods (e.g. food) is not compatible with long waits in charging stations to recharge trucks and vans, making this an enormous barrier for the adoption of EVs for commercial scopes.

Future research and investments should be aimed at reducing the charging times required for EVs, thanks to the adoption and installation of fast chargers (Rezvani, Jansson, & Bodin, 2015; Hackbarth & Madlener, 2013) and make those times comparable to the ones required to refill a tank (Bunce, Harris, & Burgess, 2014). A possible solution may be represented by battery swap stations, where drivers can leave their discharged battery and fit in the car a new charged one: this would allow enormous time savings (Mak, Rong, & Shen, 2013; Neaimeh, et al., 2017).

- *Diffusion of public charging stations*

Lack of public charging station is another big issue addressed by literature. This problem is widely cited as one of the main barriers at international level for the diffusion of EVs: considering (Adhikari, Ghimire, Kim, Aryal, & Khadka, 2020), this is presented as the most important barrier which scares possible customers from the purchase of EVs, even more of the high purchasing price. This is seen as the major barrier against EVs diffusion by (Hackbarth & Madlener, 2013; Huang & Ge, 2019) due to the strong discomfort that this problem generates in users (Hackbarth & Madlener, 2013). This, indeed, can limit the flexibility of usage of the cars, making them unattractive (Haddadian, Khodayar, & Shahidehpour, 2015). Research also shows how a well-established charging infrastructure would be more appealing than the possibility of exploiting non-economic incentives (e.g., usage of bus lanes). Considering literature focused on single areas or countries, this is one of the major criticalities both in rich regions (alpine regions (Tomasi, Alyona, Pizzirani, Dal Col, & Balest, 2021), United Kingdom (Berkeley, Jarvis, & Jones, 2018), Slovakia (Hrudkay & Jaroš, 2019), Switzerland (Plananska, 2020)) and emerging economies (Jelti, Saadani, & Rahmoune, 2020; Meszaros, Shatanawi, & Ogunkunbi, 2021), sign that still efforts are required to develop the network. The only exception is China (Meszaros, Shatanawi, & Ogunkunbi, 2021): the charging infrastructure is supported by high numbers of fast and superfast chargers, thanks to huge investments deployed by the central government to develop EV industry; in the country there are about 210,000 fast

chargers installed and nearly 300,000 "normal" chargers. Looking at Europe, there are nearly 210,000 public charging points, with just 11% of them which are classified as "fast"; they are still too few to satisfy the demand in case of wide adoption of EVs.

The necessities of political action to support the creation of adequate public charging infrastructure is crucial to boost the diffusion of electric vehicles, as cited by (Mahdavian, et al., 2021; Rezvani, Jansson, & Bodin, 2015).

- *Low autonomy for electric vehicles*

Another critical point for the diffusion of EVs is the low kilometric range in comparison to ICEs (or also PHEVs). Current technologies allow car makers to realize vehicles with 300 km of autonomy in the most cases, with just some outliers like Tesla, which can offer vehicles with autonomy of nearly 550 km (Zago, 2020). This is still lower than the ones offered by ICE vehicles, with city cars which can reach 600 km, and touring cars which can exceed 1,000 km of autonomy. In addition, ICEs can be filled in minutes, while EVs require much more time (Moons & De Pelsmacker, 2012). The low kilometric range becomes a concern that potential buyers keep in mind and consider crucial. (Adhikari, Ghimire, Kim, Aryal, & Khadka, 2020) cites this as one of the major barriers for EV adoption, classifying it among the technical barriers. Anyway, this barrier can be overcome in urbanized areas like Europe and its states, where there are limited distances between cities: range anxiety can be mitigated by the fact that majority of people use cars for short journeys in everyday life (less than 100 km a day), so autonomy of vehicles is more than sufficient (Lieven, Mühlmeier, Henkel, & Waller, 2011; Hackbarth & Madlener, 2013). The situation is totally different in areas like Asia or Africa: (Meszaros, Shatanawi, & Ogunkunbi, 2021) reports the limited range of vehicles as a huge obstacle for EVs diffusion, since in those areas cities are separated much more kilometres, so it becomes impossible to move from one city to another without stopping. In addition, in rural areas charging stations are practically null, making this problem even worse.

Considering company fleets, kilometric range is a problem (Di Foggia, 2021) since companies cannot lose time to recharge the vehicles for hours or risk to ruin the goods they are transporting (Wikström, Hansson, & Alvfors, 2016). EVs are still not yet perceived as viable solutions to satisfy the necessities of companies, which prefer ICE vehicles; in some cases EVs are given just to employees working in offices and to managers who do not need to cover lots of kilometres a day.

- *Change of habits required to user*

The usage of EVs requires the changing of habits, something which may scare the potential users and deter them from buying one. These changes can be:

- *Necessity to change driving style:* with pure BEVs the best way to drive efficiently and enlarge battery duration is through "coasting", in which accelerations and decelerations should be as smooth as possible to allow the best functioning (Berkeley, Jarvis, & Jones, 2018). This may be hard to apprehend if a person has used ICEs for years.
- *Necessity to plug the vehicle:* (Meszaros, Shatanawi, & Ogunkunbi, 2021) report that a change of everyday habits is required to avoid risks of running out of charge of the vehicle. As examples, we can mention the necessity to plug the vehicle as we get home to recharge it overnight to have it recharged in the morning, otherwise in case of low battery, it is not possible to refuel the vehicle in seconds like an ICE.
- *Necessity to rethink the usage of optional features on board:* in case of low battery, it is also important to use wisely the features onboard to have the possibility to get home, an aspect which may be detrimental for the comfort of usage. For example, if there is low autonomy, it may be impossible to use the air conditioning system, otherwise the necessities of energy would be too high (Ala, et al., 2020).

This problem can be a significant barrier for EV diffusion, since drivers may be scared or unwilling to change the consolidated habits they had for years.

- *Lack of possibility of having private charging points*

This is another concern which can limit the diffusion of electric vehicles. In urban zones people live in majority in flats, without the possibility to have access to a private box to leave the car, so they leave vehicles on the road (Berkeley, Jarvis, & Jones, 2018). This is a problem, since in this way they cannot charge the vehicle overnight and must rely just on public charging points during the day. In other situations, the access to the private charging point is not possible due to condominium decisions of not installing a charging station in the building (Berkeley, Jarvis, & Jones, 2018). This can be a significant problem since (Formánek & Tahal, 2020) reports that most of the recharges of cars are performed overnight in private contexts. In poorer areas this is a significant barrier since there is no economic possibility to install them (Meszaros, Shatanawi, & Ogunkunbi, 2021; Bhosale, Gholap, Mastud, & Bhosale, 2019; Om Bansal & Goyal, 2020): majority of people can hardly afford an electric vehicle, so the additional expense to buy a private charging infrastructure would be unsustainable.

In addition, there is also a problem related to the adequacy of the electricity grid: in rural areas the grid is not reliable, and in some cases there is not even the possibility to have access to it, making impossible their installation. The adequacy of the grid is a key prerequisite to allow the diffusion of EVs (Junquera, Moreno, & Alvarez, 2016): in most developed countries, the situation is good, thanks to investments from public (Plananska, 2020), but in developing countries this is a big problem, since grids are in many cases inadequate. This is cited as a common problem in (Jelti, Saadani, &

Rahmoune, 2020; Meszaros, Shatanawi, & Ogunkunbi, 2021), studying developing countries in Asia, Africa, and South America. In these places the grid is still not satisfying for everyday activities, with frequent blackouts. This translates in a very poor service, with enormous difficulty to recharge electric vehicles, making this an important barrier for their diffusion. This is a problem which may limit the diffusion of EVs also for fleets (Di Foggia, 2021).

- *Insufficient assistance services*

The last barrier regarding the comfort of usage is related to the assistance services. Consumers want to be sure that in case of problems car there are mechanicians capable of fixing them (Di Foggia, 2021). The problem for EVs is that, being a new technology, there are less technicians who are trained to operate on them, so buyers are worried that, in case of problems, they struggle in finding a mechanician. This is a problem that both private owners and companies perceive (Di Foggia, 2021): in case the maintenance is managed internally to the company there is the necessity to find specialized figures who can work on these vehicles, increasing the efforts required for the management of the fleets. Also (Jelti, Saadani, & Rahmoune, 2020) says that there is still lack of specialized mechanicians who have the skills to work on EVs, making this a significant hurdle. This is true for most developed countries like UK (Berkeley, Jarvis, & Jones, 2018), but is even more important for developing ones: in contexts like Morocco (Jelti, Saadani, & Rahmoune, 2020), majority of people drive old vehicles, thanks to the fact that they can afford only them; the same applies for many of the nations analysed in (Meszaros, Shatanawi, & Ogunkunbi, 2021), where the low purchasing power allows people to just use older cars. This determines that most mechanicians are specialized in fixing these typologies of vehicles, with completely different architecture and different components, so they are not ready to work on EVs (Mahdavian, et al., 2021).

In addition to mechanical assistance, there is the necessity of assistance for the usage of the vehicles: EVs are a new technology, so users do not know at first how to effectively use them. In addition, they may fear the new technology, so support and assistance are essential (Wikström, Hansson, & Alvfors, 2016). The same concept can be extended to car sharing: the uptake of EVs in platforms for sharing is slowed down by the fact that some users still perceive they cannot use them, so they prefer ICE ones as they are perceived simpler; also car sharing platforms should help and support users when renting an EV (Mattia, Guglielmetti Mugion, & Principato, 2019).

- *Low offer of EV models available*

Another barrier is the low offer of appealing models. This is a strongly subjective theme since every person has different tastes when it comes to buy a car and, in addition, the purchase of a vehicle is associated to the emotions generated by the car

in the buyer (Moons & De Pelsmacker, 2012). This is cited as a problem for the diffusion of EVs by (Biresselioglu, Kaplan, & Yilmaz, Electric mobility in Europe: A comprehensive review of motivators and barriers in decision making processes, 2018; Plananska, 2020), which report a low availability of electric models in comparison to the ones powered by ICEs; this is due to the fact that the established car makers are starting just in last years to provide electric versions of their models, or developing specific electric models. In addition to this, there is the fact that, especially in the past, electric cars were characterized by "extreme" designs aimed at maximizing the aerodynamic efficiency and by poor attractiveness. People did not like those designs and preferred buying a traditional vehicle. Another problem is the lack of EV models for poorer countries (Meszaros, Shatanawi, & Ogunkunbi, 2021; Bhosale, Gholap, Mastud, & Bhosale, 2019; Om Bansal & Goyal, 2020): in these nations people have low purchasing power and in many cases they cannot afford a car. They are not interested in high-end and expensive EVs, but just in having the possibility of buying a basic car: in many cases in these states there are no suitable EV models, so people buy ICE (Bhosale, Gholap, Mastud, & Bhosale, 2019).

(Wikström, Hansson, & Alvfors, 2016) reports that this problem is present also for fleets: sometimes companies cannot find models which can satisfy their needs (e.g., too low battery duration) or because there is no electric version of models they already used and liked. This can be true also if we consider vans and commercial vehicles, where, for example there is no EV version which can carry a certain weight or which has a certain volume of charge (Wikström, Hansson, & Alvfors, 2016; Laberteaux & Hamza, 2018).

Moreover, the research of the right EV model can become more difficult because studies report how some car dealers tend to "hide" electric models in their saloons to the customers, offering them ICE vehicles. This is true since dealers tend to gain low margins from the sale of electric vehicles (Kumar & Alok, 2020; Matthews, Lynes, Riemer, Del Matto, & Cloet, 2017) because they have to offer discounts to attract customers because of the high cost of EVs themselves. In addition, EVs have lower maintenance costs than ICEs, so the dealers who get a major part of their earnings by providing assistance and maintenance services become more are reluctant to sell EVs.

These two issues determine the fact that, in some situations, EVs are unavailable in some showrooms, or there is the possibility that dealers promote more ICE cars than EVs, influencing the final decision of users (Plananska, 2020; Matthews, Lynes, Riemer, Del Matto, & Cloet, 2017). This aspect influences in negative terms the spread of EVs (Cahill, Davies-Shawhyde, & Turrentine, 2014).

### *Personal barriers*

These barriers are linked to personal sensations and thoughts about EVs, which have the power to influence individual choices. They are not universal barriers, but they are strongly related to the personal sphere and the trust that person can have in advertisements or test drives from third parties.

- *Lack of knowledge of economic benefits for purchasing and using EVs*

From the previous analyses it was clear how the economic incentives promoted by governments can be great drivers for the purchase of an EV, both directly (discounts financed by states) and indirectly (exemption for parking, toll roads, …). Sometimes people are not aware of these benefits (Pucci, 2021), so in the evaluations they make when it is time to change car they just focus on the listing price opting for an ICE, cheaper at the purchasing time but more expensive in the long term.

This is one of the most cited barriers, present both for private owners (Biresselioglu, Kaplan, & Yilmaz, Electric mobility in Europe: A comprehensive review of motivators and barriers in decision making processes, 2018; Shao, Taisch, & Ortega-Mier, 2016; Berkeley, Jarvis, & Jones, 2018) and for fleet managers (Di Foggia, 2021; Wikström, Hansson, & Alvfors, 2016); this makes it very important to be analysed. The responsibility of this issue is due to the lack of informative actions by the states: users and managers should inform themselves, but at the same time they should be provided by the governments with information and explanations on incentives on the plate (Formánek & Tahal, 2020). Also informative actions by car dealers are fundamental (Plananska, 2020), to show to potential users the advantages linked to EVs (Matthews, Lynes, Riemer, Del Matto, & Cloet, 2017). (Plananska, 2020) suggests that policy makers should create platforms for coordinating the plurality of specific information sources. It would allow the presence of all information required about EVs in just one place, increasing their informative value and consumer knowledge about EVs. Policy and car makers should also make EV training programs for car dealers: increasing their EV-related knowledge could make sales personnel less hesitant to promote EVs to customers and so increase sales of EVs. (Tomasi, Alyona, Pizzirani, Dal Col, & Balest, 2021) show a dependency relationship between the propensity to purchase an EV and knowledge; it reveals that a proper informative campaign acquires a key role in the diffusion of EVs. This process can be more difficult in poorer contexts, with less informative channels, or in nations where majority of inhabitants live in rural areas less reachable (Meszaros, Shatanawi, & Ogunkunbi, 2021; Om Bansal & Goyal, 2020). For what regards knowledge about benefits, also fleets are affected by this barrier: (Di Foggia, 2021) reports that fleet managers have low knowledge about the possible economic and image advantages coming from the usage of EVs, and related payback times (Rezvani, Jansson, & Bodin, 2015); company owners have an even lower knowledge about them, making this an important barrier.

- *Lack of technical knowledge about EVs*

Since EVs are a new technology, very few people already had the possibility to test it or to be informed about it. For this reason, people are reluctant to buy an electric car since they know what ICEs and their performances, but they don't know fully EVs (Axsen, Bailey, & Castro, Preference and lifestyle heterogeneity among potential plug-in electric vehicle buyers, 2015).

This is a strong barrier which is cited both for private users (Biresselioglu, Kaplan, & Yilmaz, Electric mobility in Europe: A comprehensive review of motivators and barriers in decision making processes, 2018; Shao, Taisch, & Ortega-Mier, 2016; Berkeley, Jarvis, & Jones, 2018) and for commercial fleets (Di Foggia, 2021; Wikström, Hansson, & Alvfors, 2016). (Della Valle & Zubaryeva, 2019) says that people are more prone to buy a vehicle – or in general a product – of which they already tested the utility and of which they know well how it works; they are more reluctant to buy a BEV or a PHEV since, being new technologies, they still haven't had the possibility to try them and make an idea. The same problem afflicts fleet managers and employees: they may choose ICE vehicles instead of EVs because they are already experienced with the first ones, and they are reluctant in adopting a technology they are not confident with, or which has never been tried (Di Foggia, 2021).

The only way to overcome this barrier is through experimenting the technology: (Tomasi, Alyona, Pizzirani, Dal Col, & Balest, 2021) suggests to governments and car dealers to organize "demonstration projects" open to private drivers and fleet managers to test the vehicles and ask information to improve their knowledge. As seen, according to (Berkeley, Jarvis, & Jones, 2018) there is a positive relation between the knowledge of a product or a technology and its purchase/adoption, so the more users are aware about it, the more is probable the purchase of an EV. Along with that (Plananska, 2020) suggests the usage of a unique informative portal also to share info about the technology, along with partnerships between governments and car dealers to organize informative projects to inform users and managers about technologies.

As seen the lack of experience with this kind of vehicles can be a problem for their spread, so the actions to be pursued should be aimed at diffusing knowledge about them, along with the direct experimentation of the technology, to get user acquainted.

- *Lack of trust in ads and in EV producers by public*

This personal barrier refers to the level of trust that people have in advertisements by in car makers. As a first issue, (Biresselioglu, Kaplan, & Yilmaz, Electric mobility in Europe: A comprehensive review of motivators and barriers in decision making processes, 2018) says that some people do not trust the environmental benefits promised by car makers by adopting EVs: they perceive some unsolved problems like the dismantling of the vehicle and the recycling of batteries; sometimes these issues are not considered when promoting a car, generating distrust in potential customer.

In addition, there is an enormous gap between customers' expectations and real perceptions: this is due to the fact that buyers are not enough informed, so there is no alignment between expectations and reality (Barisa, Rosa, & Kisele, 2016). The issue of distrust by users towards the promises of car makers can be seen also in (Shao, Taisch, & Ortega-Mier, 2016): in many cases the purchasing process of green products is mined by lack of trust in the promises and expectations made by companies, which not believed by people. (Tomasi, Alyona, Pizzirani, Dal Col, & Balest, 2021) shows how one of the most distrusted issues for EVs regards the battery duration and environmental impact: the 27% of the sample analysed by the authors cite this as the main barrier which prevents them from the purchase of an EV, preceded only by the high cost of vehicle. As a last remark (Mohd Suki & Mohd Suki, 2019) says that purchases are influenced by peer influence more than advertisements: people trust more people they know and their experience instead of something which is said by a company or someone they don't know personally.

- *Low interest in environmental problems by drivers*

Barriers for the diffusion of EVs may arise from the lack of environmental motivation from possible buyers, who may not be interested about ecological issues and who may be interested only in owning a car for the prestige. (Adhikari, Ghimire, Kim, Aryal, & Khadka, 2020; Axsen, Goldberg, & Bailey, How might potential future plug-in electric vehicle buyers differ from current "Pioneer" owners?, 2016) reports that one of the barriers for the diffusion of EVs is the lack of environmental awareness about EVs, coupled with limited understanding about their performances. This is a hard barrier to overcome: it is not only related to the environmental theme, but is also rooted in the personal convictions and preferences about a product; if a person has low motivations in preserving the environment, that person will be hardly interested in buying an electric vehicle. (Rezvani, Jansson, & Bodin, 2015) is on the same wavelength, specifying how one of the barriers for EVs is represented by the lack of interest of some individuals for the preservation of the environment.

As for the drivers, in Table 4 there is the summary of the major barriers for the diffusion of EVs. Also in this table there is a categorization based on the nature – endogenous or exogenous – of the barrier.

| BARRIERS | | | |
|---|---|---|---|
| | NAME | CATEGORY | NATURE |
| ECONOMIC | High cost of purchase & rental | Private/fleet | Exogenous |
| | Insufficient state incentives | Private/fleet | Exogenous |
| | High ownership costs | Private/fleet | Exogenous |
| | High cost of point | Private/fleet | Exogenous |
| ENVIRONMENTAL | Negative envir. impact | Private/fleet | Exogenous |
| IMAGE | Bad EVs perception | Private/fleet | Endogenous |
| COMFORT OF USAGE | Long charging times | Private/fleet | Exogenous |
| | Diffusion of public charging stations | Private/fleet | Exogenous |
| | Low autonomy | Private/fleet | Exogenous |
| | Change of habits required | Private/fleet | Endogenous & exogenous |
| | Impossibility of having private charging points | Private | Endogenous & exogenous |
| | Insufficient assistance services | Private/fleet | Exogenous |
| | Low offer of EV models available | Private/fleet | Exogenous |
| PERSONAL | Lack of knowledge of economic benefits | Private/fleet | Endogenous & exogenous |
| | Lack of technical knowledge | Private/fleet | Endogenous & exogenous |
| | Lack of trust in ads EV producers | Private | Endogenous & exogenous |
| | Low interest in environmental problems | Private | Endogenous |

Table 4: Recap table for drivers and their nature

### 1.2.3 Mediators/moderators

The factors presented in this categorization cannot be fitted in categories as drivers or barriers, since they are not enablers or obstacles for the purchase of EVs per se, but they are just mediators of the phenomenon. In other words, particular trends can be detected when analysing the diffusion of EVs in relation to aspects as income, age, gender and other conditions peculiar of each individual.

- *Age, income, region of residence, degree of education, gender*

We refer to "socio-economic mediators" as the situation in which an individual is in, in terms of availability of capital and social condition (Plötz, Schneider, Globisch, & Dütschke, 2014). They are personal factors which modify and influence individual propension towards EVs and hybrid cars (Formánek & Tahal, 2020). Great importance is attribute in literature to gender and age-based differences, but along with them great importance is given also to socio-economic and lifestyle factors, along with the provenience of the individual (Formánek & Tahal, 2020). Indeed, the factors which are mostly investigated are the age of the user, along with the income, the region of residence, the degree of education and the gender, as they are factors which can influence the approach and the tendency of people towards electric cars (Formánek & Tahal, 2020). They are crucial since they strongly influence individual choices (Higgins, Mohamed, & Ferguson, 2017). Indeed, literature addresses significant differences towards the adoption of electric vehicles on the basis of these factors, leading to different propensions towards these cars:

  - Women and older individuals are more prone to adopt environmentally friendly vehicles, thanks to a higher environmental sensitivity (Axsen, Goldberg, & Bailey, How might potential future plug-in electric vehicle buyers differ from current "Pioneer" owners?, 2016; Axsen & Sovacool, The roles of users in electric, shared and automated mobility transitions, 2019; Plötz, Schneider, Globisch, & Dütschke, 2014).
  - Men are more incline to better appreciate the technical innovations and performances regarding EVs (faster acceleration, higher speed, ...) than women, who are keener on the environmental benefits (Axsen, Goldberg, & Bailey, How might potential future plug-in electric vehicle buyers differ from current "Pioneer" owners?, 2016).
  - In luxury car segments (SUVs, high-end sedans) men are more incline to buy EVs than women thanks to the better image derived (Higgins, Mohamed, & Ferguson, 2017).
  - Older respondents perceive EVs as a responsible and prestigious choice more than younger people: for them, the acceptance of this position is 23.2% and 30% higher than for younger people (age 15–24) (Formánek & Tahal, 2020). Middle aged groups show highest willingness to buy an EV (Axsen & Sovacool, The roles of users in electric, shared and automated

mobility transitions, 2019; Huang & Ge, 2019; Plötz, Schneider, Globisch, & Dütschke, 2014). (Axsen & Sovacool, The roles of users in electric, shared and automated mobility transitions, 2019; Huang & Ge, 2019) say that individuals between 40 and 50 years old are the most likely to buy EVs thanks to their higher capital availabilities (Zhang, Yu, & Zou, 2011; Junquera, Moreno, & Alvarez, 2016).

- Males are more likely to have previous personal experience with EVs in comparison to women, at equal economic conditions (Formánek & Tahal, 2020); for youngsters, car sharing increases the contact with EVs (Junquera, Moreno, & Alvarez, 2016). High earning individuals are more likely to pay premiums to gain fuel economy and reduce emission (Hackbarth & Madlener, 2013).
- High-earning individuals are more likely to report EV-experience (Formánek & Tahal, 2020). This is confirmed by other studies – like (Zhang, Yu, & Zou, 2011; He, Zhan, & Hu, 2018; Higgins, Mohamed, & Ferguson, 2017) – which report a correlation between income and propensity to pay a premium for acquiring an EV instead of an ICE.
- Drivers from city areas are more likely to have already experience with EVs in comparison to the ones from the suburbs or countryside (Hackbarth & Madlener, 2013), so they show more propensity for the adoption of EVs (Formánek & Tahal, 2020; Guglielmetti Mugion, Toni, Di Pietro, Giovina Pasca, & Renzi, 2019).
- Men are more prone to acquire vehicles with new technologies (e.g., automated vehicles, EVs) earlier than women; they show higher willingness to pay more for new technologies (Mahdavian, et al., 2021).
- People with higher levels of education show more propensity in buying EV (Mohd Suki & Mohd Suki, 2019). This aspect is confirmed by (Plötz, Schneider, Globisch, & Dütschke, 2014; Huang & Ge, 2019; Higgins, Mohamed, & Ferguson, 2017; Hackbarth & Madlener, 2013).
- People who already own one or more vehicles tend to buy EVs as second or third car (Axsen, Goldberg, & Bailey, How might potential future plug-in electric vehicle buyers differ from current "Pioneer" owners?, 2016; Zhang, Yu, & Zou, 2011; Hackbarth & Madlener, 2013).
- Low incomes limit the diffusion of EVs, especially for low end segments (Meszaros, Shatanawi, & Ogunkunbi, 2021; Helveston, et al., 2015). EVs are more expensive than ICE cars, so individuals with limited income ì choose for the latter ones when it is time to buy a new car (Biresselioglu, Kaplan, & Yilmaz, Electric mobility in Europe: A comprehensive review of motivators and barriers in decision making processes, 2018). This is an issue which afflicts developed countries but even more the emerging ones, where incomes tend to be lower and where very small percentages of inhabitants have the possibility to buy a car (Meszaros, Shatanawi, & Ogunkunbi, 2021). Indeed, (Mahdavian, et al., 2021) describe how the

poorest individuals in these nations do not even have the possibility to own a vehicle, moving with public transport or by foot or bicycle, with the most fortunate who can hardly afford a motorbike.

The socio-economic context in which an individual lives has a very strong effect on shaping the tendency in buying an EV or not, thus influencing their diffusion.

## 1.3 Literature Gaps

In this section the focus shifts towards the literature gaps encountered in the contributions analysed. Indeed, despite the abundance of documents available worldwide, not all the possible facets of the phenomenon have been studied, with space for future contributions.

Starting from the theme of TCO, in too many cases the propensity of users to buy an EV is only evaluated through economic dimension (namely TCO). In reality, it is wrong to assume that consumers will always select the option with the lowest financial TCO: for example, in many countries, the lowest TCO travel modes are public transit and small cars, options which have the lowest market share. This means that users are also motivated by other factors in buying a car, and not just by the economic ones. This requires a broader analysis, considering all the mediating factors less related to the economic aspect assess the drivers and barriers in their entirety, considering also the possible negative consequences related to the wide adoption of EVs (e.g., emissions from production, social problems caused by them, …). This is a deeper analysis which may be very interesting in case of a large presence of electric vehicles on the road, thus when they are close to a complete substitution of ICE cars; at the current status they are still affected by low presence on the Italian territory. In addition, in some areas of Italy the public transport is not enough capillary nor frequent, so the alternative of public transport is rejected a priori even if cheaper, with people preferring using a car for their daily commutes thanks to its higher flexibility of usage.

Still, analysing the buying decision process for EVs, there is limited integration of other factors apart from the cost of the car itself. Indeed, the price is still seen as the major hurdle to overcome, so too little attention has been given until now to other factors which may influence the process. These aspects can be the development of oil or electricity prices, the evolution of EV technology, organizational factors like the availability of charging points and the consumer acceptance of EVs or individual driving behaviour. This determines that the inclusion of all these factors can be very important to better address the reasons of a slow uptake process, considering also factors not directly related to the vehicle itself, but which can be the tip of the scale for the adoption of EVs. This aspect should be investigated in detail in order to have a complete assessment of the drivers, the barriers and the overall experience of usage of EVs, which is very different from the one of an ICE car For that reason this gap is analysed in different facets on different perspectives, ranging from the usage of public points of recharge to the installation of a point at home, and focusing also on the overall experience onboard with the vehicle.

Another aspect which is not so analysed in literature is the impact of emotions and personality of the individual when buying a vehicle: emotions have a key role in the purchase of a vehicle, since the buying process is strongly influenced by the feelings an individual perceives when approaching and driving a vehicle. Literature has mainly focused its attention on analysing drivers and barriers looking at demographic

variables like income, age, households composition, neglecting all the aspects related to personality (for example the image related to the ownership of a vehicle) and emotions, which are cited as influencers in the purchasing process. This aspect is not so crucial for the entire discussion regarding the theme, so our analysis will consider those aspects marginally, giving a brief hint in the evaluation of drivers and barriers related to these hedonistic themes, but without focusing just on them, and giving more space to the economic and environmental subjects.

Another gap identified by literature is the fact that in majority of adopters of BEVs have been studied as one homogenous group, overlooking the possible differences existing between high and low-end adopters . Indeed, drivers and barriers towards the adoption of EVs can differ between different groups of adopters, mainly due to their socio-economic conditions (e.g., level of education, salary, …) and personal attitudes (e.g., attention towards environment); adopters can choose different kinds of car with different prices and features considering those differences highlighted before. These differences can determine significantly different results, thus it becomes fundamental for policymakers to highlight and understand them – in order to better tailor their actions – and for car maker, in order to develop cars with the exact characteristics required by each group. Referring to this, to have a complete analysis of all influencing factors acting on individuals, it is important to consider demographic aspects like age, gender, education, income, composition of households and others. This because they are related to differences in the positive effects of attitude, product perception and monetary incentive policy measures on consumers' purchase intention, shaping the possible actions put in place by legislators. This is a less urgent theme to be analysed than the previous one, but anyway these differences should be investigated, in order to be more precise in the description of the phenomenon: indeed the barriers and the drivers for the purchase of EVs are dependent on the type of vehicle the customer is interested in. For example, a person interested in a high end and expensive car may be driven in this decision by the environmental benefits and the better image provided by owning such it, while may not be interested at all in the lower total costs of ownership associated to it. On the opposite, an individual looking for a small and cheap car is driven mainly by low costs of maintenance and usage. In addition, many parameters – like kilometrage, costs of maintenance, … – are strongly dependent on the type of car under analysis, thus these parameters should be taken into account to provide a complete analysis of the theme.

Still referring to this, nearly no studies have segmented consumers on the basis of the type of vehicle they are most interested in purchasing. This is an important issue since, looking at the established ICE market, there is a wide diversity of choice among different kinds of vehicles ranging from minicars to SUVs. Car market can be divided in seven clusters of vehicle: compact or economy, intermediate-size sedan, full-size sedan, luxury sedan, minivan/crossover, sport utility vehicle (SUV), and pickup truck. Each of these categories is characterized by different characteristics (e.g., size, performance, styling, fuel economy) and potential customers, so a clustering of the

potential buyers for the different categories of vehicle can be useful also for the world of EVs in order to better address the necessities of the audience and of companies. This gap poses at the same level of the previous one: indeed, the themes proposed in it are very similar to the previous one, since a differentiation of the discussion on the basis of the segment – thus the socio-economic indicators characterising each person – is still not present in the literature, at least in a wide dimension. This determines that to have more precise and detailed results it is necessary to consider the different segments of cars and price of vehicles, creating a clustering of the users.

In many cases the surveys to assess opinions were given to non EV users who may be very distant from this world, and thus may distort the results of the surveys; for this it becomes important to administer surveys to an audience where the EV and non EV users are pretty much in the same proportion, to avoid misrepresentations and problems regarding the validity of the results. This allows to better understand the reasons behind the fact that the adoptions of EVs are still too few and assess the possible success factors which can push the purchase by private owners and by companies for their fleets. This is the most important aspect to keep in mind, in order to obtain answers coming in equal manner from one group and from the other. In addition, since with experience the judgement on EVs radically changes, having the possibility to assess answers from a group "not exposed" to EVs – so non users – and from a groups constantly exposed to them – namely users – allows to obtain interesting trends of evolution in the answers, looking at the differences among the two pools of interviewee.

In addition to this, an analysis about the of future purchase intentions of actual BEV adopters is still missing: this refers to the intention or not by BEV owners in buying again a BEV, and strongly relates to the attributes of vehicles to comprehend which reasons determine a high likelihood of continued adoption. This is not the most important aspect of the analysis, but it may be interesting as a final test to confirm or disconfirm the positivity of the overall experience with the electric vehicle.

Another gap present in literature is the fact that the theme of drivers and barriers affecting the diffusion of EVs is marginally analysed in Italy: despite the importance of the automotive market in the country, there are few studies which cover organically the theme of electric cars and the enabler and obstacles for their diffusion, making this a very important gap to tackle for future research.
Moreover, among the few examples analysed in the literature review, the majority of them do not analyse the country in its entirety. They indeed study in detail limited areas of the nation, without giving an overall view of the situation considering the entire peninsula. This is a problem since allows just to obtain region specific results, which can not be extended in general to the entire nation since they are strongly influenced by the characteristics of the territory and of the inhabitants covered by the study.

Shifting the analysis towards commercial fleets, the main criticality is the fact that there is lack of literature analysing the importance and the improvements that electric vehicles can determine in fleets for companies, along with the reasons why the electrification of this sector is so slow. The lack of detailed literature documents focused on corporate benefits is a gap recorded both in Italian and international context, with the major problem represented by the fact that only few some aspects are analysed for the scenario (like the financial one), while other dimensions, like operational and practical ones, are neglected, or at least not sufficiently covered. This gap is a crucial one for the commercial world, thus it requires a strong analysis in the survey. Indeed the individuation of all the drivers and barriers which can influence the adoption of EVs at company level can not be performed without directly asking to the managers involved in companies what are their perceptions and the factors influencing them in the decision process.

The last gap relates to the lack of analysis on possible interesting market opportunities which can emerge with the new technology introduced by EVs: in literature, not enough attention has been paid to the mobility behaviours and individual preferences by users in order to highlight the more suitable conditions for the diffusion of electric mobility, with the possibility of blending different solutions for everyday necessities by citizens (e.g., electric car plus e-bike sharing to reach the workplace). In addition, despite the growing importance of PSS[1] approach, academic literature has remained sparse, especially in the field of electric vehicles. No analyses have been carried out to identify the main possible PSS clearly and systematically in the electric car industry and to identify the critical success factors in marketing that may increase the diffusion of electric cars. This is a problem since with new business models and possibilities, like leasing and PSS, the spread of EVs may be fostered, thanks to the fact that it would be no more essential for users to buy a vehicle: they can just pay a small monthly fee and drive the EV, avoiding the issue of high cost of the vehicle. This is a gap we are not so interested in our analysis, since we are adopting the perspective of the final user and of fleet managers in companies, assessing their thoughts and perceptions on the phenomenon. This theme is more related to other players in the EV industry, namely car sharing platforms and alternative mobility providers, so the importance of this gap is lower than the previous ones.

This overview reveals that there are still significant gaps in the literature, only partially covered by the contributions read and discussed in the section regarding the state of art. In detail, the most important gaps for our scope regard the lack of a comprehensive literature regarding pros and cons described by users for what regard the uptake of EVs in Italy. In addition to this, there is also lack of reviews and documents discussing completely the advantages which can derive for companies if they adopt electric vehicles in their fleets for operations and for representants and employees.

# 2. Chapter two: Research Design

For the analysis of the drivers and barriers characterising the diffusion of EVs, the approach exploited a *survey-based methodology*. It is based on the usage of surveys with the aim of obtaining information from a sample of individuals to analyse trends and characteristics of the population of which the answerers are members. It is a research aimed at describing quantitatively specific aspects and trends related to a population, and it is based on the highlighting of trends among variables basing on data gathered directly from people. Its final aim is to analyse the answers to a survey of a portion of the population, in order to generalize and extend the emerging trends to the entire population (Pinsonneault & Kraemer, 1993).

Indeed, questionnaires with different typologies of questions, on the basis of the sample under analysis, are developed to ask directly to users and managers from companies their perception and their thoughts (Plananska, 2020). This simple procedure allows to obtain high number of responses and immediate results easy to analyse through descriptive statistics, in order to highlight trends which can emerge. In addition to this, since answers to surveys are anonymous, persons can express freely their opinions, without the fear of being judges by the questioner, an aspect which can lead to altered answers, which may invalidate the entire study.

To investigate drivers and barriers for the adoption of EVs in "real world" two surveys are proposed – one for private car owners, one for fleet managers of companies. They both have been drafted and developed in April and May 2021 through the usage of a specific platform provided by Google (*Google Modules*) which also allowed the recording of the answers and a first sampling of the replies, along with a profiling of the answerers. The two questionnaires have been kept open from May 2021 to September 2021.

For both questionnaires, 3 main typologies of answers have been proposed:

- *Open questions*
- *Likert Scales*, with different ranges depending on the question
- *Multiple Choice questions*, some with the possibility of choosing only one answer, others with the possibility to choose more options

Of course, the two surveys were sent through different channels, differentiating between some which were more adapt to reach private owners and others which were more suitable for fleet managers of companies. In each of the two analyses provided, the channels will be specified in detail.

## 2.1 Private car owners

Starting from the survey for private owners, it has been sent through different channels, to reach the highest possible number of potential answerers; the different targets of the questionnaire have been:

- Personal acquaintances (through WhatsApp chats and groups)
- Telegram groups focused on green mobility
- Social media, like Facebook and LinkedIn

### 2.1.1 Questionnaire and Measures

The survey for this category is divided in 6 sections, in order first to perform a profiling of the respondents and then to assess some of the aspects highlighted in the literature gaps.

The first section is thought principally to ask for permission of treatment of data, along with a first profiling of the respondents, comprising personal questions as age, region of residence, age and level of education. After this part, it was asked if the respondent owned an EV or not: this question posed different paths for the subsequent part of the survey, with owners who were proposed specific questions and non-owners who were asked to answer other questions.

Non-owners were asked to give motivations of this aspect, to assess also future willingness to buy an electric vehicle. Along with that, question regarding the sufficiency of incentives and the knowledge about them were asked. These questions are important in order to assess the barriers for non-users which prevent them from buying an EV, which allows to tackle the major issue of the entire work.

On the other hand, EV owners were asked to give information about their cars, like age, cost and modality of purchase (leasing, rent, acquisition), along with the motivations which pushed them in purchasing such vehicles. In the same section also questions about the type of car (power supply and segment[7]), the expected and actual usage of the EV – in terms of kilometrage – and the savings from the usage of EVs instead of ICEs. In this way it is possible to analyse the drivers and phenomena like costs of maintenance, usage and other dimensions in light of the kind of vehicle and the cost of the vehicle itself, or in relation to the kilometrage covered each year by users. This section is very important to cover one of the major literature gaps highlighted in precedence, namely the dependence of drivers, barriers and other dimensions over usage, cost and sociodemographic characteristics of the sample.

[7] As, for example, segment A (mini-car), segment B (small car), segment C (medium car) and so on.

Indeed, all the aspects present in this section are also evaluated in light of gender, level of education, geographical provenience and age, which literature has observed as mediators, but which has not yet been analysed, especially in the Italian scenario.

The following section, still dedicated to owners, aims at assessing the knowledge and the judgement that they have towards the public incentives to buy the vehicle, along with the impact they had on that decision. Also in this case there is a high interest in evaluating the responses to the questions in light of the different sociodemographic mediators introduced before, since literature suggests a different distribution of answers on their basis. In this way it becomes possible to perform this detailed analysis.

After this small section the focus moves towards the charging infrastructure: EV owners are asked to give information about their charging habits (e.g., place, power of recharge, tariffs, …) and if they own a private point of recharge, reporting also their experiences with it. Also in this case there is a differentiation between EV owners who also own a private charging point and those who do not own it, with the first ones who are asked to answer questions about incentives for installation and other technical questions to assess in detail their experience (like the trends of usage, the criticalities faced in installation, who they asked to install the point, …). After this focus on private points, all EV owners are asked to answer similar questions regarding charging point at their workplace and about the usage of the public charging point, assessing its adequacy and the possible issues or disablers which determine its missed usage. In this last part of the section a specific focus is posed on fast and superchargers and their impact in EV diffusion. Questions about recharging phases are very important, thanks to the insights which can be gathered by crossing these answers with the demographic information, assessing the different distribution of responses on their basis. Indeed, the lack of consideration of such aspects when evaluating the theme of charging operations is another gap found in literature.

The last section is aimed at assessing the level of knowledge by EV owners about themes like the presence of incentives for the purchase of the car, the impact of EVs on environment and other important aspects related to the world of EVs. The last question is about the willingness by EV owners to get back to ICE cars, to assess their overall satisfaction (or dissatisfaction) with EVs.

In detail, the questionnaire is made of the following questions:

- ***SECTION 1***
  - Do you consent to the treatment of personal data?
  - Gender
  - Age
  - Region of residence
  - Degree of education
  - Do you own an EV?

- ***SECTION 2***
  - Are you planning to buy an EV?
  - Why?
  - How much do you consider the following barriers to the purchase of an EV (Likert scale from 1 to 5)?
    - High cost of purchase of EV
    - Diffusion of public charging stations
    - High cost of private charging points
    - Complexity of installation of private charging points
    - Low autonomy for electric vehicles
    - Low offer of EV models available
    - Economic impact due to COVID-19
    - Negative environmental impact caused by electric vehicles
    - Change of habits required to user
    - Insufficient assistance services
    - Perception of unsafety (e.g., presence of electric charges)
  - Are you aware of the existence of public incentives for the purchase of EVs?
  - How do you rate the amount of incentives available?

- ***SECTION 3***
  - When did you buy your EV?
  - How much do you consider the following drivers for the purchase of an EV (Likert scale from 1 to 5)?
    - Lower Total Cost of Ownership
    - Perception of EVs as cool choice and better image coming from EV usage
    - Environmental benefits
    - More exploitation of renewable energy sources
    - Tighter emissions standards and domestic laws
    - Diffusion of public charging points
    - Specific vehicle characteristics and accessories onboard
    - Possibility to install a private charging point

- Are there other factors which influenced your purchase?
- Which typology of EV did you purchase?
- Which type of car did you buy (segment A, segment B, …)?
- What was the cost of the EV?
- Give an estimation (%) of the following types of journeys on the total covered in a year:
  - Short (less than 50 km)
  - Medium (50-100 km)
  - Long (> 100 km)
- How many long journeys (>100 km) do you expect to cover in a year with the EV?
- Estimate the annual costs of maintenance of the EV
- Estimate the annual savings related to restricted traffic areas
- Estimate the annual savings related to free access to toll parking
- Did you exploit incentives for the purchase of the EV?
- How much did the presence of incentives influence the purchase of the car?

- ***SECTION 4***
  - Give an estimation (%) of the amount of charges performed at :
    - Home
    - Workplace
    - Urban roads/parking spots
    - Extra urban roads/highways
    - Public points of interest (malls, supermarkets, …)
  - Give an estimation (%) of the amount of charges performed at:
    - Less than 22 kW
    - Between 22 and 50 kW
    - Between 50 and 100 kW
    - More than 100 kW
  - Do you have a domestic charging point?
  - Why are you planning to install a domestic charging point?
  - Why did not you install a domestic charging point?
  - How do you consider the following drivers for the choice of the domestic charging point? (Likert scale from 1 to 5):
    - Easiness of usage
    - Design
    - Cost
    - Recommendations from car dealer or other figures
    - Speed of charge
    - Smart charging functionalities
    - Usage through app

- Did you exploit incentives for the installation of the charging point at home?
- Did the presence of incentives influence the decision to install the charging point?
- Do you have also a photovoltaic plant installed at home?
- Do you have also an energy storage system installed at home?
- How many times per week do you recharge the car at home?
- How much time does the car remain in charge?
- Can you recharge the EV at workplace?
- How many times per week do you recharge the car at workplace?
- How do you consider the following barriers for the missed usage of the public charging infrastructure? (Likert scale from 1 to 5):
    - Scarce presence on territory
    - High cost of charge
    - Too high times for recharge
    - Point of recharge out of order or occupied
    - Complexity of usage
- Are there any other barriers?
- How many times per week do you recharge the car at public points of charge?
- Does the presence of a charging point influence the choice of a public point of interest instead of another?
- Do you think that the current public charging infrastructure is adequate?
- What is the role you attribute to the public charging infrastructure?
- Where do you think that the public charging infrastructure should be more present? (Likert scale from 1 to 5):
    - Urban roads
    - Extra urban roads
    - Highways
    - Public point of interest (malls, supermarkets, …)
    - Train stations, bus stations, airports, …
- Are there any other areas where the public charging infrastructure should be improved?
- How do you consider the following requisites of the public charging point? (Likert scale from 1 to 5):
    - Reliability
    - Speed of charge
    - Price
    - Easiness of usage
    - App functionalities

- ***SECTION 5***
  - How important do you consider the presence of fast charging points (> 100 kW) in the following places? (Likert scale from 1 to 5):
    - Urban roads
    - Extra urban roads
    - Highways
    - Public point of interest (malls, supermarkets, …)
    - Train stations, bus stations, airports, …
  - Would a higher presence of fast chargers increase the propensity in undertaking long journeys (>200 km) with the EV?

- ***SECTION 6***
  - How do you rate your knowledge about the following themes regarding EVs (Likert scale from 1 to 5)?
    - Presence of incentives at state level for the purchase of EV
    - Presence of incentives at local level for the purchase of EV
    - Presence of taxes linked to emissions of vehicles
    - Presence of incentives level for the purchase a private charging point
    - Fiscal incentives (e.g., free parking spots, exemption form payment of restricted traffic areas, …)
    - Lower TCO
    - Environmental benefits and impacts linked to EVs
    - Presence of norms linked to the emission of vehicles
    - Technical knowledge about EVs (performances, autonomy, …)
    - Increase of infrastructure of recharge
    - Increase of offer for EVs
  - Would you come back to an ICE vehicle after having owned an electric car?

### 2.1.2 Data Analysis

After submitting these questions to create the survey, the data collected are analysed through descriptive statistics, with a major use of graphs on *MS Excel*. In addition, especially for Likert scale questions, the average and the standard deviation have been useful to assess the answers and obtain useful information from the numerous answers received. In this way it is possible to sum up the multitude of answers received in a relatively easy and comprehensive way.

Through the usage of *pivot tables* it is possible to link the answers to the questionnaire to the socio-demographic mediators cited in literature review, allowing to obtain trends for drivers and barriers associated to age, gender, education and region of residence. Indeed, thanks to the functions in the software it is possible to cluster all the respondents on the basis of the socio-demographic factors asked at the beginning of the survey, creating categories of answerers (e.g., those coming from North of Italy, those form the Centre and the ones from the South) and read the answers given in light of these aspects.

These results can be important to address future implications and to drive possible corrective actions by car makers and administrations to foster the uptake of EVs.

## 2.2 Company Fleets

### 2.2.1 Questionnaire and Measures

For companies the survey is made of 5 sections, with a preliminary part of profiling in order to obtain information regarding the companies responding to the survey, aspects which can be used later on to gather further information from the answers obtained.

The first section aims at asking the permission for treatment of data and to profile the managers answering. In addition, questions regarding the size and the location of companies are asked, along with the presence or not of a fleet manager. These preliminary insights are the corresponding of the sociodemographic ones cited before for the private car owners, useful to link specific trends to characteristics of the respondents.

Then the survey goes in detail to analyse the composition of current fleets used by the companies answering, asking information regarding the numerosity, the type (gasoline, Diesel, …) and the kind of usage, in terms of kilometrage, of the cars. In the same section also the ways in which cars are acquired are investigated (rent, leasing, …), along with the drivers and barriers for the choice of a certain kind of motorization instead of another. In the same section there is also a focus on the ways in which fleets are managed by the company, for example if there is a fleet manager or not and if there are specific platforms used to accomplish the work. Along with that also question regarding the age of vehicles and alternative solutions for mobility are asked. With these questions it becomes possible to respond to literature gaps seen before, as the interconnection and influence of parameters as the size of company upon the barriers, or the choice of specific models of vehicles and specific phenomena of usage.

In the following section there is the main focus of the survey, namely the drivers and barriers for the electrification of fleets. In this part, through the usage of Likert scales and open questions, those aspects are analysed to give managers the opportunity to stress the most critical aspect which can foster or obstacle the process. In this way a direct assessment of the perception by managers is performed, allowing us to obtain direct feedbacks regarding the theme.

In the subsequent part, questions are centred on the recharging infrastructure, in detail the points installed in the company: aspects like the number and the power of the points are asked, along with the tariffs applied and the resellers and installers of the point. In relation with that also questions about the deployment of V1G and V2G projects are asked, along with the possible doubts generated by them.

The last part of the survey is, like for the one dedicated to private owners, aimed at assessing the level of knowledge by managers about themes linked to EV world: for example, the presence of incentives to buy the car and the charging infrastructure, emission taxes and others.

In detail, the questionnaire is made of the following questions:

- ***SECTION 1***
  - Do you consent to the treatment of personal data?
  - Name and surname
  - E-mail
  - Company
  - Role inside the company
  - Number of employees in the company
  - Number of operative headquarters of the company
  - Location of operative headquarters of the company
  - Is there a fleet manager in the company?

- ***SECTION 2***
  - Give an estimation (%) of the repartition of vehicles on the basis of the type of acquisition:
    - Purchased
    - Long term rental (more than 24 months)
    - Medium term rental (up to 24 months)
    - Leasing
    - Other
  - Give an estimation (%) of the repartition of vehicles on the basis of the powertrain:
    - Gasoline
    - Diesel
    - HEV
    - Methane
    - LPG
    - PHEV
    - BEV
  - Give an estimation of the average kilometrage of vehicles on the basis of the powertrain:
    - Gasoline
    - Diesel
    - HEV
    - Methane
    - LPG
    - PHEV
    - BEV
  - Give an estimation (%) of the repartition of vehicles on the basis of the type of usage by employees:
    - Shared
    - Ad personam

        - Other
    - How are the following drivers considered for the choice of the powertrain of the vehicles in the company fleet? (Likert scale from 1 to 5):
        - Cost of purchase of car
        - TCO
        - Design
        - Performances
        - Fuel/electricity consumption
        - Emissions
        - Reliability
        - Corporate image associated to the usage
    - Does the company outsource fleet management to third parties?
    - Which are the fleet management services requested by the company?
    - How many years are the vehicles used by the company before a substitution?
    - Does the company exploit specific fleet management platforms?
    - How are the following functionalities considered for the choice of the fleet management platform in the company fleet? (Likert scale from 1 to 5):
        - Real time localization of vehicles
        - Performance monitoring
        - Real time warnings (e.g., accident, …)
        - Optimization of fleet
        - Management of workforce
        - Integration with digital tools in the company
        - Traffic monitoring services
    - Are there any other factors related to the choice of a fleet management service?

- ***SECTION 3***
    - Is the theme of sustainable mobility important for the company?
    - How are the following factors considered for determining the choice of adopting electric vehicles in the firm? (Likert scale from 1 to 5):
        - Pursuit of sustainability goals of the company
        - Promotion of green corporate image
        - Reduction of emissions
        - Reduction of costs related to mobility
        - Introduction of restrictions for polluting vehicles
        - Possibility to install a private charging point in company sites
        - Availability of charging infrastructure close to company sites
    - Are there any drivers for the choice of EVs in the company?

- How are the following barriers considered for discarding the choice of adopting electric vehicles in the firm? (Likert scale from 1 to 5):
  - High cost of purchase of EV
  - Diffusion of public charging stations
  - High cost of private charging points
  - Complexity of management of charging infrastructure for company sites
  - Complexity of installation of private charging points
  - Low autonomy for electric vehicles
  - Low offer of EV models available
  - Economic impact due to COVID-19
  - Negative environmental impact caused by electric vehicles
  - Change of habits required to user
  - Insufficient assistance services
  - Perception of unsafety (e.g., presence of electric charges)
- Are there any other barriers?

- ***SECTION 4***
  - Enumerate the number of point of charge in the company sites with a power of:
    - Less than 7 kW
    - Between 7 and 11 kW
    - Between 11 and 22 kW
    - Between 22 and 50 kW
    - More than 50 kW
  - Did the company exploit public incentives for the installation of charging points in their sites?
  - How are the following drivers considered for what regards the choice of the charging infrastructure for the firm? (Likert scale from 1 to 5):
    - Cost
    - Availability of solutions to satisfy the requirements of the company
    - Presence of integrated services (installation of point and software for its management)
    - Integration with existing software of the company
    - Availability of mobile apps for management and usage of the point
    - Availability of mobile apps for management and usage of the point personalized for the firm
    - Availability of fleet management platform
    - Possibility to have access to many different public charging points
    - Other

- Who did install the charging point in the firm sites?
- How many times per week is recharged an EV in the company (on average)?

- ***SECTION 5***
  - How do you rate your knowledge about the following themes regarding EVs (Likert scale from 1 to 5)?
    - Presence of incentives at state level for the purchase of EV
    - Presence of incentives at local level for the purchase of EV
    - Presence of taxes linked to emissions of vehicles
    - Presence of incentives level for the purchase a private charging point
    - Fiscal incentives (e.g., free parking spots, exemption form payment of restricted traffic areas, …)
    - Lower TCO
    - Environmental benefits and impacts linked to EVs
    - Presence of norms linked to the emission of vehicles
    - Technical knowledge about EVs (performances, autonomy, …)
    - Increase of infrastructure of recharge
    - Increase of offer for EVs

Also in this case the answers collected are analysed exploiting descriptive statistics and tools from MS Excel, mainly average, standard deviation and graphs, which resulted to be the best and most intuitive way to sum up the information obtained in just one place in an easy way.

### 2.2.2 Data Analysis

Also in this case data are collected and analysed through descriptive statistics on *MS Excel*. In the same way an extended use of averages and standard deviations is made to sum up the answers and obtain general answers considering the whole sample of respondents.

In this case it is hard to obtain general linkages between aspects like the size of the company and a specific phenomenon or a particular driver or barrier. This because the answers from companies are much less than the ones of private owners, mainly because of the difficulties in contacting them and the issues regarding privacy, which prevented some companies from answering to the survey. For these reasons the data analysis carried on for fleets is a general analysis which considers, but does not differentiate in detail, large and small companies, which can have very few or thousands of employees. The work carried on for private users, which exploited *pivot tables* to put together the answers with aspects as number of workers, number of sites and others was not possible in this context, since it would not have a significant value due to the lower number of responses which does not make possible the extraction of general concepts applicable to all companies in Italy.

# 3. Chapter three: Results

## 3.1 Private car owners

### 3.1.1 Survey and Sample

The survey recorded 895 answers, and a first clustering phase has been performed in order to highlight interesting insights between the answers to the questions and mediators like age, gender, provenience and level of education.

| CHARACTERISTICS OF RESPONDENT PRIVATE USERS | | |
|---|---|---|
| **Category** | Variable | Survey Sample (895 answers) |
| **GENDER** | Female | 18.7% |
| | Male | 80.8% |
| | Prefer not to answer | 0.4% |
| **AGE** | 18-30 | 16.03% |
| | 30-50 | 46.16% |
| | Over 50 | 37.81% |
| **REGION** | North | 74.83% |
| | Centre | 12.98% |
| | South | 12.19% |
| **LEVEL OF EDUCATION** | Elementary education | 0.11% |
| | Middle school | 5.53% |
| | High school | 48.42% |
| | Bachelor's degree | 15.12% |
| | Master's degree | 27.77% |
| | Ph.D. | 3.05% |
| **EV OWNERSHIP** | Yes (EV owners) | 41.7% |
| | No (Non EV owners) | 58.3% |

Table 5: Characteristics of respondents (private users)

Indeed, according to (Formánek & Tahal, 2020), answers to the questions are strongly influenced by the personal factors cited before, with different propensity towards EV world. First of all it was important to check the gender of respondents, which can imply different propensity towards new technologies as EVs. The same holds for age. For what regards the region of residence, it is interesting to analyse the different situations currently existing in the different areas of Italy, since different regional approaches towards them may imply different results. As last, the level of education deserves to be analysed since the exposition to knowledge about EVs is crucial for adoption, so it is interesting to assess the different perceptions and inclinations about them. All these aspects of the single respondent are defined as *mediators*, since they are not actually drivers or barriers, but they exert an influencing action on the choices of a person.

As in Table 5, 80.7% of the sample is made of men, while just the 18.8% was made by women. 0.5% preferred to not specify the gender. Regarding the region of residence, 74.83% of the answers are from North of Italy, while 12.98% and 12.19% from Centre and South of the peninsula[8]. In addition, also a profiling based on the level of education has been performed: 0.11% of the sample reported an elementary education, while 5.53% stated having a middle school license; most of the sample (48.42%) has high school license, while 15.12% and 27.77% are in possess of a bachelor's degree and a master's degree. 3.05% of the sample holds a PhD. For what regards the age of the sample, 16.03% is made of people younger than 30, 46.16% by people between 30 and 50 years old and the 37.81% by older than 50. The average age is 45.12 years old.

In Table 6 it is visible how 58.3% of the individuals owns an electric car (BEV or PHEV), while 39.1% does not. 2.6% of the sample has an EV, but it is owned by the company they work for (company car).

Majority of EV owners are represented by males, who double the percentage of females; at the same time, the majority of

| EV OWNERSHIP ON THE TOTAL OF SAMPLE | | |
|---|---|---|
| **Category** | **Variable** | **Survey Sample (895 answers)** |
| GENDER | Female | 24.10% |
| | Male | 45.95% |
| AGE | 18-30 | 14.79% |
| | 30-50 | 47.61% |
| | Over 50 | 46.20% |
| REGION | North | 41.33% |
| | Centre | 52.17% |
| | South | 33.33% |
| LEVEL OF EDUCATION | Elementary education | 0.00% |
| | Middle school | 48.98% |
| | High school | 42.19% |
| | Bachelor's degree | 31.34% |
| | Master's degree | 44.72% |
| | Ph.D. | 48.15% |
| **EV OWNERS** | | |
| **Category** | **Variable** | **Survey Sample (370 answers)** |
| EV OWNED | BEV | 87.4% |
| | PHEV | 12.6% |
| COST OF EV | Below 25,000 € | 34.71% |
| | 25,000 € - 50,000 € | 49.04% |
| | Over 50,000 € | 16.25% |

Table 6: EV ownership on the total of sample

[8] The *Istituto Italiano di Statistica* (ISTAT) reports a division of Italian regions as it follows:

- North: Liguria, Lombardia, Piemonte, Valle d'Aosta, Emilia-Romagna, Friuli-Venezia Giulia, Trentino-Alto Adige, Veneto.
- Centre: Lazio, Marche, Toscana Umbria.
- South: Abruzzo, Basilicata, Calabria, Campania, Molise, Puglia, Sicilia, Sardegna

owners is represented by older individuals, over 30 years old. Surprisingly, the Centre of Italy is the area of the country with the widest percentage of EV owners according to the respondents of the survey. Among the different levels of education, in nearly all cases approximately the half of the holders of a certain title own an EV, with the exception of elementary level and holders of bachelor's degree; in other levels half of the sample with a certain level of education also possesses an electric car.

The majority of EV owners opted for a BEV, while just a minor part of the total sample decided to buy a PHEV. This reflected on the price of the vehicle, with BEVs which result to be more expensive than BEVs; the majority of vehicles analysed has a price between 25,000 € and 50,000 €, with a lower percentage of vehicles under 25,000 €. Premium cars – whose price is higher than 50,000 € – are less present.

### 3.1.2 Results

*Non-owners*

Analysing the answers of the non-owners, the 55.4% of the sample reports that they are interested in buying one, while the 43.2% claims they do not want to purchase an EV (as in Figure 1). The 1.4% of non-owners says that it is does not depend on them, since they use company vehicles. The motivations for the purchase are related to environmental concerns: most of the open answers given report a willingness by non-EV users to change their behaviours in order to have less impact on the planet. To do so, the shift from ICE vehicles towards EVs is seen as an essential step to accomplish. Another important motivation from public is the coupling of EV technology with renewable energy sources, both at domestic level (with the installation of rooftop PV panels) and at industrial level, with choice of green energy providers, The second most cited reason for propension to buy an EV is related to the lower TCO: the lower expenses for fuel and taxes related to car usage are more than appealing for potential customers, who see this as an important driver for the uptake.

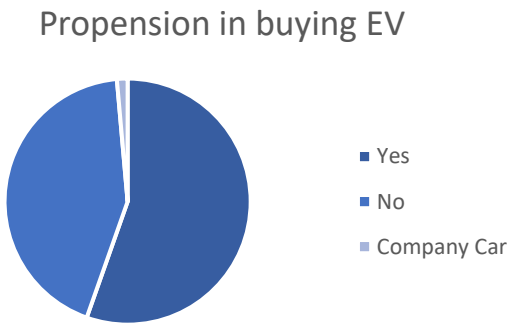



Figure 1: Propension in buying EV

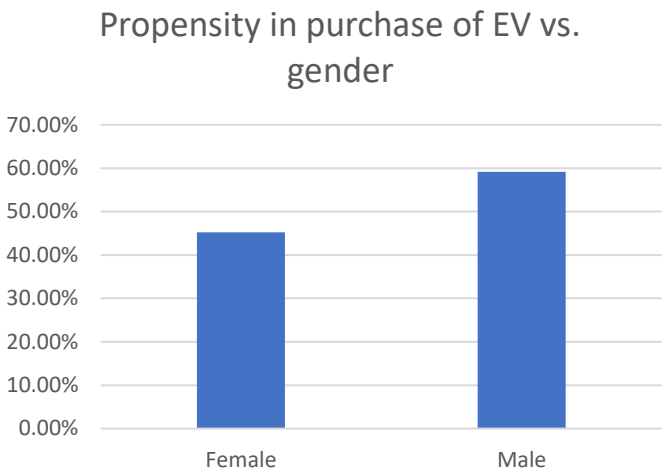



Figure 2: Propensity in purchase of EV vs. gender

There is a higher tendency for men in comparison to women in acquiring an EV: looking at Figure 2, 59% of male sample reports that they would be interested in buying an electric vehicle (BEV or PHEV), with just the 45% of women who would be pleased to do so. With a focus on the geographical area of the respondents, it emerges how the most propense regions are the central and the southern one of Italy: in these areas the favour for EVs reaches peaks of, respectively, 60% and 59%, while in northern regions it achieves just 54%. This is an interesting result since in northern regions the charging infrastructure is more developed than in the other areas cited, but this does not translate in a higher propensity for purchase.

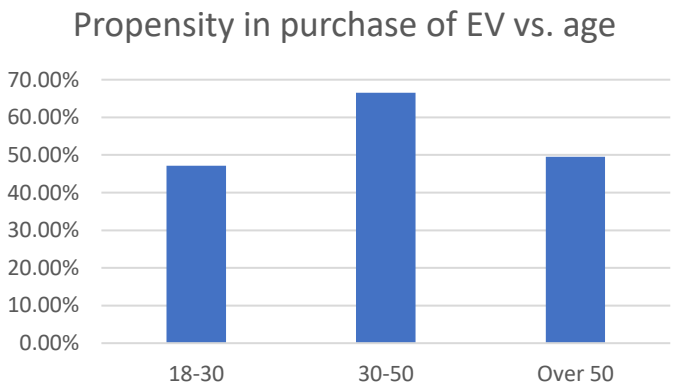



Figure 3: Propensity in purchase of EV vs. age

Anyway, the most interesting data regards the age groups (Figure 3): the most interested age group results to be the one between 30 and 50 years old, with an outstanding result of 66.50% of favours; this can be explained by the fact that this groups is the one with a higher economical availability than younger ones between 18 and 30 years old, coupled with the higher confidence with new technologies in comparison to the older ones over 50 years old. Indeed, young people report just 47.11% of propensity, while, among older ones, just the 49.49% of answers reports a favour for EVs. This goes partially in contrast with what is said in literature, where youngest generations (18-30 years old) are associated to a higher propension for new technologies such as EVs; this surprising result from the survey disavows what said by practitioners cited.

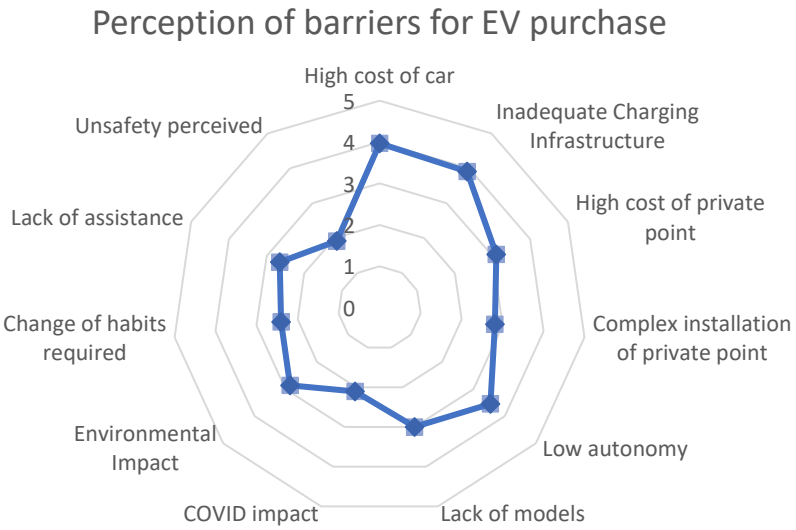



Figure 4: Perception of barriers towards EV purchase

Analysing the barriers for the purchase, it is visible in Figure 4 that the major one is the high cost for the vehicle and for batteries: it is still seen as a heavy hurdle to overcome for people, evidence which becomes even more important in case of low salaries by the respondents (e.g., students). In addition to this, also the inadequate and sparse charging infrastructure is slowing down the process: respondents report that they are "scared" of buying an EV because they fear that there are not enough charging points available at country level, apart from the ones installed in their households. This aspect, coupled with the range anxiety for EVs, pushes away potential buyers, who may opt for ICE cars. Another well present motivation cited by the sample regards the driving pleasure: many answers report how EVs are still affected by the negative aura they had several years ago, being them seen as boring and unemotional cars to drive, an aspect which can demotivate car enthusiasts in opting for EVs. The most perceived barriers, basing on a classification thought Likert scale, are the high cost of the car, the inadequacy of the public charging infrastructure and the low autonomy of BEVs: these are the main obstacles which are slowing down the process of diffusion of EVs at large scale in Italy. Other barriers such as low availability of models, difficulties in installation of the charging infrastructure and change of habits required to users are less important for consumers, thus they are not so crucial in this context. This preliminary result reaffirms what I said in the literature review, with the economic barriers (for both vehicle and charging point) and the ones linked to the charging infrastructure which are the major inhibitors of the wide adoption of EVs. The ones linked to other aspects (habits, assistance, …) appear not to be so impacting on the overall phenomenon, as said in the previous chapters.

Analysing the public incentives for the purchase, 94.4% of non-owners is aware of their existence, with a split on the judgment about their extent: 41.6% considers them too limited, while the 35.6% sees them as adequate. Just the 3.8% believes they are too high, while even the 19.1% of the sample has no idea about the theme. The effect of this barrier is more evident for low end customers, who have limited economic availabilities to purchase the car: for them the presence of high incentives can be a

boost for the purchase, while for high earning customers, who are interested in premium cars, the usage of incentives is not such a game changer.

Analysing the linkages with socio-demographic factors – like age, degree of instruction, gender and geographical provenience – no linkages have been identified with the level of education of the respondents (all well above 90% of knowledge). On the other hand men resulted more aware than women, with 96.64% of positive answers against the 87.30% of females. Analysing the geographical areas, the "most aware" results to be the Centre of Italy (96.36%), but also North and South show a good performance, with respectively 93.83% and 95.83%.

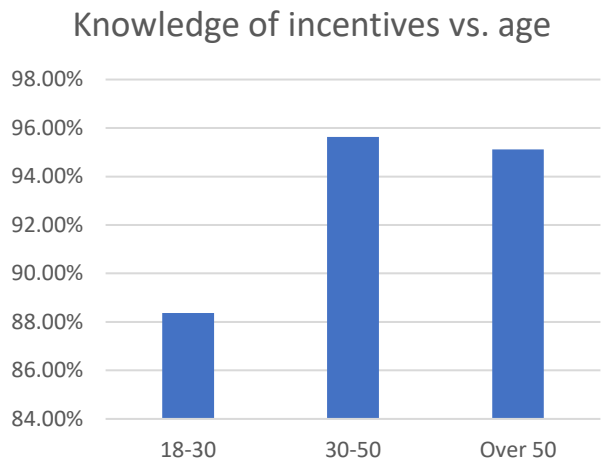



Figure 5: Knowledge of incentives vs. age

The most interesting results are related to age, in Figure 5: in this case there is a strong gap between different classes – unlike for other parameters. Groups between 30-50 and over 50 show a very high level of knowledge (95.63% and 95.12%), while in the youngest group of respondents between 18 and 30 years old only 88.37% is aware of the incentives on the plate. It is of course a good result, but it has the highest difference in comparison to the other parameters analysed before.

The evaluation of incentives in Figure 6 results to be "too low" in the central areas of degree of instruction, with a negative peak for bachelor's degree owner, in which only 22.09% reputes them adequate, while for other classes the percentage is higher (from 30% onwards). Analysing the gender, women are more critical than men: for nearly 45% of the sample, they are too low (against 39.21% of men), with just 23.73% who thinks they are adequate (against 39.21% of men). It is important to say that in women there is also a much higher percentage of interviewee who do not expose on the theme – 28.81% – while in men this percentage is just 16.32%. For

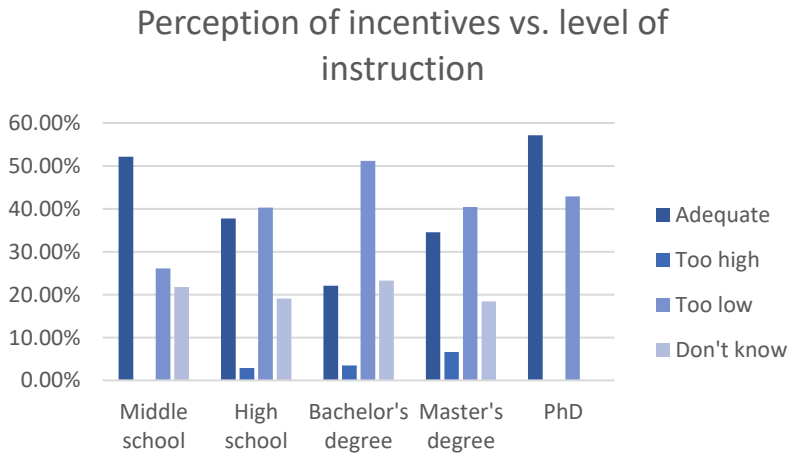



Figure 6: Perception of incentives vs. level of instruction

geographical areas, data are similar all along Italy: percentages between 40% (North) and 47% (Centre) reputes them adequate, with the 44% of South. A higher discrepancy is between those who thinks they are too low: in the North they are the 34.75% of the sample, with just the 30.91% in the Centre; in the South they are more, with the peak of 42.03%.

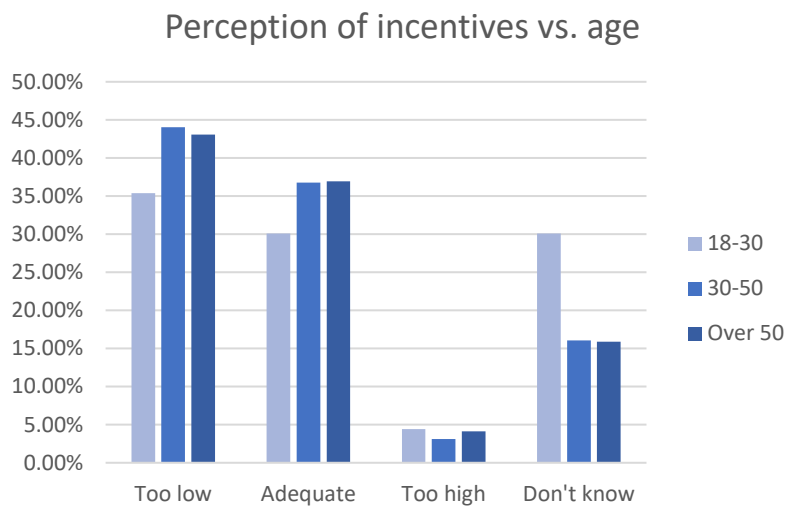



Figure 7: Perception of incentives vs. age

Analysing age, older groups are the most critic towards the amount of money available (Figure 7); among 30-50 years old and over 50 years old, the ones saying they are too low are respectively 44.04% and 43.08%, way higher than the 35.40% of the youngest range. In addition, the part of respondents between 18 and 30 years old is the one which less exposes on the issue: even 30.09% of the sample of this range of age does not know how to judge the amount of incentives, against the 15% of the other two classes.

*Owners*

Shifting the attention towards EV owners, 87.3% of EV owners has a battery vehicle (BEV), while the remaining 12.7% has a plug-in hybrid car (PHEV). 73.8% of owners report that their vehicle has been registered after 2020, sign that there is a strong evolution of the market for EVs, with the purchase which is the most preferred solution to acquire these vehicles (83.2% of the cases), followed by long term rental (9.5%); other solutions like leasing, monthly rental and others have just marginal presence.

The "most successful" cars have been medium ones (segment C), with the 47.7% of the preferences, followed by small and large cars of segment B and D, with respectively 23.2% and 11.9% of choice. Other segments (mini cars, executives, SUVs and luxury) are less present, with an aggregate 17% all together. These choices determined that most car owners have a car

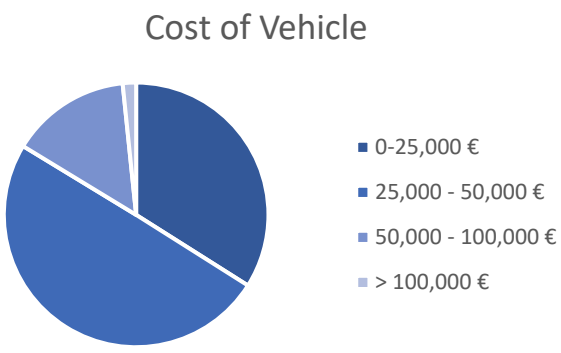



Figure 8: Cost of vehicles of sample

whose price is between 25,000 and 50,000 € (49.7%), while the second most successful range of price is the one below 25,000 €; the average cost of the vehicles of the respondents is 33,655.31 €. This segmentation of the answers regarding the cost of the vehicle allow us to introduce the differentiation of responses on the basis of the type of car acquired, so indirectly on the income of respondents, satisfying one of the major gaps of literature highlighted before. This key of analysis will be useful later on for the next themes.

The majority of EV owners is represented by males, who reach nearly 46% on the total interviewee, both owners and non-owners: the percentage of women owning an EV is just 24% on the total; this trend can be explained by the fact that, also in literature, men are seen as more curious and prone towards new technologies than women, an aspect which can make EV ownership a phenomenon more present in the first ones than in the latter. This aspect confirms the trends seen in literature which link gender and possession of electric vehicles. Ownership of EVs is more diffused in the centre of Italy, where the 52.17% of respondents have an electric car; the percentage slightly decreases in the north, where just 41.33% has an EV. The worst situation is in the south of the peninsula, where only 33,33% of interviewee owns an electric car. As cited by the literature, the development of the charging infrastructure can be an influencing factor: in the North and in the Centre of Italy the numerosity and capillarity of charging points is higher than in the South (Pucci, 2021), a factor which increases the discomfort in usage for Southern owners. No trends are identified in the relation between EV ownership and the degree of instruction of the respondent, thus no evidence can be extracted from this factor.

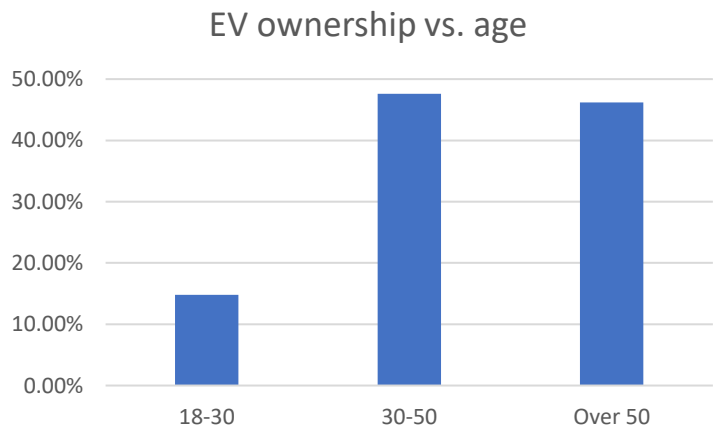



Figure 9: EV ownership vs. age

The same cannot be said for age groups, as confirmed in Figure 9: the age classes with the highest EV ownership levels are the ones from 30 to 50 years old and the ones with over 50 years old respondents (47.61% and 46.20% respectively), while for 18-30 the percentage is just 14.79%. This distribution is due to the fact that EVs are characterized by high costs, thus the younger individuals are much more likely of not having enough economical availabilities to buy such cars, in opposition with the other two groups, who have enough money to make this choice. This is definitely the most important factors which determines such differences from the propensity in having an EV and the effective ownership of the car, confirming the

problem represented by economic barriers analysed, along with the surprising result which sees a lower propension for EVs by the youngest reference group.

Shifting the attention on the type of vehicles owned, it is interesting to see how the possession of BEV vehicles decreases with the level of instruction achieved by the user (Figure 10): among EV owners, this percentages decreases from a 95% for middle school level to just 84% for PhD holders, with of course the percentages of PHEV owners which follow the inverse path, increasing from 5% to 16%. Analysing the preferences basing on the gender, women have higher tendency in owning a BEV: 92% of female owners have a BEV, while men owning that type of vehicle is just 86% approximately, preferring in larger measure PHEVs. This can be explained by the fact that women tend to cover less kilometres during the year, mainly in urban areas where the charging infrastructure is more present and capillary, thus making the choice of BEVs more comfortable and reasonable. Along with that, literature reported a higher environmental attention by women in comparison to men, an aspect which is confirmed by these data, with female who are more incline on BEVs (with no direct emissions) than men, for whom there is a higher profession for PHEVs (characterized by presence of direct emissions from usage). No evidence of higher or lower possession of a certain type of EV can be linked the geographic area of provenience of the answerers, as well as for the age, with nearly 86-87% of preference for BEVs in all areas of Italy and in all ranges of age under analysis (18-30, 30-50 and over 50 years old).

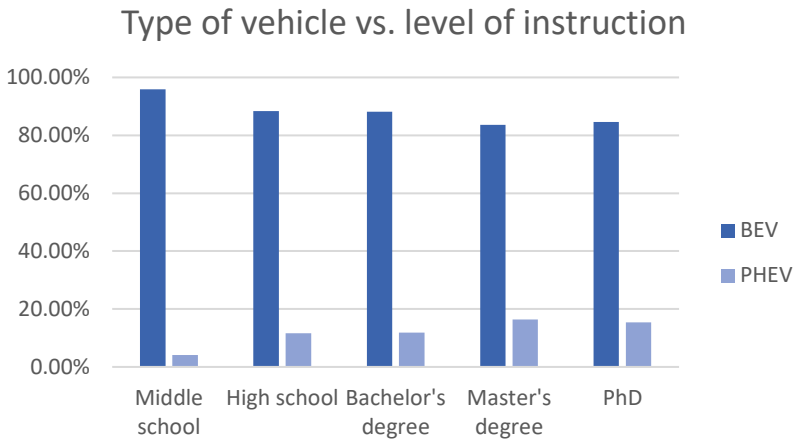



Figure 10: Type of vehicle vs. level of instruction

The wide majority of EV owners have made this purchase for two aspects: the lower TCO in comparison to ICE vehicles and the lower environmental impact caused by EVs, which registered the highest ratings in Figure 11. These are the two major drivers for this choice, jointly with the possibility of having a private charging point at home, a feature which can undoubtedly improve radically the overall usage experience. This evidence denotes how the major drivers for the adoption of EVs are imputable to economic and environmental reasons. These proofs reaffirm strongly the drivers highlighted in the literature analysis, putting Italian EV owners in accordance to the international researches read. Governance and image drivers are not so relevant for users: very low importance is given to status symbol associated to possession of EVs and to stringent pollution laws or improvements of public charging infrastructure.

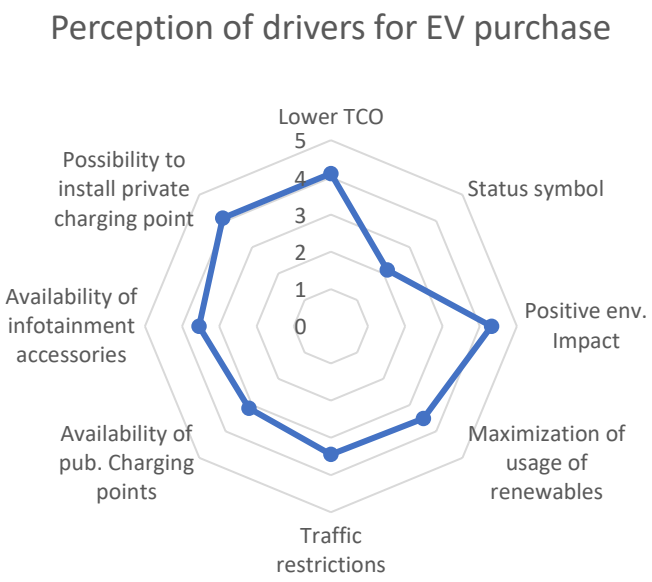



Figure 11: Perception of drivers motivating purchase of EVs

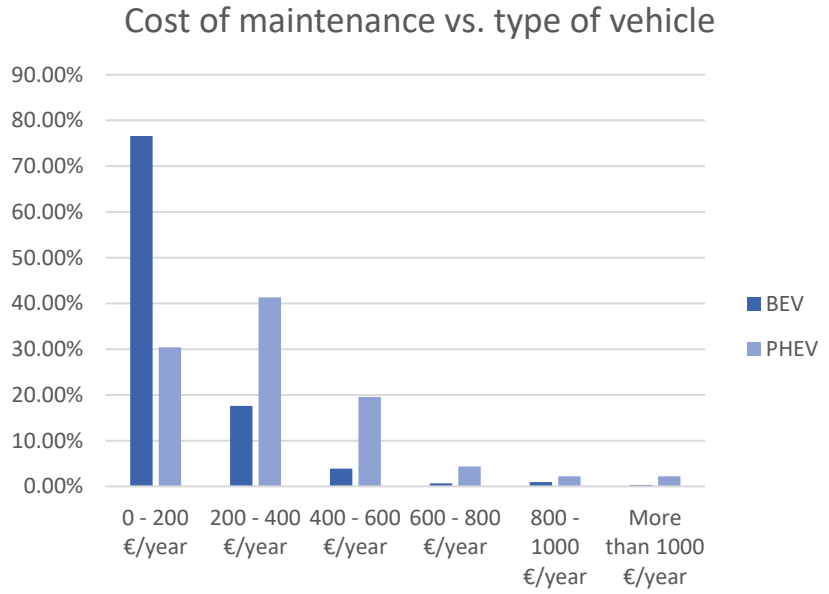



Figure 12: Cost of maintenance vs. type of vehicle

Introducing the indirect costs associated – to the vehicle to satisfy one of the major literature gaps – it is interesting to see how they are higher for PHEVs than for BEVs. As visible in Figure 12, majority of BEV owners (75% approximately) report costs of maintenance lower than 200€ per year, while PHEV owners show a majority of answers in the range 200€/400€ per year, or even higher. This is due to the simple structure of BEV

cars, which require less maintenance and less expensive check-up operations than PHEVs. Indeed, the latter couple both ICE and batteries inside of them, making the maintenance operations more complicated and expensive.

Unsurprisingly, the cost of maintenance also shows an increasing trend with the cost of vehicle: as shown in Figure 13, the higher the cost of the car, the higher the expenses faced by the user to maintain it, with the major difference which can be seen for automobiles with cost higher than 50,000 €. This is due to the fact that more expensive vehicles are characterized by more complex architecture, thus they require more time – and consequently more money – to perform maintenance procedures. Along with that, those vehicles have more expensive spare parts, which furtherly increase the costs for maintenance and repairs. Anyway, in most cases, those costs never overcome 400€ per year, apart from very few situations.

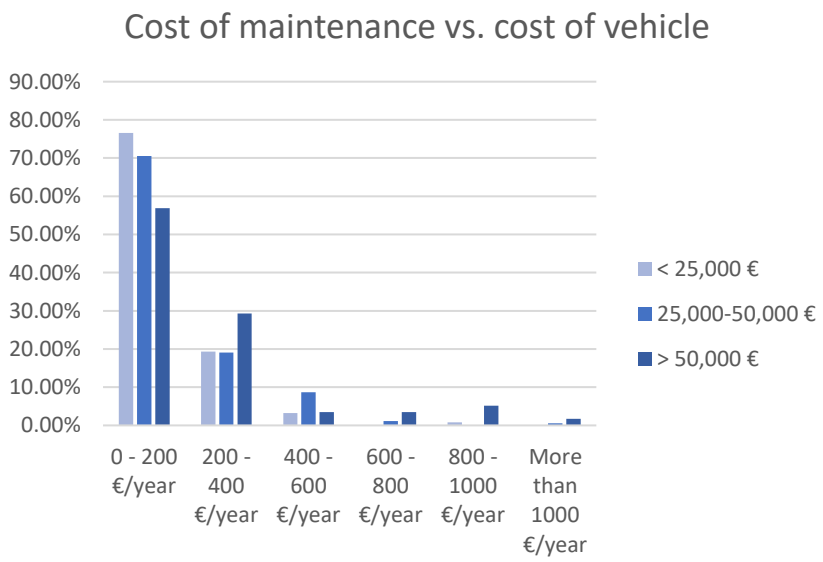



Figure 13: Cost of maintenance vs. cost of vehicle

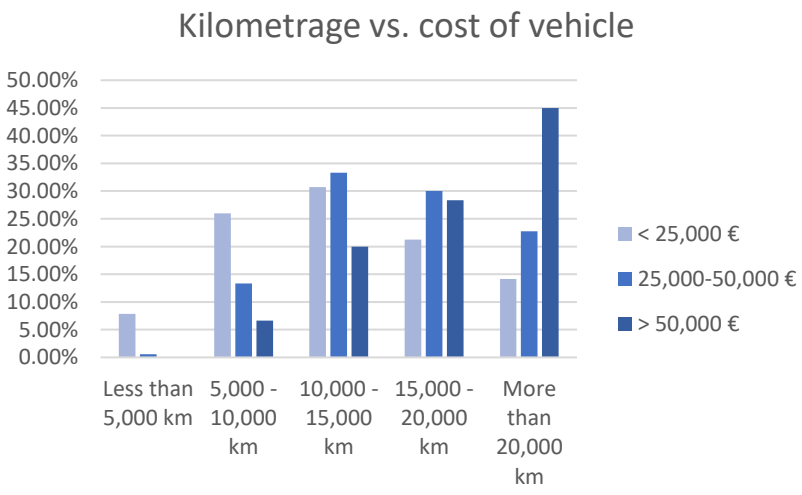



Figure 14: Kilometrage vs. cost of vehicle

In addition, it emerges how more expensive vehicles are associated to higher utilization (Figure 14). Indeed, those expensive vehicles are in many cases executive cars, used to cover many kilometres every day, mainly for working reasons. This determines a strong utilization of the car, which can cause a stronger wear of tyres and other consumable of the vehicles, which can require a replacement. This, coupled

with the higher cost of repairing operations on these cars, cause a higher cost of maintenance.

Analysing the usage of EVs, majority of the sample report a strong usage of the car during the year, with more than 80% of the sample which expects to cover more than 10,000 km per year. Despite the strong usage of vehicles, the autonomy perfectly fits the necessities of owners: 81.7% of sample reports they never or hardly ever accomplish long journeys (more than 100 km) during the year, with maximum one per month. In the remaining answerers, 13.5% covers long journeys once per week, while only the 4.9% does that every day. This determines that battery capacity and autonomy of vehicles are more than enough to cover necessities from users, disavowing range anxiety related to BEVs.

Introducing socio-economic mediators, there are no trends linking level of education to the kilometres covered with the EV.

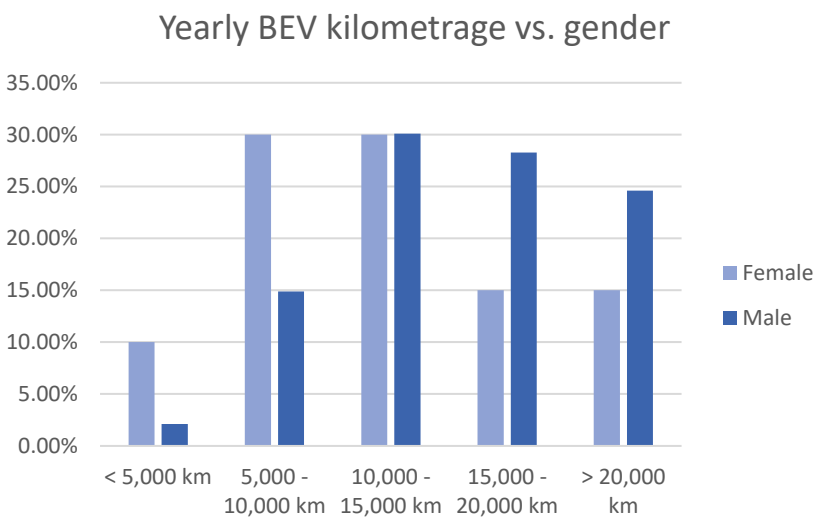



Figure 15: Yearly BEV kilometrage vs. gender

More interesting aspects emerge analysing the gender: males report higher kilometrages with EVs in comparison to women, with more than 50% of the sample covering more than 15,000 km yearly, and even 82% of them reporting more than 10,000 km covered each year with the EV (Figure 15). For women these percentages decrease: only 30% of them report more than 15,000 km per year, while just 60% covers more than 10,000 km each year.

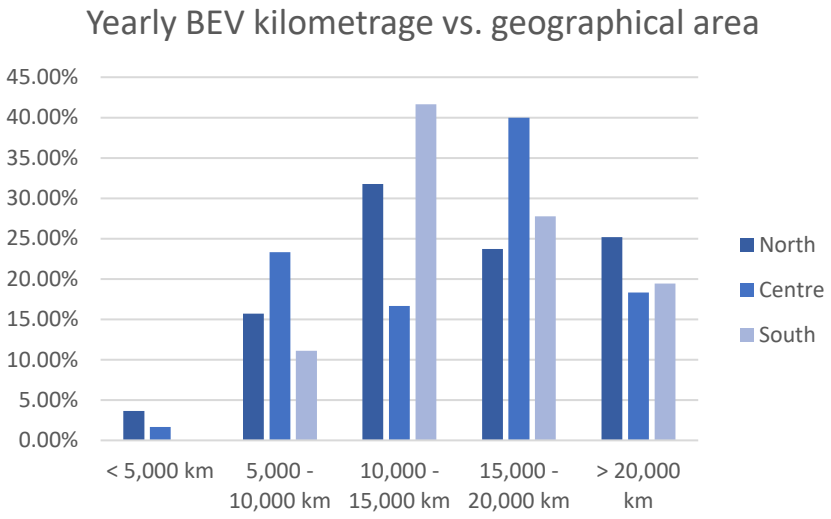



Figure 16: Yearly BEV kilometrage vs. geographical area

Analysing the geographical area as in Figure 16, in the North most of the sample reports kilometrages between 10,000 and 15,000 km per year, with nearly half of the sample who covers higher distances. The scenario changes in the Centre, where there is a stronger utilization of the cars: 40% covers between 15,000 km and 20,000 km each year, with 18.33% who covers even more than 20,000 km annually with the EV; in this area lower utilization of the EV is less present, with 15.69% covering between 5 and 10,000 km, and just 3.65% less than 5,000 km. The southern regions of the peninsula face a trend like the North, with 41.67% of the sample covering between 10,000 and 15,000 km per year, while 47.22% shows a higher kilometrage. Lower utilizations are marginal in this area, with just 11.11% saying that they cover less than 10,000 km per year. For what regards the age, the only interesting aspect is that majority of the young users covers between 10,000 and 15,000 km per year, while older users are linked to stronger utilization of vehicles.

80.6% of EV owners have exploited public incentives to buy the vehicle, with an enormous success for statal incentives (used by 98.3% of those who exploited the public funds); regional incentives are less used (27.1%), while provincial and communal ones are just marginal. With an average value of 8,668.15 € per buyer (Table 7), the provision of incentives determined a significant influence over the purchase of an EV, with 80.2% of buyers who report a strong effect on their decision. This reaffirms the strong motivational effect determined by public incentives at purchase in the buying process, as cited in the literature.

| | |
|---|---|
| AVERAGE CAR COST | 33,655.41 € |
| AVERAGE INCENTIVE | 8,668.15 € |

Table 7: Average cost of car and incentive for purchase

Shifting on their effective usage of incentives by consumers, nearly 80% of owners of EVs exploited them, with no sensible differences between different levels of education. The same holds for the gender: men and women used incentives in the same amount, with relatively 80.24% and the 82.5% of positive answers by the two categories. North

of Italy results as the region which most took advantage of the public funds, with 82.48% of EV owners who used them; the region is followed by South of Italy, with 77.78% of respondents who exploited incentives for the purchase, and the Centre, with just 73.33% of electric car possessor who exploited the opportunity.

The only interesting trend of usage is related to age (Figure 17): indeed, it is possible to see that the usage of public money for the purchase of EVs decreases with the age. The most virtuous are the younger owners, with 95.24% of positive answers, followed by middle aged (82.68%) and older ones (76.47%). This particular behaviour can be explained by the fact that sometimes the unlock of public bonuses for such purchases are related to the economic situation of the individual (possessions, income, ISEE parameters, …): older classes are characterized by higher incomes and higher richness than the youngest people, thus to those classes the access to some bonuses may be unable since they are over the economic parameters required to exploit them. This acts as a confirm of the economic drivers and barriers analysed in literature, which says how it becomes difficult for young people to buy an EV without a public monetary support.

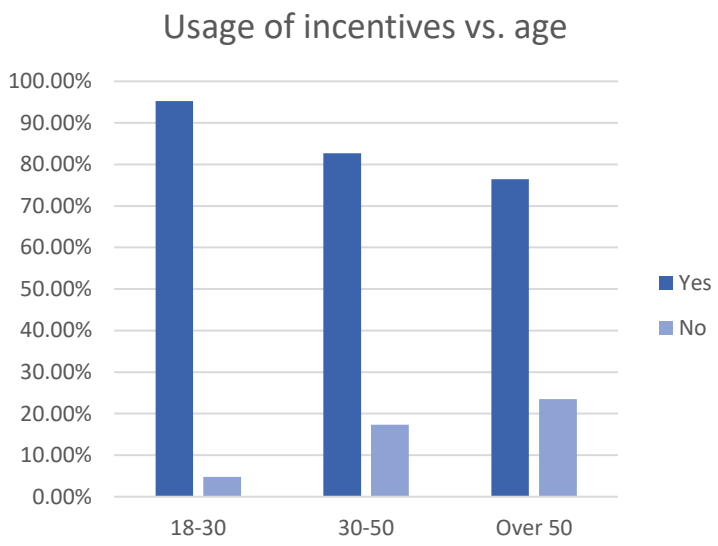



Figure 17: Usage of incentives vs. age

Moving the attention on the charging phases (in Figure 18 aside), majority of the sample reports that the recharge of the car happens mainly at home: this is the most utilized point of charge thanks to its ease of use and comfort; other locations like workplace, public points on roads and

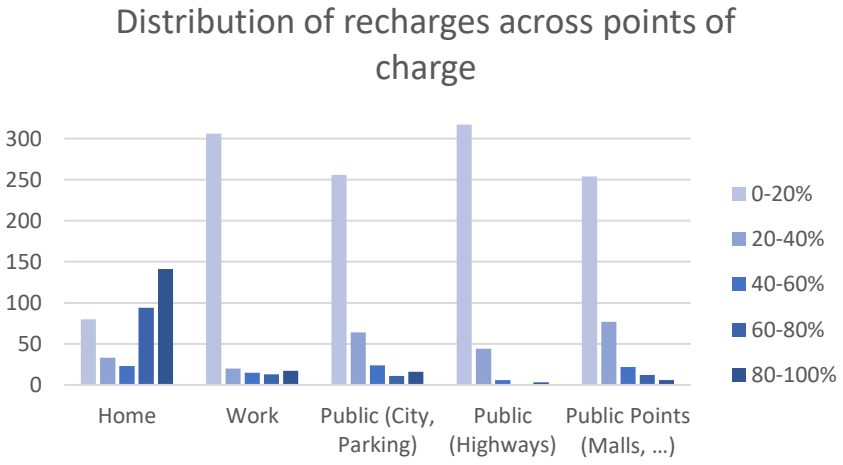



Figure 18: Distribution of recharges across points of charge

points of interest are less used, and mainly they are exploited in case of real necessity – for example in case of very low battery – or in case the point is present in areas with other amenities, like supermarkets or restaurants. The usage of these points is still marginal in comparison to home.

To remark this fact, the 70.9% of EV owners have a private charging point installed at their home, and, among the 29.1% of those who do not have one, the 15.6% is thinking about its installation. In addition, people were asked the reason for which they decided to install a point in their household: most answerers say that they did so for reasons of comfort (in terms of fastness of charge and possibility of not leaving the car on the road) and costs, thanks to favourable terms agreed with their energy providers. Linking with this theme, there is also the possibility to exploit more the photovoltaic panels installed in their households, with the possibility to couple them with energy storage systems.

While there is no relationships among ownership/installation of point and the degree of instruction, the same does not hold when we deal with the gender: men are both more prone to the ownership of charging point (71.63% against 62.50%) and to the installation (87.84% against 75%). On the perspective of geographical areas, North and Centre of Italy are the places where the percentage of ownership and propensity to installation of charging points at home is more present: the peaks are in the central zone, with 76.67% of possession and 90% of propensity, followed by the North, with 70.07% of possession and 87.23% of propensity. South struggles, with just 66.67% of ownership of point and 75% of propensity.

No evidence is present in relation to the level of instruction of the respondent, while a trend is related to the age: while the propensity to install the point is nearly constant among all the groups (about 85-87%) the actual ownership registers a peak for the 18-30 range, with 83.33% of EV owners in it who own a private charging point. In the other age groups the percentage decreases to 71.35% and 68.18% for 30-50 and over 50, as shown in Figure 19. This is a trend which is not extended analysing the literature, due to the cost of the points: anyway, the provision of public subsidies for their installation can help the younger layers of EV drivers to purchase one, reducing an expense which may be impracticable in other cases.

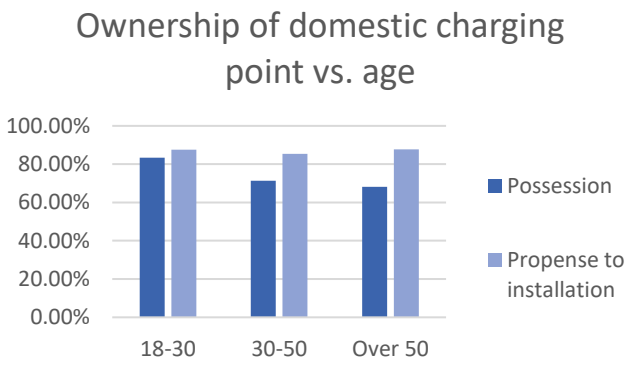



Figure 19: Ownership of domestic charging point vs. age

The presence of a charging point at home is not so dependent on the kilometrages covered by the vehicle: indeed, percentages among 70% and 80% report the presence

of a private charging point at home, no matter if they cover less than 5,000 km per year or more than 20,000 km per year; there is just a negative peak for kilometrages between 10,000 and 15,000 km per year, where users owning a private point at home are just 64.29% of the total EV owners interviewed. The same holds for the type of vehicle bought (BEV or PHEV): in both cases about 70% of owners report they have at home their own charging point.

A much more interesting result is related to the cost of the vehicle: while for vehicles below 50,000 € the percentage of owners of a point are just near 70%, for cars above that price the percentage of point owners increases up to 80.00% (Figure 20). This can be explained by the fact that private points are in many cases not installed because of their cost, thus for cost sensitive car owners it can be a hurdle to overcome; for buyers who decide to purchase an expensive vehicle the problem does not emerge.

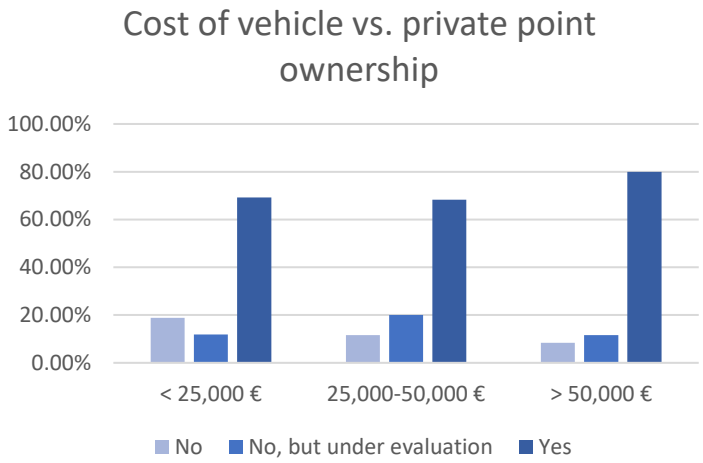



Figure 20: Cost of vehicle vs. private point ownership

Those who do not have a private charging point at home report as main motivation for their choice the impossibility of installing them, since they have no private box and so they are obliged to leave the car on the road at night. This is the most registered motivation which determined this choice, coupled with the high cost for the wall-box: this determines in many cases the preference in using the cable provided with the car plugged to the normal sockets in the box. In other cases, users can exploit free or convenient charge at workplace, making the ownership of a domestic wall-box inconvenient. All these inhibitors are widely present in the contributions analysed in precedence, thus there is a perfect accordance between literature and "real world" opinions by users.

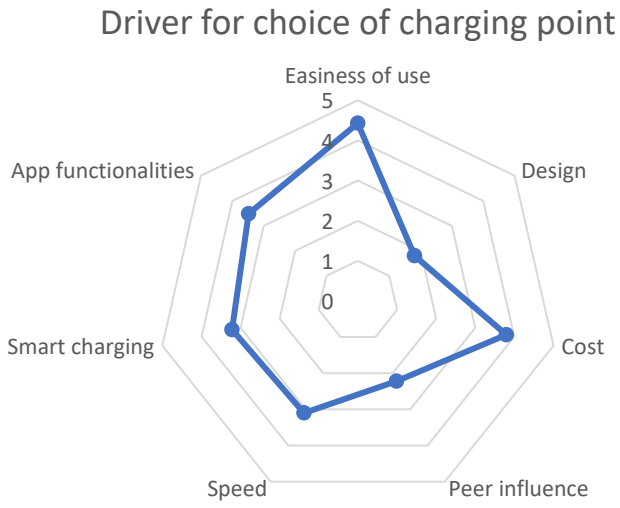



Figure 21: Drivers for choice of charging point

Studying the purchasing process by users, 83.7% of drivers owning a charging point have had the possibility to choose in first person the solution to install, with those who could not choose it report that the point was already installed in the household, or it was provided with the vehicle. The choice of a model instead of another is motivated mainly by the easiness of utilization of the point itself, along with the cost of the point, following the same trends faced in literature; also, the possibility to manage it by app and the presence of smart charging solutions (e.g., V1G, V2G) have a slight influence on the decision, while design, peer influence and speed of charge showed much lower influence on the final judgement. All the drivers for the choice of the charging point are reported in Figure 21.

Majority of the points (36.1%) required less than 300€ for purchase and installation, while other ranges of cost show similar percentages, all near 12-14% (Figure 22). Talking about maintenance, in all cases costs are very low: in 96.6% of situations those expenses are below 50€ per year. The points are in majority of the cases provided by specialized technology providers (45.1%), followed by car manufacturers and utilities (14.1% and 6.1% respectively); other solutions like electricians or online resellers are less chosen. Analysing the installation, the first choice is on electricians (63.8% of the cases), followed by the direct intervention by the technology provider (9.8%); other solutions like utility and do-it-yourself are marginal. Assessing the possibility to share the private charging point with third users, only 25.5% of the

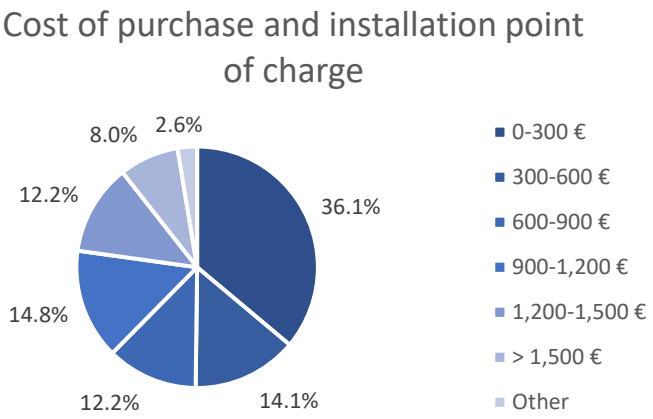



Figure 22: Cost of purchase and installation point of charge

sample is available to do so. People welcoming the idea do so for sense of community and to facilitate the diffusion of charging points to speed up the uptake of EVs, along with economic reasons, as the remuneration of the service.

In this case the usage of public incentives has been way less diffused: 63.9% of point owners declare they did not benefit of any money put on the plate by public entities, referring just to their own financial resources. As a confirm, only 30.1% give high importance to incentives when they opted to install the point: the wide majority of the sample has given low weight to them, with even 39.1% who gave no value in the decision process. Most of points have been installed in a private box at home (84.1%), while the other most present solutions are garages (6.5%) and common areas in condominiums (4.6%).

The usage of points at home is quite variegated, with the majority of people charging the point 2 or 3 times a week, with an even distribution also for other choices, as visible in Figure 23. For what regards the timeslots for recharge, most of recharges are performed at night between 20:00 and 08:00; other moments of the day are way less chosen since users are out of their home or they are using the vehicle.

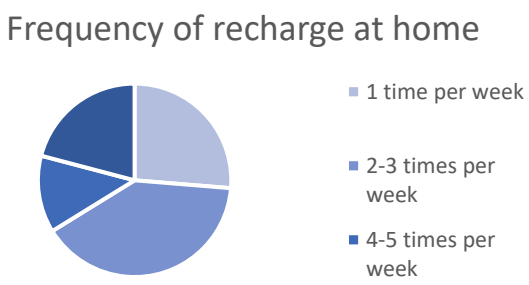



Figure 23: Frequency of recharge at home

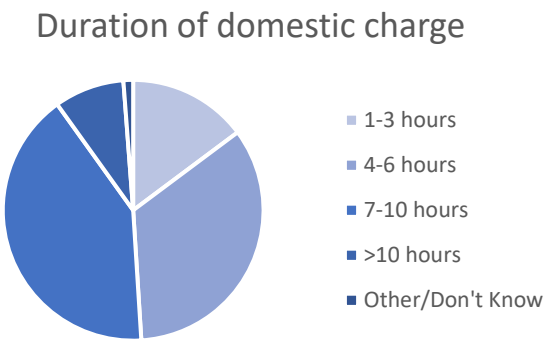



Figure 24: Duration of domestic charge

During domestic recharge cars remain plugged in great majority of the cases from 4 to 10 hours (75% of the cases combined, as visible in Figure 24); this is motivated by the fact that most users leave their automobiles in charge at night, and by the low power of domestic wall-boxes, which determine high charging times. The large part (60.5%) of domestic charging phase starts with battery between 20 ad 50 percent of the total capacity, while the 23.2% takes place with battery between 50 and 80 percent of the *state of charge*. Recharging at extremely low (less than 20% of battery) and high (80% of battery) capacity are less common, with respectively 15.2% and 1.1% of the cases.

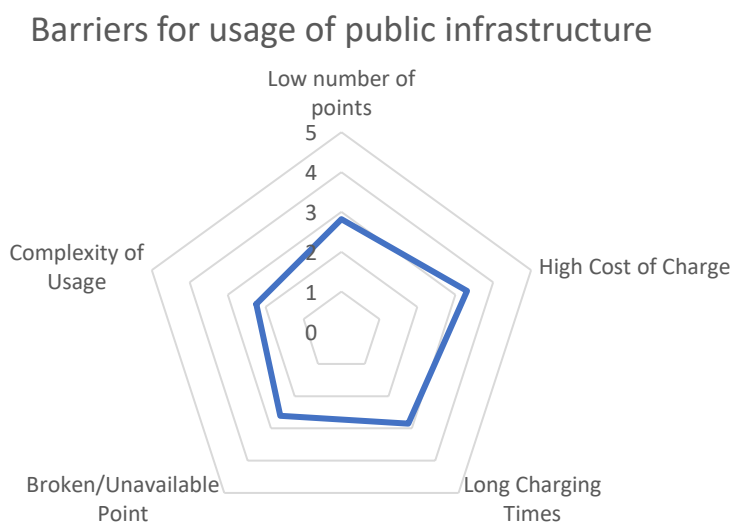



Figure 25: Barriers for usage of public infrastructure

Shifting the focus on the public charging infrastructure, the wide majority of EV owners uses it: 25.6% reports a daily use of that, while 58% of them says that they use it occasionally. The remaining 16.4% of the sample does not use it, preferring other solutions, like domestic point. The main barriers for the missed utilization of the point are the high cost to recharge the vehicle, which makes domestic charging cheaper, along with the long times required to charge the car (Figure 25). These two barriers are among the most cited in literature, with the cost becoming a wide issue especially when dealing with fast charging. Other issues are related to the malfunctioning of the point, coupled with the low presence of points on the Italian territory, still a problem registered in countries with low penetration of EVs (like Spain). Users report that they do not recharge their car at public point since they do not need it: their daily kilometric needs are way below the autonomy of the vehicle, so they are able to cover the route to work and back to home and to satisfy their needs without the necessity to recharge the car during the day, preferring to do so at home, where they have less worries and spend less money on the recharge.

The usage of the charging points appears to be independent from the cost of vehicle, with in all cases the 55%-60% of respondents who say they use the public infrastructure occasionally, while 15%-20% claim a regular usage.

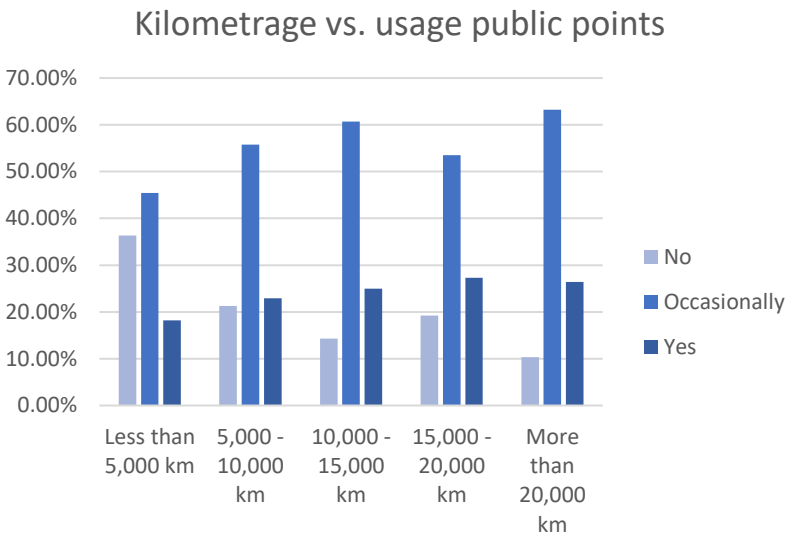



Figure 26: Kilometrage vs. usage public points

Analysing the kilometrage there are interesting insights, showed in Figure 26: people who cover less kilometres are also the ones who less exploit the public charging infrastructure, while the percentage of users of it increases with the number of kilometres driven by the user. Percentages of occasional users increase from 45.45% (for those covering less than 5,000 km each year) to 63.22% (for more than 20,000 km); the same trend can be seen for regular users, who increase from 18.18% to 26.44% in the ranges cited before. This can be explained by the fact that if a driver covers few kilometres he/she may recharge the car at home, since they will never be far from their residence, while for strong users the referral to public infrastructure becomes crucial to recharge the vehicle during the day, when they are out of home and they are on the road.

The usage does not change with the level of instruction of EV owners, but there are slight differences based on the gender: men are more prone in the usage of the public charging infrastructure than women, with 58.97% of male users who recharge quite often at public points (against 52.5% of women) and even the 84.50% who do that at least occasionally (against 77.5% of women). The Centre of Italy is the region with the highest utilization of public points, with 30% of high usage and 90% of at least occasional one; for North and South the percentages reach 25.18% and 19.44% for the prolonged use, while 82.12% and 83.33% considering also the occasional.

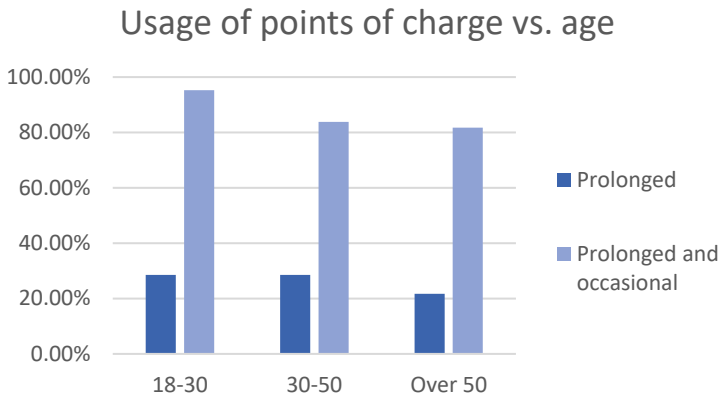



Figure 27: Usage of points of charge vs. age

The most interesting trend relates with the age groups in Figure 27: in this case the usage of the public points faces a decreasing trend, with the prolonged usage peaking for the 18-30 range (28.57%) and then declining to 28.49% and 21.79% for respectively 30-50 and over 50 range. The same can be seen also considering the occasional utilization of the points: for 18-30 years old users it reaches 95.24%, while for the other two groups it is respectively 83.80% (30-50 years old) and 81.76% (over 50 years old). This trend can be explained by the higher disposition by younger people for new technologies, also charging points: one of the main barriers faced by EV users in literature is the fact that sometimes charging points are difficult to use. Difficulties are more evident for older groups, which may be less accustomed to those points, deciding to avoid their usage.

The most used public points are the ones located in public points of interest – as restaurants, malls, … – and the ones on urban roads, followed by the ones on public parking spots. The points on highways are less used since the costs are higher, coupled with the fact that on highways people don't want to spend lots of minutes waiting for the car to be recharged. Anyway, the usage of the public charging infrastructure is still low diffused: 39% of EV owners report they use them once per month, while 14% once every two weeks, and 14.5% just once per week; strong usage (once per week) is rare, with 12.3% of cases, while the remaining 20.2% employs public point very seldom. Recharges last for less time than private and workplace points: nearly 50% of them last less than 1 hour (8.4% less than 30 minutes, 34.5% between 30 minutes and 1 hour), with 28.7% which report times between 1 and 2 hours. It is important to highlight a decreasing trend for the duration of charge: it lasts more for private points at home, then for points at workplace it decreases, reaching the lowest duration for points of the public infrastructure. This is due to the fact that for public points people cannot wait too much time for the recharge, unlike the points at home and at work.

For what regards the importance of the presence of charging points in *POIs*, they are important drivers which determine and influence the choice of one point instead of another: 71.6% of EV users give a high importance (4 and 5 in Likert scale) to the presence of a charging point in a *POI* when it comes to choose one (Figure 28).

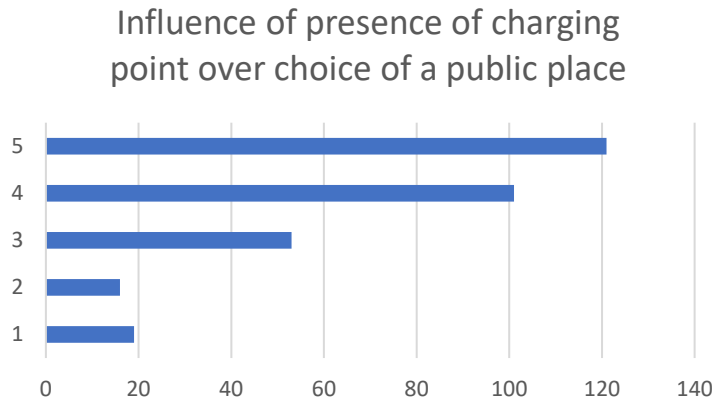



Figure 28: Influence of presence of charging point over choice of a public place

In this perspective, owners of interest points can exploit this phenomenon to boost their affairs and economic results. In most of the cases recharges did not register any problem, or at least in very few cases (in 85.2% of sample), with 10.6% of EV users who registered issues in 20-40 percent of the cases. These issues were mainly due to a malfunctioning of the charging column (70.3% of cases), while just in 1% of the situations the problems are due to the cable. In the remaining 28.7% of problems the reason has not been specified.

Focusing on the drivers for the choice of the public point of charge, the main one is the presence of the point along the route chosen by the user, followed by the power of the point, so consequently the time required to recharge the vehicle, as seen in Table 8. On the podium of the drivers the third most present are the price to charge the vehicle and the proximity to the final destination of the user. The fourth one results to be the overall experience of usage of the point, with preference for intuitive and easy to use points to have a smooth experience of charge.

| DRIVER FOR CHOICE | PERCENTAGE OF ANSWER |
|---|---|
| Presence along route | 66.1% |
| Power of the point | 55.8% |
| Price | 50% |
| Proximity to destination | 50% |
| Usage experience | 10.3% |

Table 8: Major drivers leading the choice of public charging point

When asked about the role of public charging infrastructure, the 61.2% of EV owners think that it is crucial for the wide adoption of electric cars, while 37.2% sees it only as a complement to private charging, still perceived as the preponderant and most important one for recharging EVs. This 37.2% is composed by a 20.2% who says that intervention should be made both at urban and extra-urban level, while 17% thinks that interventions are required only for extra-urban routes. Just the 1.6% gives no importance to the development of public charging infrastructure for the diffusion of EVs.

As hinted before, the most critical area where points of charge should be installed widely are highways, to allow overcome issues which emerge for long journeys; other points which are perceived as critical for action are public points of interest, public parking spots and public places of interest as airports, stations and bus stops.

These are the areas where EV owners repute action is required to enlarge the number of points installed, places where the current amount of charging stations is seen as insufficient for the current and future necessities. In urban roads the number of points is surely higher, thus they are not as critical as the other areas in Figure 29.

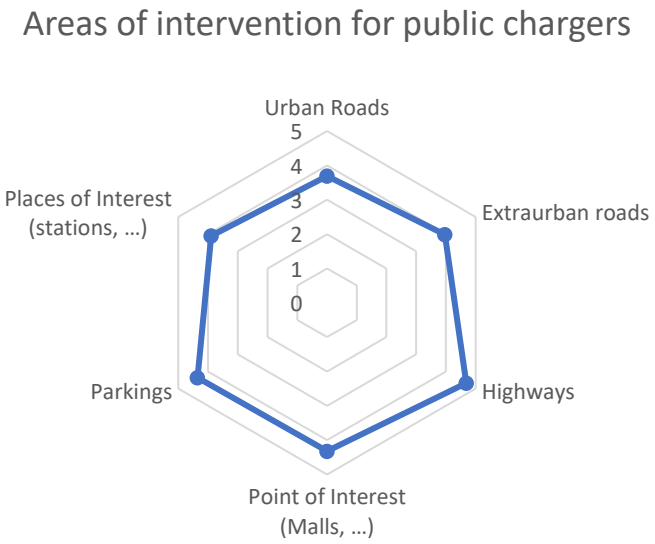



Figure 29: Areas of intervention for public chargers

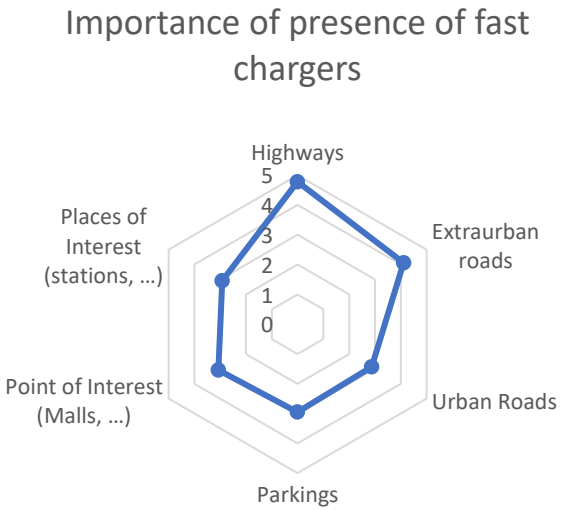



Figure 30: Importance of presence of fast chargers

One of the critical areas of analysis cited before regards fast charging[9], and its potentialities for the spread of EVs in the future. Indeed, interviewee give high importance (4 and 5 out of 5 in Likert scale) to them for fostering the diffusion of electric mobility in the future, with nearly 80% of consensus (Figure 30). In accordance with what said before, fast chargers are seen as crucial assets in highways – where people cannot and do not want to lose time when travelling – as well as on extra-urban routes. Surprisingly, their importance is perceived lower in other areas, like urban areas, along with parking spots and points of interest: this because people, when charging takes place, can distract, and do something else while waiting, for example do shopping or others.

This gives us the direction for future development of charging infrastructure: in urban areas and points of interest it is more than enough to install many points with low

[9] Recharge with points at more than 100 kW of power

power, containing the costs and satisfying more vehicles in the same time. This because in those places people can spend time in other activities, so the long charging times associated to low power points are not a dramatic problem for user. On highways and suburban roads the investments should be aimed at the setting of fast charging points to reduce waiting times when recharging, trying to make them similar to the ones of classical refuelling with gasoline. Indeed along these route people has no activities to do when waiting, so the important charging times caused by low power charging becomes a distress for the user.

To confirm this, people affirm that the presence of fast chargers on highways and extra-urban routes would increase their propensity in using EVs for long journeys (more than 200 km), as in Figure 31: this is a clear sign that investments in the charging infrastructure, with the criteria cited before, can increase the utilization of electric cars also for long trips, overcoming the range anxiety which can discourage users.

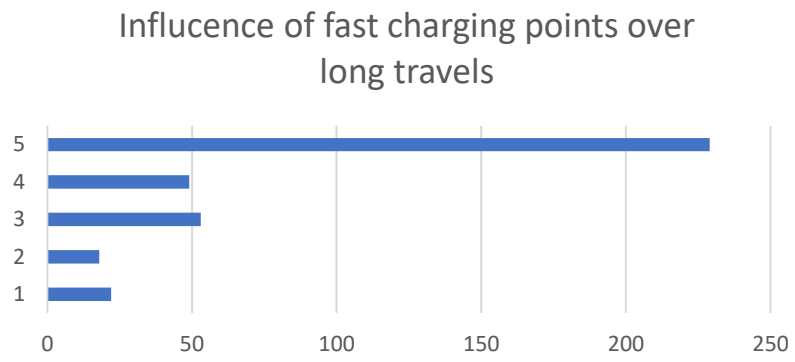



Figure 31: Influcence of fast charging points over long travels

The same critical points of installation are present in the literature, with highways which appear to be the least served and the most requiring places for fast chargers, in accordance to what expressed by users in this survey.

In last analysis EV owners were asked to give personal impressions about their degree of knowledge about the theme of electric mobility, which literature sees as a fundamental driver which can boost the diffusion of EVs. As confirmed in Figure 32, users are quite well aware of the benefits coming from the usage of EVs, both from economic (lower TCO, lower taxes) and environmental side (lower emissions), with also a good knowledge about governance themes like limitations for polluting vehicles. In addition, they perceive a good level of knowledge about the technical

aspects of cars (autonomy, performances) and the offer of models on the market, sign that they keep them informed about novelties which are released. The only critical areas regard the development of the charging infrastructure (growth rates) and the development of V1G/V2G projects, themes on which users should be informed more.

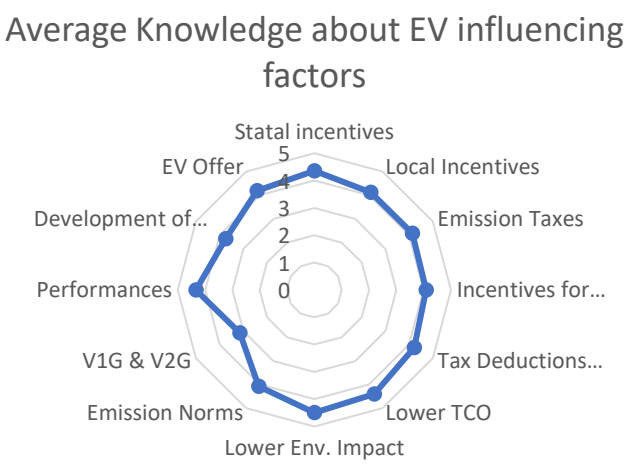



Figure 32: Average Knowledge about EV influencing factors

As last question, EV owners were asked if they would come back to ICE cars: the answer is a strong no, with 91.5% of the sample who would not change their EV with an ICE one, sign that with the direct experience with the vehicle consumers appreciate the technology and its features, preferring it against traditional ones.

## 3.2 Company Fleets

Moving towards the survey about fleets, it has been designed in the same way of the previous one, with different questions, both regarding the profiling of the respondents and the questions present in the investigation. In this case it has been more difficult to find out the right channels to exploit in order to reach the desired audience, due to the fact that we had to reach the exact person who, inside the companies, is in charge of building and managing the fleets of vehicles, plan the maintenance, choose the cars and assign them to the employees. For this scope we exploited different channels in comparison to the case of private owners:

- Personal acquaintances who work with a company car
- LinkedIn (searching keywords in the search bar such as "fleet manager")
- E-Mails directed to companies

Also in this case a preliminary screening of the answerers has been performed, to have an overview of what kind of companies we were dealing with. First of all we considered the number of employees of the company, with the following division (Portale delle Pubbliche Amministrazioni Italiane, s.d.):

- Micro enterprises, with less than 10 people in the personnel
- Small enterprises, with a number of employees between 10 and 50
- Medium enterprises, with more than 50 workers but less than 250
- Large enterprises, with more than 250 employees

### 3.2.1 Survey and Sample

To better understand the reasons why electrification of fleets is so slow, and thus work on one of the literature gaps identified, the best way was to directly to managers their opinions, asking first information about their companies, which are condensed in Table 9. This first step revealed that, among the 34 respondents to the survey, the 6.06% was represented by micro enterprises, followed by 9.09% of small enterprises and by 6.06% of medium ones. The large companies represented the 78.79% of the sample analysed, so the wide majority. The 40% of the companies have sites located in the North of Italy, while the 54.06% of the sample has sites distributed across regions belonging to different areas of the country. Just 2.86% of the companies is situated in the South of Italy, while 2.86% of them did not specify where its sites are positioned.

| CHARACTERISTICS OF RESPONDENT COMPANIES | | |
|---|---|---|
| **Category** | **Variable** | **Survey Sample (34 answers)** |
| **SIZE** | Micro | 6.06% |
| | Small | 9.09% |
| | Medium | 6.06% |
| | Large | 78.79% |
| **REGION** | North | 40.00% |
| | Centre | 0.00% |
| | South | 2.86% |
| | Distributed in Italy | 54.29% |
| | Not specified | 2.82% |
| **PRESENCE OF FLEET MANAGER** | Yes | 40.6% |
| | No | 28.1% |
| | No, but under evaluation | 31.3% |
| **NUMEROSITY OF FLEET** | 0-25 | 18.8% |
| | 25-50 | 9.4% |
| | 50-150 | 9.4% |
| | 150-200 | 12.5% |
| | 250-500 | 28.1% |
| | Over 500 | 21.9% |
| **DURATION OF LIFE IN FLEET OF VEHICLES** | Less than 2 years | 0.0% |
| | 2-5 years | 96.9% |
| | 5-8 years | 0.0% |
| | Over 8 years | 3.1% |

Table 9: Characteristics of respondent companies

Nearly half of companies has a fleet manager who is in charge of administrating the fleet of the company, while, among the remaining ones, the majority does not have one but is thinking of adding it in the organigram of the firm. Just 28.1% of the companies has no fleet managers and is not interested in having one. Analysing the numerosity of fleets, there is an even distribution of them among the different clusters showed in

the table, with a prevalence of the range 250-500 vehicles. In nearly all cases, the vehicles remain in fleets for a time between 2 and 5 years.

### 3.2.2 Results

Among the companies which answered to the survey, only 40.6% currently has a mobility manager inside of them, with 31.3% which are currently thinking of inserting one and the remaining 28.1% which are not interested. The role of mobility manager is in many cases in the hands of managers covering also other tasks, which can range from head of human resources to facility managers. It is not always a specific and single role which takes care of just the management of car fleets; this is even more true in smaller companies, where a single individual has to take care of more tasks at the same time.

Analysing the current fleet in their company: in 21.21% of the cases they had between 0 and 25 cars, while in 9.09% of the situations the amount of vehicles in fleets was between 25 and 50 vehicles and between 50 and 150 automobiles. 12.12% reported having from 150 to 250 cars, while 27.27% has a fleet of 250 to 500 autos. The remaining 21.21% reports a fleet composed of more than 500 vehicles. The most common solution to acquire the vehicles revealed to be the long-term leasing, in majority with duration of more than 24 months; this is the most preferred solution, since in this way companies can have the possibility to constantly have updated and efficient vehicles and reduce managerial complexity for what regards insurance, maintenance and expenses related.

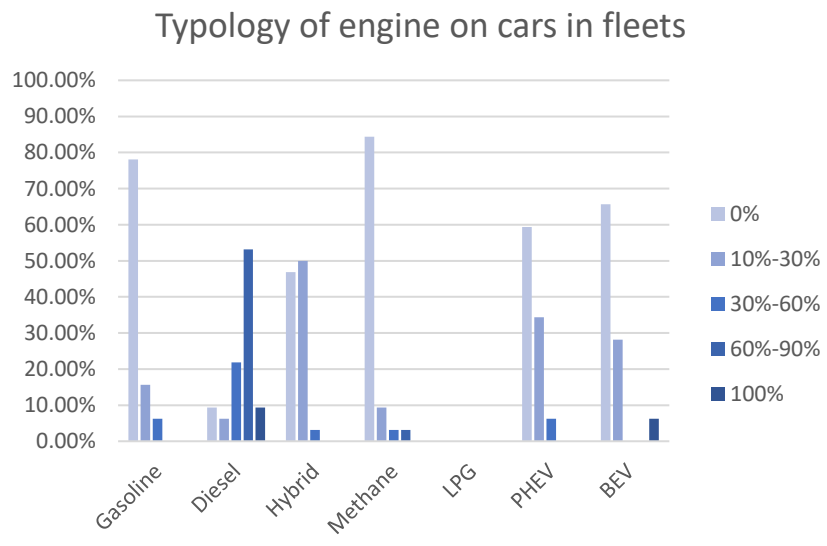



Figure 33: Typology of engine on cars in fleets

As visible in Figure 33, the most chosen vehicles are fitted with a Diesel engine, the perfect choice until now when high kilometrages are required. Indeed the higher cost in comparison to gasoline engines is largely offset by the higher efficiency and the lower cost of fuel, especially if automobiles are run for such high distances. This is the most present choice, with more than 50% of companies reporting that their fleet is

made between 60 and 90 percent by Diesel cars. Another successful choice is represented by PHEVs, which can introduce some benefits of electric mobility with the lack of stress of recharge; gasoline and GPL cars are less and less successful. BEVs are acquiring share in some companies, but they are still very little present.

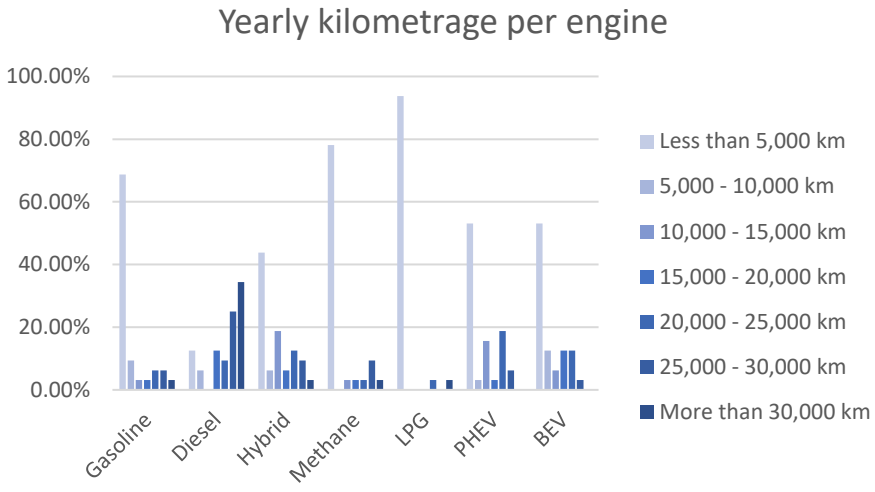



Figure 34: Yearly kilometrage per engine

For what regards the usage of such vehicles, Diesel engine cars are the choice when there is the necessity to cover long distances. Indeed, in an aggregate of 59.38% of cases, Diesel engines cover more than 25,000 km each year, leaving an enormous gap in comparison to others (Figure 34). They are followed by BEVs and PHEVs/hybrid cars, which are becoming more and more used for long journeys thanks to the lower costs of use in comparison to gasoline cars: while BEVs have only a battery – making this aspect of economy clear and immediate – PHEVs and hybrid one couple a gasoline engine with a small battery allowing to run for some kilometres in electric mode in electric mode. In addition, the battery allows more efficient operations of the engine, helping it in acceleration phases and thus reducing dramatically the consumption of fuel, making PHEVs and hybrid cars competitive with Diesel engines in terms of economy of use. Other kinds of engines (like LPG and methane) are not used so much, mainly because of the low amount of refuelling stations, while gasoline engines are mostly used if the vehicles have to cover short distances. The distribution of kilometrages retrace what is said in literature about the industrial sector: practitioners still see Diesel cars as the major choice in this field, but they are also aware of the fact that hybrid and battery vehicles are gaining momentum, in spite of pure gasoline engines, which are not efficient for a fleet usage.

In most cases the cars are given *ad personam*, in the sense that the vehicle is used by one single employee, and not shared among different workers; this latter solution is definitely less present, while other choices of attribution of vehicles are marginal.

Analysing the drivers for the choice of the vehicles, condensed in Figure 35, for fleets there are four main aspects which are given high weight by managers. The first one is

the total cost of ownership, which should be the lowest possible in order to save money for the company; it is followed by the consumption of fuel and electricity, aspects which are strongly linked to the previous one of cost of use. These aspects are in perfect concordance with the drivers present in contributions: the cost is not seen as the main issue, thanks to the possibility of different solutions to acquire the vehicles and to have tax deductions when purchased, while the operative costs are cited both in survey and contributions as important aspect to consider when opting for a vehicle.

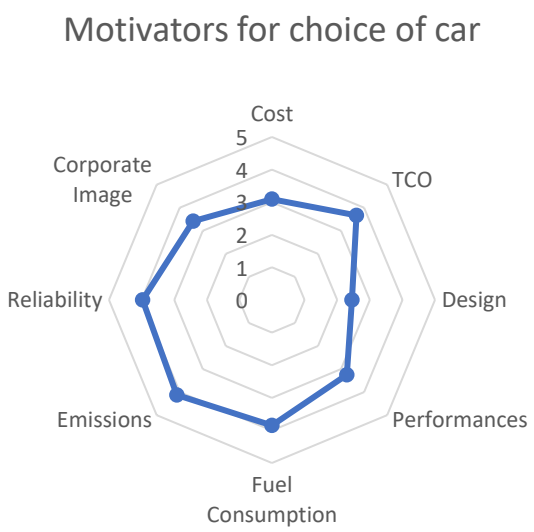



Figure 35: Motivators for choice of car

The third most important aspect is the level of emissions generated by the vehicles: since companies are getting more and more attentive towards environment, this has become a crucial aspect to keep in mind for managers when they choose cars, also to satisfy pollution norms which are getting more and more stringent in cities. Indeed, an aggregated 59.4% of managers give some level of importance (3 to 5 in Likert scale) to restrictions about traffic when it comes to a decision about vehicles to acquire. The last most important driver is reliability: since company vehicles need to cover high amounts of kilometres each year, they should be reliable, so this aspect becomes crucial for the choice of a vehicle according to managers. Other aspects like image and design are less important for the final choice.

In nearly all cases (96.9%) cars remain in service in the fleet for 2 to 5 years, while just in 3.1% of situations they are maintained for more than 8 years.

Analysing fleet management services, 40.6% outsources some of them to third party companies, while 53.1% maintain all the management activities inside the borders of the firm. The remaining 6.3% still does not do so but is thinking to refer to external entities to manage some tasks, but it is important to remark how the referral to third parties' services does not show a specific trend linked to the numerosity of the fleet. The "most outsourced" activities are ordinary and extraordinary maintenance of vehicles, along with the provision of replacement cars and change of tyres. Other successful services are the "managerial" ones, like the management of administrative practises (payment of taxes, insurance, management of accidents, …) and the provision and management of fuel cards for employees. Other services as management of fines and reselling of used cars are less successful and chosen.

The theme of sustainable mobility is indeed becoming more and more important for companies: 65.7% of them give a very high importance to the theme, a percentage which increases to 90.7% also considering those who give a medium importance to it. Just 6.3% is not interested at all.

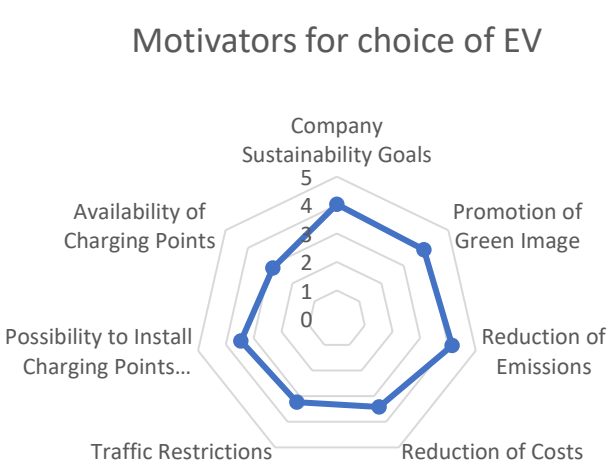



Figure 36: Motivators for choice of EV

When assessing the adoption of electric vehicles, the most considered aspects are the pursue of sustainability goals for the company, coupled with reduction of emissions and the improvement of the corporate image, as visible in Figure 36. These are the most important features which are under investigation in this phase, while issues related to charging infrastructure and norms and laws for vehicles are less considered in the decision process. Among other answers, also the provision of public incentives for the purchase of EVs can be seen as drivers to boost the change. These answers pose in accordance to the literature on the theme: practitioners report that the major motivators for the change towards EVs is represented by the pursue of sustainability goals by the company and by the promotion of a green image in consumers, to create a better perception of the company among public.

Analysing the barriers for the adoption of EVs in companies – Figure 37 – the most important one is represented by the low autonomy in comparison to necessities: in companies vehicles are used to cover many kilometres each day. The autonomy of EVs is

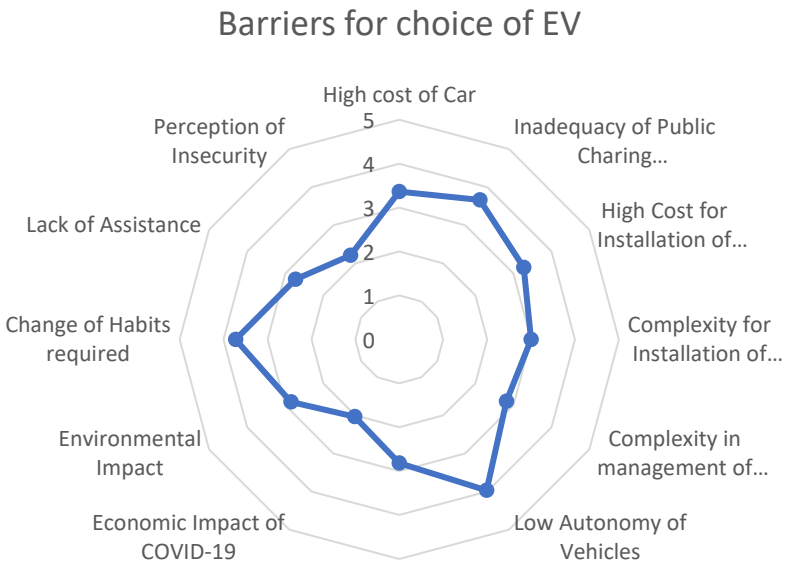



Figure 37: Barriers for choice of EVs

still under the thresholds desired by users to accomplish their goals without the necessity to stop and charge the car during the day, an action which would determine important losses of time. The second most cited barrier is related to the inadequacy of public charging infrastructure, an aspect which scares a lot in case there is the necessity of recharging cars during the day when used, so outside the boundaries of the company. This becomes an even higher hurdle for those employees who don't have the possibility to install a private charging point at home, forcing them to rely on the public network or the points at workplace. This aspect also relates to the fact that charging points are too fractioned and fragmented in the territory: better explaining, there are too many charging point operators with too few columns in each city, a problem which determines the complexity for users to find a point of a specific operator, making the operation of recharge complex and difficult. Barriers related to charging infrastructure and autonomy of vehicles are the major ones identified by literature, which can be also found in the answers by managers, who are in accordance with practitioners. A further barrier is the necessity to change habits: unlike ICE cars, which can be filled in few minutes, EVs take more time to be recharged, so users should be aware that they should put the vehicle in charge as soon as they don't need it in the immediacy in order to avoid lack of charge; in addition, this is related also to a different style of driving required to use EVs in the most efficient way, through *coasting* for example. These are all changes in the normal habits of usage which can scare managers in the wide adoption of EVs. The lack of models of interest for the necessities of the company is a possible issue to consider, but it is not a barrier as severe as the previously cited ones.

Cost and complexity for the installation of charging points in the company are not seen as huge barriers for the adoption of EVs, just like the economic impact of COVID-19: the pandemics is not seen as a possible barrier which can slow down the process, thanks to the fact that in many cases vehicles are not bought but rented or leased; for this reason also the high cost of vehicles is not perceived as an unbreakable barrier. As last remarks, the lack of assistance services and the perceived unsafety onboard are more a myth than a reality: they are not seen as disabler for the choice of an EV, since majority of companies give to these factors a low importance.

Analysing the charging infrastructure in Figure 38, there are strong investments by companies, with a preference of installation of more powerful chargers (above 7 kW) in a wide number (even more than 10 points in some industries), as visible. Anyway, there is still a lot to do, since most companies have no points installed and the ones which decided to install some points which own one or two points, in majority of cases at low power. To do so, only 21.9% exploited public incentives for purchase and installation of the charging point. For the purchase, 37.5% of companies referred to specialized technology providers, while 25% to the utility; the remaining 37.5% used other channels.

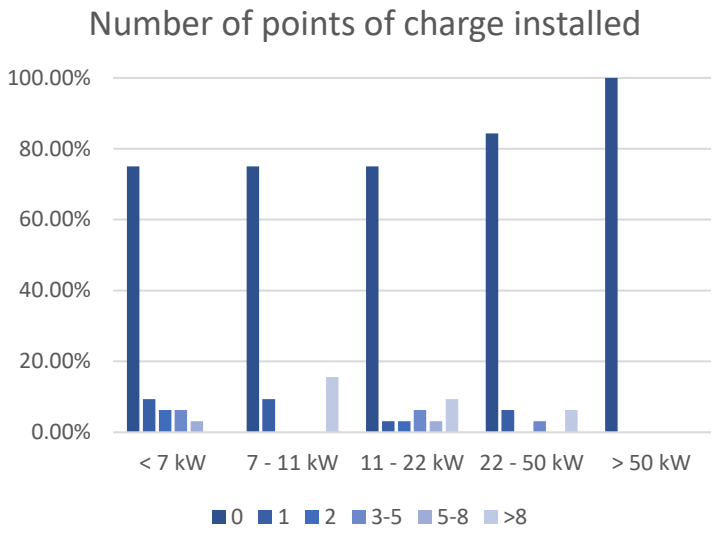



Figure 38: Number of points of charge installed

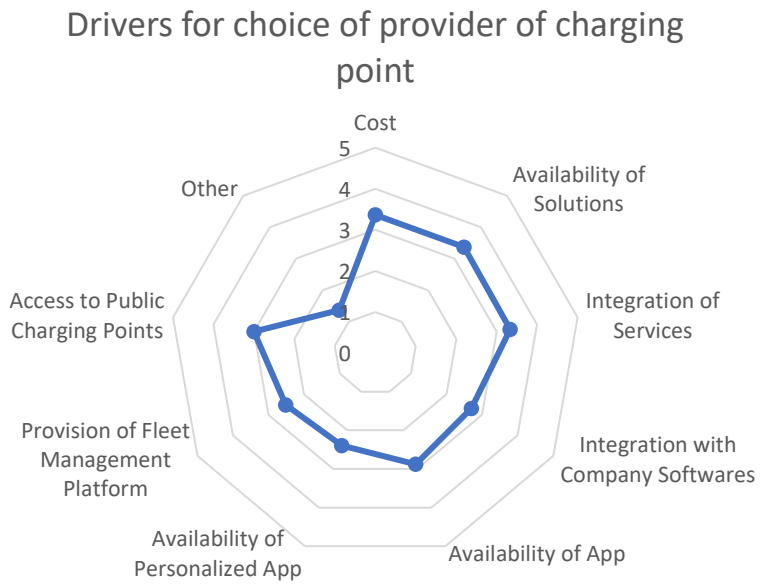



Figure 39: Drivers for choice of provider of charging point

For the choice of the provider (in Figure 39), the main driver resulted to be the possibility to have a comprehensive service comprised of installation and management, along with the cost of the point. Also, the interoperability and the possibility to have access to public points in an easy way are seen as important factors, just like the possibility to choose among many options for recharging. Other aspects as the provision of a management platform or app is not perceived as important as the previous factors. For the installation of the point there is almost equal division among four main actors: the most chosen is the electrician (28.1%), while the technology provider is at second place with 25% of

preferences; utility and other solutions split the third place at 21.9%, with car manufacturers which are very rarely chosen (only 3.1% of cases).

Regarding the usage of points, also in this case there is an even distribution: in 28.1% of companies vehicles are charged once per week, while in 37.5% they are charged 2-3 times. A stronger usage sees 9.4% of the situations in which vehicles are charged 4-5 times per week, while 25% of companies report a daily recharge of vehicles.

The last focus of the survey is about the degree of knowledge by managers and companies in reference to different themes about EVs. In general terms there is a high knowledge of nearly all themes about mobility and sustainable mobility (4 and 5 on Likert scale), with peaks registered for what regards taxes on vehicles and emission of the vehicles, along with incentives to buy EVs and charging points. Also exemptions and reduction in total TCO are topics which are well known by the interviewee, along with the growth of the available electric models proposed by car manufacturers. The only "critical" areas, where the knowledge is generally speaking lower, regards the development of charging infrastructure: both growth rates of the number points and knowledge about V1G/V2G projects and technology are aspects on which managers are less prepared, missing some important aspects which can boost even more the adoption of such vehicles. Those results are reported in Figure 40.

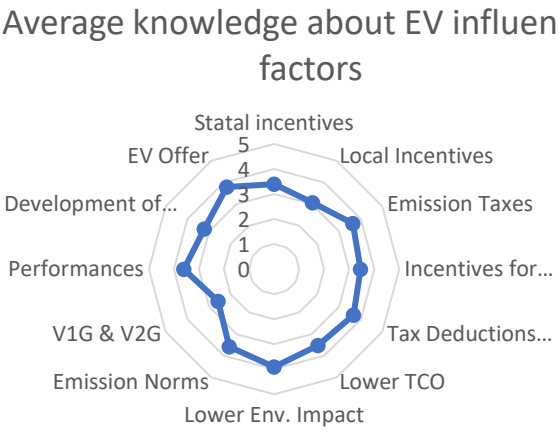



Figure 40: Average knowledge about EVs influencing factors

# 4. Chapter four: Discussion

Now the focus of the work shifts on the discussion of the results obtained from the surveys and from the data analysis, to check whether the findings gained are in accordance or not with the insights from literature.

## 4.1 Private car owners

Starting with private car owners, there is a general accordance between literature and "on field" analysis.

Indeed, the major barriers which scare non-owners and which prevent them from purchasing an EV are related to the economic aspects and to the conditions of the charging infrastructure. The high cost of the car is seen as the most important problem, along with the inadequacy of the public charging infrastructure, which is still perceived insufficient to keep up with the demand for recharge by actual and potential users. While the first barrier is in total accordance with literature, the second one emerges even more strongly in the survey than in literature: indeed, contributions analysed focus on developed countries which are characterised by a more developed network (e.g., U.S., U.K., Switzerland, …) or nations with nearly no charging stations, like emerging ones. Italy is in the middle between them: it is a developed country of course, but it still trudges in comparison to the countries which are pioneers for electric mobility. This allows the emergence of the poor conditions of charging network as an important barrier in the nation.

Along with these two barriers, the low autonomy is the third most perceived. This goes in total accordance with literature: also in researches analysed people are still sceptic about the real possibility of EVs to satisfy their necessities of mobility, since they perceive insufficient autonomy of vehicles.

Among the other barriers present, the environmental impact due to battery production and production of energy to feed EVs is only the fourth most cited. Unlike in literature, where this barrier is seen as one of the major ones, for Italian respondents it is definitely not on the same level of economic ones or the ones related to charging infrastructure. This can be both a sign of trust in battery producers and recyclers and in energy producers or a sing that the environmental concern goes in background.

For the cost and the complexity of installation of the private charging point there is accordance with literature: indeed they are not seen as the major barriers which influence the missed choice of EVs, but anyway they are still influencers on the final choice.

Unlike the environmental concerns, the lack of suitable EV models on the market increases its importance in comparison to literature: in contributions this was mainly

an issue related to companies, which could not find the right electric vehicles for their scope, with a lower importance for private users. Analysing the survey, instead, this problem gains more significance, posing an interesting implication for car makers, as they should increase the offer of EV models available on the market to satisfy all potential customers.

The last "medium perceived" barrier regards the lack of assistance perceived by drivers, which prevents them from buying an EV. This barrier is widely present in literature, both for developed countries and for developing ones, since electric mobility is seen as a new technology, thus with still few mechanics capable of working on these vehicles. Italy does not differentiate from what seen in literature, so the perception of insufficient assistance services becomes an important hurdle for the wide adoption of EVs.

Other barriers as unsafety perceived, change of habits required and economic impact due to COVID-19 are just marginal if compared to the previous ones. The same holds in literature, with these barriers which are not seen as determinants for the final choice of the car. Indeed users have trust in car makers for what regards the safety of the vehicles, and repute these car as safe as ICE ones, and in some cases even more than those, thanks to the very strict regulations in terms of protection of the battery pack, which should prevent in all cases the start of fires in case of heavy accidents on the road.

Moving the attention on drivers for the purchase of EVs, the most important ones are once again related to the economic sphere and to the environmental one. Indeed, the most important driver for the respondents is the lower TCO associated to the usage of electric vehicles, confirming totally what literature says. On the same perspective, the environmental benefits associated to the usage of electric vehicles majorly influences the choice, as said also by literature.

A surprising result is associated to the possibility to install a private charging point: in literature this driver is cited as important, but not as important as it is perceived by Italian respondents: for them this aspect is at the same level of lower TCO and environmental benefits associated to usage of EVs, so it differs in positive terms from the literature analysed. The same holds for the availability of infotainment accessories, with people who answered to the questionnaire pose this driver nearly at the same level of the previously cited ones; documents analysed perceive the importance of this aspect, but they do not attribute the same high importance as respondents do.

Moving on, availability of public charging points, the emergence of traffic restrictions for polluting cars and the maximization of usage of renewable plants are on the same level of perception for respondents. For the first two drivers we have an accordance with literature, since they are seen effectively as drivers, but with a lower importance than economic and environmental ones, while for the last one its importance is more perceived in the survey than in the documents read. Indeed, the possibility to couple renewables and EVs may differ a lot across countries, with more importance given in

nations with higher presence of RES plants, like Italy for example; in these nations the theme of utilization of renewables may be more effective to drive the choice of consumers in adopting an EV, to effectively create synergies between them and furtherly increase the environmental benefits deriving from electric cars.

As a last remark, the status symbol associated to EV ownership is definitely not perceived as a driver by Italian owners who answered the survey. This is in contrast with literature, where status symbol related to EVs was associated to a higher propensity in purchasing them, for what said about the linkages between emotions and the purchasing process of a car.

Moving the attention on socio-demographic mediators, men are effectively more prone towards the adoption of EVs since they are a new technology, as seen in literature. For what regards age groups, the most prone group is between 30 and 50 years old: this confirms what seen in literature, since this category is the one with more economical availabilities – in comparison to younger ones – and the one with more propensity for new technologies and environmental attitudes – in comparison to older ones, especially for what regards the comfort with new products. This confirms also the fact that, due to the high cost, the individuals who tend more to have an EV are the high earning ones: as seen in the chapter of results, the expense for an EV is in nearly 66% of cases above 25,000 €, a high disbursement that is impossible for lower classes of population and for the younger individuals, who are indeed the least represented among EV owners in the survey. This confirms the fact that low incomes are associated to a lower propensity in purchasing an EV, as literature and barriers analysed until now confirm.

Unlike what has been recognised in literature, the degree of education has nearly no effect on the uptake of EVs: no evidence exist between higher education and a better knowledge of incentives existing or a higher tendency in acquiring an electric car. On the contrary, as seen in the chapter for results, there is a decreasing trend between the adoption of BEVs and degree of education: EV owners with a middle school license are in nearly 95% of the cases BEV owners, with just 5% of PHEV owners. The percentage of BEV owner decreases linearly with the increase of the level of education, reaching 85% for PhD holders. This is in clear contrast with the literature, where high levels of education are associated to higher propensity towards ownership of BEVs.

Analysing the effect of socio-demographic mediators, there is a confirmation of the fact that men are more prone to purchase EVs than women. Despite the higher environmental sensitivity of females, men are more incline to adopt earlier and with more conviction new technologies, thanks to the higher interest they have in automotive and innovations, and the higher appreciation for the performances of electric cars. Results confirm literature also for what regards the age groups: the most incline to buy EVs are the individuals between 30 and 50 years old, with lower percentages associated to younger and older generations. Surprisingly, there is no correlation between the propensity in buying an EV and the level of education: no

differences have been highlighted about that shifting from middle school license to PhD holders, unlike what is said in literature, where higher levels of education are associated to higher environmental sensitivity, thus to higher tendency in choosing an electric car whenever possible.

An interesting aspect which has not been found in literature regards the knowledge of incentive schemes available to buy EVs. Indeed, the survey shows how the most informed users are the ones above 30 years old, who are aware of the subsidies put in place by the government. Younger people appear to be less informed, and also less convinced about their extent: indeed, they are the class of age which in largest part does not know how to evaluate their extent (if too low or too high or adequate), while over 30 respondents in majority consider them too low or at least adequate.
Analysing the answers of EV owners, instead, for what regards the effective usage, it emerges that incentives are utilized in majority by the youngest respondents; this evidence can be explained by the fact that they have the lowest economical availabilities in comparison to older classes, so they are more likely to fit the parameters to be granted the public incentives for the purchase of EVs (for example, parameters linked to the income).

Another literature aspect confirmed by the analysis is the fact that EVs are still "reserved" to older individuals. Indeed, due to the high cost, their purchase is precluded to younger people, who are characterized in average by lower wages and lower economical availabilities than older respondents. This issue determines, as seen in the contributions, that high earning and older individuals are the persons with the higher possibility of owning an electric car. Lower wages, and consequent low capital available, slow down the process of adoption of EVs.

A novel aspect, which has not been found in literature, is about the linkage between the type of vehicle owned and the level of education. In all cases the majority of interviewee owns a BEV, but it is interesting the fact that the percentage of BEV owners decreases as the level of education increases, with a switch towards PHEVs. Indeed, middle school license holders own a BEV in more than 94% of cases, while this percentage decreases to just 84% for PhD holders, with a linear decrease across the intermediate levels of education. It is interesting as well to see how women tend to own BEVs more than men, with 92% against 86%. No correlations can be obtained with the region of residence and the age.

Still relating to gender, men tend to cover more kilometres with BEVs during the year in comparison to women; this is an aspect not analysed by literature, but it remarks that men are characterized by higher utilization of cars.

Studying the possession of charging points, it emerges that owners of expensive cars tend more to have also a private charging point at home; this can be explained by the fact that they can have more space to install it, and more economical availability buy one since the cost of private chargers is seen as a significant barrier. A surprising result is related to the age of owners of private points: in percentages, the possession is more

diffused in younger drivers than in older, despite the higher economical availability of the latter. This is due to the possibility to exploit incentives to buy the charging point, and by a higher confidence with technology by young persons. Indeed, the complexity of usage of the point is often cited as a barrier for the usage and ownership of private charging points at home. To remark this fact, also the usage of public charging points is stronger for younger people: percentages of occasional usage of the infrastructure decrease from nearly 95% of the range 18-30 years old to the 80% for over 50 persons. This is due to the complexity of usage of the points, which scare older users, who are less keen on technology in comparison to younger generations. This can be a problem anyway, since it can push away the generations with higher capital available from buying an EV, slowing down the process of adoption. As a last remark about the topic of charging points, unanimous consensus is registered for what regards the importance of fast chargers: they are seen by EV owners as the real game changer for the diffusion of EVs: indeed, they can positively influence the decision of buying an electric car, since they can help overcome the range anxiety and the long charging time of vehicles, especially when users face long journeys. All responses attribute great importance to the development of their presence, especially on highways and suburban roads.

A final remark, not analysed by literature, is on the overall satisfaction of EV drivers for their experience with the vehicles: when asked if they would buy again an electric car, there is a plebiscite of positive answers (more than 90%). This demonstrates, as seen in literature, that an experience with EVs positively influences future purchasing decisions for vehicles, with high percentages of re-purchase.

## 4.2 Company fleets

For what regards company fleets, literature has not deepened a lot the theme of drivers and barriers regarding the adoption of EVs from firms; for this reason, the insights obtained from the survey are novel, and just in part cover those already present in contributions and documents.

Starting from the motivators for the choice of vehicles for fleets (including also ICE cars), the major motivators are those related to the performances of the car, along with the TCO. Indeed, in accordance with literature, the major influencers of choice are reliability, fuel consumption, emission levels and performances of the car: the major requirements from companies are the warranty of a heavy usage of the car without the fear of breakdowns and with the assurance of having reasonable consumption of fuel, to avoid high expenses for the company. Emission levels are important too, but mainly to have the possibility to circulate without fear of traffic blocks for polluting cars, and so to carry on the activities of the company without interruptions. Along with these themes there is the TCO associated to vehicles: this is another important motivator for companies, widely present in literature too, since firms of course want to minimize the expenses for operating vehicles, so when it is time to decide among different models they will choose the one with the lower projected TCO.

Unlike what said in literature, low value is given to price of the vehicles. This comes from the fact that, according to the wide majority of the sample interviewed, firms do not buy the vehicles, preferring other solutions as rental and leasing. This helps them to reduce the expenditure for acquiring the cars and to have the possibility to change vehicles after some years, in order to keep up with the technological developments on the field and have less polluting and more efficient automobiles. Another literature driver disavowed from the survey is related to corporate image: according to the answers collected, companies' main motivators for choosing a car are economy related and usage related. The image given to the public is not seen as a major driver of choice, as long as the design of the vehicle.

Shifting the attention on EVs, the situation slightly changes: as confirmed also by literature, firms choose electric cars mainly to reduce emissions and so to pursue the corporate objectives for what regards sustainability. In this case the economic drivers are less perceived, with the reduction of costs which is not the main motivator as literature confirms. High value is instead attributed to the green image the company gives to stakeholders: firms may decide to use electric cars to give a better image to customers and public, and improve the perception about it; this acquires a central role for EVs, since people is no more interested in the prestige of a powerful vehicles (as seen for generic car choice before), but is interested in the limitation of environmental damages associated to electric vehicles, BEVs and PHEVs. The choice of electric cars as "ambassadors" of the company can contribute to the perception of the company as a defender of the environment, giving the idea of being active upon environmental issues and pioneers for the adoption of novel technologies. Traffic restrictions are not

a central pillar for the uptake of EVs: since vehicles are acquired through solutions as leasing or rental – allowing a constant turnover of cars with more efficient and less polluting ones – companies are not so scared of possible restriction which can impede them their operations. To better explain this aspect, the survey reveals how vehicles remain in fleets in majority of the cases for maximum 8 years. This turnover of vehicles allows companies to have cars which are always at the best level of efficiency, and which respect the law and norms regarding emissions in cities and states, overcoming the possibility of traffic blocks for the most polluting vehicles.
This is in partial contrast with the literature, where the actions from local authorities aimed at limiting the usage of ICEs is perceived more as a driver of choice for BEVs and PHEVs. In discordance with literature there is also the fact that companies do not perceive as a crucial driver the abundance of public charging points: this driver is more perceived by private users, as seen in contributions, while companies are less incentivized, especially because they have a higher possibility of installing private points in their sites where they can easily recharge at lower cost the vehicles.

Moving on, the attention now shifts on the barriers for EV adoption by companies. The high cost of cars does not appear as important as for private users, mainly thanks to the fact that companies acquire vehicle through solutions which avoid undertaking the entire expense for them; this aspect was not so analysed in literature, so it is hard to say if it is in accordance or discordance.

Two aspects which are in total accordance with contributions are the low autonomy and the change of habits required for users. They are important barriers since commercial vehicles and cars in fleets must cover a lot of kilometres everyday, thus if they have a low autonomy they can not satisfy the necessities of the firm, as clearly stated in the literature analysed. In the same way there is the problem of change of habits required to employees in order to use the EVs in the best way, something which may be hard to introduce (especially if drivers have been driving ICE cars for many years) and to automatize, as explained in the review of documents. For example, EVs require to be charged overnight in order to have a vehicles which can be used the day after to accomplish the actions required by the company; if an employee does not plug the vehicle before leaving the sites the evening before, the day after the car can not be used, because it can not be recharged in few minutes as traditional ICE. It may require hours in case of absence of superchargers, which are still very low diffused in Italy.

Another important barrier for EVs adoption is instead the inadequacy of the public charging infrastructure: as well depicted by documents read, companies are still scared by the low number of points present on roads and public places. This may be an enormous problem since the low autonomy of cars, associated with the high daily kilometrages required by companies, may determine the impossibility to satisfy the necessities of firms. This barrier is widely present in the literature about company fleets, and it is confirmed by "on-field" research carried on in this work.

Other barriers are instead less perceived by companies. First of all, the environmental impact associated to EVs is not seen as an important barrier, since firms perceive that the benefits largely offset the associated problems related to battery and energy production. This is in concordance with the literature on the theme, as well as the perception of costs and complexity for the installation of charging points: they are not high barriers for the adoption of EVs by companies, since they have higher possibilities in terms of money and space to install private charging points in their sites. In the same category there is also the lack of models suitable for the necessities of companies: this is not perceived among the major barriers for adopting EVs in companies, while it was perceived as so in literature. Indeed, this was a crucial theme in the contributions analysed, especially for what regards commercial vehicles as vans and lorries: the necessity of having big battery packs to reach the autonomy desired would decrease significantly the space to load goods to be transported. In reality this issue is not so perceived by companies, thus there is discordance between the review made and the results of survey.

Finally, it is the turn of the least perceived barriers. The complexity of management of the charging points in the company sites is not an inhibitor for the adoption of EVs, thanks to the fact that this kind of activity can be also outsourced, as seen in the survey questions. Along with that, the lack of assistance services and the perception of unsafety are way less considered and do not obstacle the adoption of electric cars. While the unsafety perceived is not so considered in literature (as explained when studying private users), the lack of assistance is seen by authors as an important barrier for the adoption of electric cars. In this case this barrier is disavowed by the Italian managers consulted in the survey.

# 5. Chapter five: Implications

In this chapter the attention moves on the implications which derive from this study, namely the actions which should be put in action by managers and policy makers and the insights which help enrich the knowledge about the theme of drivers and barriers for the uptake of EVs. For this reason, the chapter will focus on the *theoretical implications*, the *managerial implications* and the *policy implications* which have been obtained.

## 5.1 Theoretical implications

Starting with the theoretical implications, this study is one of the first attempts to investigate a wide spectrum of drivers and barriers which characterize the purchasing and adoption process of EVs. In addition, this is one of the very first studies which cover the entire Italian nation, without focusing just on specific areas of the country.

Analysing the effective implications obtained from the work, the first one is about the purchasing process of the electric vehicles under analysis.

As depicted in the literature gaps, contributions analyse this topic mainly on an economical perspective, without focusing on aspects as the environmental concerns or the effective comfort of usage. These other aspects are important for the adoption of EVs, otherwise, analysing TCO, everybody should understand that they are more economic to use than ICE cars, so the most reasonable choice should be the shift towards electric. Indeed, the survey revealed how the environmental impact is seen as a partial inhibitor for the purchase of those models, mainly because of the perplexity regarding production and dismantle of batteries, which moves away potential buyers, especially the most sensitive about environment.

Along with the environmental aspect there are the issues regarding the network of charging points publicly accessible. This is widely seen as one of the major barriers for private users when they have to choose a new car, so they tend to remain with ICE cars instead of EVs because they fear they cannot find public charging points when they need; this, coupled with the lower autonomy of electric cars, increases the range anxiety by users. This problem is more evident in Italy, where the network of public points for recharge is still way less developed than the pioneers country of electric mobility, as Norway or Netherlands, remarking the big importance of this barrier.

The study brings out the fact that the lack of appealing models for the public is a widely perceived barrier from the public. Indeed, users strive to find the electric cars they desire, mainly due to lack of enough models or because the electric version of a model they like is not yet available on the market. Since, as seen, the purchase of a car

is based also on emotions and personal feelings, this issue still prevents many potential buyers in purchasing an EV, so this aspect should be more considered as a negative influencer.

This reflection reaffirms strongly how the decision to buy an electric vehicle is not only influenced by economic factors – for example a lower TCO – but also by many other factors as the environmental one, the comfort of usage and the emotional ones, as the perception about a certain model or the like and dislike about a specific car. This means that to analyse the purchasing process by final users all these factors should be considered as concurrent all together, and not separate one from the other.

An important theoretical implication which confirms what said by literature is related to the socio-demographic factors, who revealed to be very important to understand the propensity towards EVs by people. Indeed, the survey showed how the propensity to but an EV, the knowledge of incentives, the usage of the public charging infrastructure and other facets of the theme are dependent on factors as gender, education, age and region of residence, because of different inclinations of individual towards new technologies and because of different penetration of EVs in the market in different areas of the country. These differences can determine also different motivations to choose an electric vehicle, for example for prestige or for environmental reasons. This confirms the role of socio-demographic mediators in the purchasing process of a vehicle, posing in accordance with the literature on the theme.
These aspects should be more investigated in order to understand where to act and how to increase the probability of choosing an EV for an individual, for example targeting a certain age group with informative action to increase the awareness about incentives. Still related to this, it was interesting to assess differences in usage and behaviour of vehicles on the basis of the type of car acquired, from the cheapest ones to the premium ones; these differences determine different kilometrages during the year, thus different uses and different necessities, which can determine different drives and barriers regarding the utilization of EVs. This aspect, rarely present in literature, can help policy makers and car makers in adjusting their actions assessing the necessities and usage of vehicles by the public.

Another important aspect brought out by this thesis is the fact that with this survey we asked impressions both to EV users and non-users. With this double perspective it is possible to better understand the motivations which scare potential customers from buying EVs (and obtain insights on how to act on them), but at the same time it allows to identify which are the motivators which had the major effect in influencing people in choosing an EV, in order to exploit them also on other people to increase sales. For EV owners, we have the confirmation that the major drivers are the economic and environmental ones, while for non-owners we see that the major barriers are related to the initial cost of the car and the perceived environmental impact. This result confirms what has been analysed in literature, reaffirming the necessity of considering both points of view when assessing the theme of electric cars.

In addition to that, the theoretical and subsequent implications obtained from the study can be extended to the entire territory of Italy. Indeed, the study has been carried out proposing the surveys to interviewee (final users and companies) from all Italy, form the North to the South. In this way all the insights obtained and all the results are comprehensive of all the differences existing among the different regions, not focusing on just one of them as some studies did. This increased the theoretical knowledge regarding Italy thanks to the generality of the results, which are nationwide and not region-specific, allowing the draft of managerial and policy implications valid for the entire territory.

Relating to this, it is very important the fact that, asking to EV users, nobody declares they would go back to ICE cars, a sign that after a real experience with the car users are more than impressed by this technology, paving the way for the future of automotive.

A further implication of this study is the fact that it was possible to enlarge the theoretical basis on EV theme for what regards companies and their fleets. Indeed, in literature this theme was only marginally analysed, with very few documents world-wide and only one regarding Italy in detail. With this investigation it was possible to understand that the major motivators for the EV adoption by companies are related to sustainability and abatement of operative costs for vehicles, along with the promotion of a green image of the firm itself. On the contrary, the major criticalities are related to the low autonomy of cars and the difficulties of the development of the public charging infrastructure, aspects which still limit the diffusion of electric cars in corporate fleets and their usage in intensive activities which imply high daily kilometrages.

## 5.2 Managerial implications

Now the attention moves on the managerial implications, so the possible actions which can be put in place by companies to favour a wider adoption of EVs globally, both at the dimension of private users and for firms.

From both the surveys proposed, it appears clear that car makers should work heavily to improve the performances of their vehicles. On one side, performances as acceleration, top speed and comfort of driving are already well perceived, but they still should do a lot for what regards the autonomy of the vehicles. Citizens and companies perceive the autonomy of current vehicles as insufficient, so car companies should develop new solutions to enlarge it, with the improvement of autonomy which can be fundamental to enlarge the diffusion of EVs. This should be done of course starting from vehicles which are subject to very intensive usage (like commercial vehicles or executive cars), but it should be also done for smaller cars. Indeed, even if they are mainly used for short commutes every day, they can also be utilized for occasional long journeys, where the range issues may emerge more evidently than for bigger

vehicles. This translates in the necessity for car makers to develop all car segments at the same time, trying to avoid neglecting some of them.

Car makers should also develop new procedures on large scale to reduce the impact linked to battery production and dismantle of batteries: in this sense some producers (like Daimler and Volkswagen) are already working to increase the percentage of recycled material from dismantled batteries which can be re-used to produce new cells for new cars. This allows a lower mismanagement of batteries, which can cause environmental disasters because of the elements present in them. Along with that, also a reduction of the extraction of raw materials can be achieved, with lower pollution and energy usage, along with less exploitation of work in the production countries. Indeed a lower environmental impact associated to vehicle production can convince the individual who are more critical about the sustainability of the processes to realize batteries and to assemble cars. The recycling processes may also lower the total costs related to the production of batteries, allowing a reduction of cost of the entire vehicle, an aspect which can boost the sales of EVs, since purchasing price is seen as an important barrier, especially by private users.

Still regarding car makers, there is the important issue about the lack of models available on the market. Indeed, there are still few models of electric cars available on the market and, especially in the past years, they were characterized by designs which optimized aerodynamics but did not match the tastes of public. In last years there has been an important development, with a gradual increase of the development of "born electric models" (models which are designed from the beginning to be electric) with more appealing shape. At the same time models already existing with ICE engines started being proposed with hybrid or full electric powertrains, trying to exploit models already welcomed by the public. Anyway, there is still lot to do about this theme: private users and companies still strive in some cases to find the right EV which can satisfy their needs of autonomy and space. This problem is more evident for companies, since they require vehicles which need to cover many kilometres each day and which may require to transport important loads (for example in vans), and in this sector the offer is still missing models which can satisfy the needs of firms. For this reason, coupled with the one explained for private users, car makers should enlarge the offer of EVs in their listings, focusing both on cars and commercial vehicles, developing automobiles and vans with enough autonomy for the needs they have to satisfy and with enough space and practice to accomplish the work required. While developing those new models, car makers must work on the improvement of performances such as autonomy, to favour the diffusion of EVs even more.

Aside from car makers, also the manufacturers of charging points should act in different ways. First of all, one of the major barriers perceived is related to the complexity of installation and management of the charging point in private areas (e.g., private boxes or company sites). For this reason, technology providers should try to work on their products, making them easier to install and to manage, in order to

encourage their adoption, and consequently favour the spread of EVs. Indeed, the possibility to have a private charging point is seen as a major driver for EV adoption, so it is clever to keep working on these devices and improve the overall experience for the user. Still following this path, they should also try to reduce the cost of the charging points, since it is perceived by private users as a consistent burden for them in adopting an EV.

Considering the drivers for the adoption of EVs, we can deduce that clean energy should be used in order to power the vehicles. This aspect may be hard to pursue since it would require the collaboration of energy companies, but surely, as confirmed by the survey, it would enlarge the environmental benefits associated to EVs, increasing the possibility of adoption. This would be true for private users who are attentive to environment, but it is even more important for companies, since it would help them in reaching their sustainability goals and make their image even more green.

Another important implication for car makers is that they should invest also in the formation of their dealers, increasing their knowledge about EVs and helping them in understanding and communicate in the best way to potential buyers the advantages and the possibilities related to the choice of an EV. Indeed, knowledge has been cited as a pillar for the diffusion of EVs, since only if users fully understand the characteristics and the benefits of owning an electric car instead of an ICE one they may decide to buy an electric car. In addition, literature highlighted how in some cases dealers tend to avoid offering to public electric vehicles, in some situations because of personal advantages (as seen), while in others since they are not fully prepared to explain to the customer all the characteristics and benefits related to them. A better formation of car dealers may result in a higher propension by users to choose EVs instead of traditional cars.

As a last remark, still for car makers, car dealers should offer as much as possible test drives to potential customers, with the aim of smoothing their doubts and reluctances about EVs. Indeed, literature and the survey confirm how a previous experience with electric cars can positively influence the potential customer in effectively buying one. For this reason, dealers should offer, if the customer desires, a test drive of the EV, to get him/her acquainted with the vehicle and allow customers to understand the potentialities and performances of the vehicle. In this way the potential customer has a clear view and a real test of how it feels to drive an electric car, obtaining a direct experience, increasing the probability of purchase of the vehicle.

## 5.3 Policy implications

Last but not least, it is important to analyse the policy implications, so those which are related to policy makers and the actions they can put in place to speed up and facilitate the spread of EVs.

First of all, the surveys and the literature showed how the role of the public charging infrastructure is essential to favour the diffusion of EVs, since the number of points and their capillarity on the territory are perceived as crucial both by private users and by companies. The major issues related to range anxiety are indeed related to the low autonomy of cars, coupled with the insufficiency of charging points on public roads. For this reason, an important lesson for central and local governments is that they should favour and encourage the installation of these points, reducing the costs for MSPs for the installation and promoting joint efforts and investments to increase even more the presence of points. In addition to that, particular attention should be focused on fast chargers, which are seen as game changers to encourage the usage of EVs, especially for long routes. Indeed, in cities it is possible to rely just on "normal" chargers, since it is possible to dedicate to other activities while the car is in charge (e.g., shopping, work, leisure, …); along extra-urban roads and on highways this is not possible, so the recharge should be as fast as possible in order to lose minimal amounts of time at the charging point and be able to resume the journey. This implies the installation of fast chargers or superchargers, which should be supported by public administrations with joint investments or with reduction of expense for charging point operators. These joint actions can increase the availability of public charging points, thus increasing the possibility of usage by EV drivers; this can translate in a lower range anxiety by potential buyers, who may decide to choose an EV instead of an ICE car.

Another policy implication to enlarge the adoption of EVs is related to incentives at purchase. It may seem a simplistic proposal, but public administrations should increase the amount of incentives available for the purchase of PHEVs and BEVs, since the most important barrier for the purchase, especially for private users, is the high price of vehicles which make impossible the acquisition for many interested and potential buyers. Of course, it may be difficult for governments to find the funds to put in place, but the economic incentive resulted to be the most important and most appreciated tool to boost the sale of EVs, both for private users and companies.

On the same wavelength, governments should provide more funds to incentivize the installation of private charging points for those private users and companies who have the possibility – in terms of space – to do so. The support may include tax deductions, as already is being done, to reduce the expense for the citizen or the firms deciding to undertake this investment. Indeed, the high cost of the charging point is seen as an important barrier for both private users and companies, an economic issue which moves away them from purchasing an EV. In addition, the support for the installation of charging points can have more than one effect: first of all, it may encourage the adoption of electric vehicles, but it can also reduce the congestion of public charging points, reducing the number of points required to be installed and thus reducing the expense to support that installation. Indeed, if all the drivers and the companies which have the possibility to install a private point do so, they have less necessity to rely on public charging infrastructure; this reduces the risk for users who cannot install a point

at home to find public points occupied. This can reduce the necessity, in the short term, to install public charging stations since there would be less peaks of demand for recharge. Of course, this can be just a temporary solution, since it will be necessary to install many and many public charging points, but it can help governments to increase the time horizon to do so while at the same time increasing the diffusion of EVs, diluting the investment on more years.

Another action which can be put in place by administration regards the information and formation of users regarding EVs. Indeed, literature shows how the knowledge about the theme of EVs can positively influence users in purchasing one. This is valid for all the dimensions of knowledge related to EVs, starting from the economic one (e.g., lower TCO) and arriving to the environmental one (e.g., lower or even zero emissions while driving). The survey revealed a general good level of knowledge for all the aspects analysed, but governments should try to better inform citizens, with seminaries or digital tools where they can find all the information they desire regarding the theme of EVs. To make an example, a portal unifying all the useful information about the theme can help citizens and companies to learn more about electric vehicles in an easy way, without the necessity of consulting plenty of different websites or offices. This can be done by direct action of the government with the collaboration of the national automobile club (ACI in Italy).

# 6. Chapter six: Limitations and Avenue for Future Research

This study encountered some limitations which can be deepened and further analysed in the future.

The survey proposed allowed us to investigate drivers and barriers for EVs diffusion in the entire Italian territory – both for private users and companies – solving one of the major literature gaps highlighted. Anyway, not all of the gaps have been solved, and in addition some future fixings to the surveys can be made to improve the level of detail.

First of all, the literature gap regarding emotions and feelings linked to the purchase of the vehicles has been analysed in small part, with just few hints in the survey. Literature expresses clearly how emotional and irrational factors can influence the choice of a model instead of another, so more space should be given to this aspect. This can be done inserting extra questions to understand which can be the major factors, apart from the technical ones, which can determine the decision of the final customer for the purchase. A better knowledge about this can help car makers in better addressing the final customer, for example improving the design of the vehicle or acting on the promotion of the vehicles to the public, creating interesting managerial implications for the future.

Another future assessment which can be done to improve the study is, if possible, the analysis of the income of respondents to better link the answers with the socio-demographic mediators introduced in this thesis. Age, level of education, region of residence and gender have been largely investigated to highlight trends about the adoption of EVs and the influencing action of those socio-demographic moderators. Still lower importance has been given to the income: this is due to the fact that it is a very personal information to ask, so interviewee may decline the participation to the survey if asked this question. Income has been "deduced" by asking the cost of the car the answerers bought, but it would be more significative and precise to ask directly the salary the receive to make a better portrait about the influence of income on the adoption of EVs.

A further path which can be followed for future research is linked to novel technologies as V1G and V2G. They can help the stabilization of the electric grid during the recharge phase of vehicles and at the same time, in case of V2G, determine a source of remuneration for the EV owner. Consequently there are economic and technological drivers which can push users in adopt an electric car. Anyway these factors have not been analysed in detail in the survey, nor in the literature review, so

it can be interesting for future research an analysis of the influence that they can exert on potential buyers.

A limitation for this study regards the fact that it is country specific and related to Italy and its context. The study analyses in detail the situation of private users and companies located in Italy, with the specific drivers and barriers which are characterized by the current development of EV market and infrastructure in the nation. For this reason, the study can only be used as a starting point, and not as an exhaustive analysis, to study other countries, in Europe or other areas of the world. This because the development of the EV market and related infrastructure is largely country specific, with different levels of progress which can definitely be different from countries where EVs are largely diffused (e.g., Netherlands) and others where they are way less common (e.g., Spain). To analyse those contexts, it is necessary to develop country specific analyses and surveys to assess the real situation in the territory studied, with this work which can be a good starting point to initialise the investigation.
In addition to this, in other countries drivers and barriers may differ also because of country specific economic parameters. To make an example, between different countries there can be different cost for energy sources to feed the vehicles: to make an example, in countries where the cost of gasoline is very low (e.g., Venezuela) the TCO of electric cars will inevitably be higher than for ICE vehicles. This example helps to understand that a survey must be built considering country specific factors which can differentiate drivers and barriers from a nation to the other.

Another limitation of this work regards the sample size, especially for the survey directed to companies. Indeed, the reaching of a high number of respondents for private users was quite easy, thanks to the fact that there were broad channels we could use to send the questionnaire and reach a high number of answers.
For companies, instead, it was more difficult. First of all, it was necessary to find the companies and contact them, an activity which required more time and which resulted less successful than for private users. As a second issue, some companies refused to participate to the survey, fearing the loss of reserved information. For this reason, the sample of companies resulted to be quite low. This allowed the extraction of interesting insights but with a lack of generality, which can be reached only with large samples. A future development of this work may be the submission of the survey to more companies, to obtain more answers and so to obtain more accurate knowledge about the theme regarding firms.

For what regards the future research based on this study, a first suggestion can be to repeat the survey-based analysis in future years (in 5 years for example). This can be a useful approach to analyse and check if something has changed in this world in this amount of time and check what and how has changed, for example if some barriers declined or if there are new ones emerging, or if some drivers have lost their "power"

on influencing the choices of potential buyers. Relating to this, the repetition of the study in the future can also be useful to understand if the actions put in place by car makers or by administrations had an effect on the adoption of EVs by private users and companies. Indeed, the measures needed to increase the adoption of electric cars require a certain amount of time to be effectively in actions, thus the repetition of the study in a time frame larger than 1 or 2 years can encompass the effect of the measures undertaken by the actors in the market.

The repetition of the test can also be useful to understand the evolution of the perception of EVs by the public. Literature, indeed, reports how the perception towards BEVs and PHEVs change rapidly in the public: as the diffusion of such vehicles increase, the number of persons who can have a direct experience with them increases. This can determine a change of opinion of the individual about those vehicles, a change determined by the better knowledge and experience gained during the years. For this reason, it is recommendable to repeat the study across years, also to keep track of the evolution of the perception of public c and companies about EVs.

# 7. Chapter seven: Conclusions

EVs are getting more and more importance to accomplish the sustainability goals fixed by international boards and committees to reduce emissions of the transportation sector and reduce the effect of global warming, or at least mitigate it. Indeed, traditional ICE vehicles are responsible of emissions of greenhouse gases and pollutants which impact on the general increase of temperatures of the globe and which put in danger the health of people and wildlife.

Electric vehicles can be a solution to reduce these problems, thanks to the fact that they generate no emissions when running (as BEVs), or at least generate lower levels of emissions compared to traditional vehicles (as PHEVs).

Anyway, despite the benefits they can determine, their diffusion is still low, due to significant barriers which obstacle their adoption. Analysing literature and proposing surveys to private users and to companies, we could analyse the different barriers cited before, along with the drivers which can motivate the purchase of these vehicles.

The most common barrier for private users is the high cost of the vehicles, which is not sufficiently offset by the public incentives put in action by governments, along with the high cost for the private charging points to be installed at home. In addition, also the limited diffusion of public charging points is a barrier which scares privet users, further limiting the purchase of EVs.
On the opposite, potential buyers can be attracted by the lower total cost of ownership associated to EVs, and which is determined by lower costs for electricity against fossil fuels and lower expenses for insurance, toll roads, parking spots and other voices of cost faced during the life of the vehicle. Along with that, another driver for private users is associated to the environmental benefits coming from the usage of EVs, which is certainly seen as an important factor which boosts the adoption of electric cars instead of internal combustion engine vehicles.

For what regards companies, also in this case the adoption of EVs in fleets is lagging, with majority of firms still preferring Diesel or gasoline engines for their cars. In this case drivers and barriers for the adoption of EVs differ in comparison to private users, thanks to distinct necessities characterising companies.
Indeed, the major barrier for the uptake of EVs by companies is represented not by the cost of the vehicle, but by the low autonomy of cars which, coupled with the low presence of charging points on public roads, becomes a significant problem for companies, which need to cover significant amount of kilometres each day. The cost does not appear as a barrier as in the case of private users since firms tend to acquire the vehicles through long term rental or leasing, without buying the vehicle. For private users, instead, the purchase of the car is the most diffused solution.
For what regards drivers, the most important one is the reduced TCO associated to electric vehicles, which can be obtained by lower costs for electricity than for fuel and

by lower costs for insurance and usage on toll roads and parking areas. Along with it, the environmental sphere has a great importance: the sustainability goals of the company and the image the company wants to transmit are important motivators which push the adoption of EVs by firms.

Anyway, the current drivers are not enough to push a wide adoption of electric cars by private users and companies, so it is important to put in action active measures to pursue that goal. The required measures are directed towards 2 main stakeholders, namely car makers and public government. These actions should be directed at producing vehicles with better performances and lower costs, acting also to reduce the environmental impact associated to the production of batteries; in addition, car makers should simplify the meeting between potential buyers and EVs by explaining the benefits of adopting them and facilitate the possibility of test them before buying them. At the same time the government should invest in improving the electric grid and improve the diffusion of charging points publicly available on roads, with a particular attention for supercharger, especially on highways and suburban roads, to facilitate the usage of EVs for long journeys. Along with that, the administration should enlarge the amount of incentives available, both for the purchase of vehicles and to install private charging points, since for private users the economic incentive revealed to be a strong driver to push the EV adoption.

Of course, this work does not expect to cover all the possible factors of the phenomenon and to respond to all the literature gaps addressed from literature. Indeed, improvements for the survey can be applied, as well as suggestions to check if the scenario changes along years and to evaluate the effect of actions by car makers and the government. In addition, some specific limitations for the study are present, and future research can be based on them to improve the knowledge about the theme.

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# A. Appendix

In the appendix we record the total list of answers by private users and company fleet managers. In detail, there are reported the average values of responses from Likert scales questions (from 1 to 5), along with the variance and the standard deviation associated to them. There are reported also the responses regarding the expense to buy the vehicle and the average public incentive received for the purchase.

| RESPONSES FROM PRIVATE USERS | | | | |
|---|---|---|---|---|
| | | AVERAGE | VARIANCE | STANDARD DEVIATION |
| **Perception of barriers for EV purchase** | High cost of car | 3.9690 | 1.4215 | 1.1923 |
| | Inadequate Charging Infrastructure | 3.9109 | 1.4688 | 1.2119 |
| | High cost of private point | 3.1008 | 1.7379 | 1.3183 |
| | Complex installation of private point | 2.8178 | 1.8932 | 1.3759 |
| | Low autonomy | 3.5465 | 1.6006 | 1.2651 |
| | Lack of models available | 2.9981 | 1.7694 | 1.3302 |
| | COVID impact | 2.1047 | 1.4387 | 1.1994 |
| | Environmental Impact | 2.8585 | 1.9160 | 1.3842 |
| | Change of habits required | 2.4031 | 1.7212 | 1.3120 |
| | Lack of assistance | 2.6512 | 1.7000 | 1.3038 |
| | Unsafety perceived | 1.9128 | 1.4594 | 1.2081 |
| **Perception of drivers for EV purchase** | Lower TCO | 4.1054 | 0.9808 | 0.9903 |
| | Status symbol | 2.1432 | 1.5281 | 1.2362 |
| | Positive env. Impact | 4.3162 | 0.9135 | 0.9558 |

| | | | | |
|---|---|---|---|---|
| | Maximization of usage of renewables | 3.5135 | 2.0282 | 1.4241 |
| | Traffic restrictions | 3.4486 | 1.5555 | 1.2472 |
| | Availability of pub. Charging points | 3.1189 | 1.8021 | 1.3424 |
| | Availability of infotainment accessories | 3.5459 | 1.5668 | 1.2517 |
| | Possibility to install private charging point | 4.1108 | 1.3093 | 1.1443 |
| **Driver for choice of charging point** | Easiness of use | 4.4275 | 1.1302 | 1.0631 |
| | Design | 1.8015 | 1.1591 | 1.0766 |
| | Cost | 3.7939 | 1.5911 | 1.2614 |
| | Peer influence | 2.2176 | 1.7122 | 1.3085 |
| | Speed | 3.0992 | 1.7459 | 1.3213 |
| | Smart charging | 3.2176 | 2.1931 | 1.4809 |
| | App functionalities | 3.4886 | 2.1964 | 1.4820 |
| **Economic parameters** | Average cost of car | 31,469.7 € | | |
| | Average incentive received | 8,507.61 € | | |
| | Effect of presence of incentives on purchase | 4.2416 | 1.1228 | 1.0596 |
| **Motivations for Missing Usage of Public Infrastructure** | Low number of points | 2.8197 | 2.6724 | 1.6347 |
| | High Cost of Charge | 3.3115 | 2.4112 | 1.5528 |
| | Long Charging Times | 2.8525 | 2.4536 | 1.5664 |
| | Broken/Unavailable Point | 2.6066 | 2.7304 | 1.6524 |
| | Complexity of Usage | 2.2459 | 1.8576 | 1.3629 |
| | Importance of presence of points of charge in POIs | 3.9320 | 1.3190 | 1.1485 |
| | Price | 4.3754 | 0.8429 | 0.9181 |

| | | | | |
|---|---|---|---|---|
| **Drivers for Choice of MSP** | Capillarity | 4.2783 | 0.9581 | 0.9788 |
| | Closeness | 3.5243 | 1.9840 | 1.4086 |
| | Apps | 3.6764 | 1.5393 | 1.2407 |
| | Possibility to Book Point | 3.4595 | 1.6529 | 1.2856 |
| | Presence of Services | 3.1715 | 1.6631 | 1.2896 |
| | Interoperability of points | 4.1553 | 1.4128 | 1.1886 |
| **Success factors for EMP** | Price | 4.3948 | 0.8344 | 0.9135 |
| | Reliability | 4.5081 | 0.6253 | 0.7908 |
| | Capillarity | 4.2945 | 0.7838 | 0.8853 |
| | Type of Charge | 4.0744 | 1.2081 | 1.0991 |
| | App | 3.9191 | 1.2135 | 1.1016 |
| | Possibility to Book Point | 3.4725 | 1.6020 | 1.2657 |
| | Complimentary Services | 2.6893 | 1.7093 | 1.3074 |
| | Proposed Tariff | 4.2168 | 1.0048 | 1.0024 |
| | Number of EMP used | 2.8905 | 1.2654 | 1.1249 |
| **Importance of presence of charging points** | Urban Roads | 3.6892 | 1.4629 | 1.2095 |
| | Extra urban roads | 3.9676 | 1.1341 | 1.0649 |
| | Highways | 4.6838 | 0.5676 | 0.7534 |
| | Point of Interest (Malls, …) | 4.3189 | 0.8983 | 0.9478 |
| | Parkings | 4.3514 | 0.8063 | 0.8979 |
| | Places of Interest (stations, …) | 3.8892 | 1.5147 | 1.2308 |
| **Importance of charging point characteristics** | Reliability | 4.6568 | 0.4038 | 0.6355 |
| | Speed of Charge | 4.2514 | 0.7125 | 0.8441 |
| | Price of Charge | 4.4486 | 0.6744 | 0.8212 |
| | Easy of Use | 4.1757 | 0.8691 | 0.9323 |
| | Usability in App | 3.9541 | 1.1952 | 1.0932 |
| | Importance of fast charging | 4.2676 | 0.9311 | 0.9649 |
| | Highways | 4.7811 | 0.3818 | 0.6179 |
| | Extraurban roads | 4.1081 | 0.9234 | 0.9610 |

| | | | | |
|---|---|---|---|---|
| **Importance of Presence of Fast Chargers** | Urban Roads | 2.8757 | 1.4008 | 1.1835 |
| | Parkings | 2.9541 | 1.7141 | 1.3092 |
| | Point of Interest (Malls, …) | 3.0730 | 1.6622 | 1.2893 |
| | Places of Interest (stations, …) | 2.9162 | 1.9308 | 1.3895 |
| | Importance of fast chargers (>100 kW) to increase the uptake of long journeys with the EV (> 200 km) | 4.1973 | 1.4503 | 1.2043 |
| **Knowledge about EV Influencing Factors** | Statal incentives | 4.3564 | 0.7719 | 0.8786 |
| | Local Incentives | 4.1170 | 1.0821 | 1.0402 |
| | Emission Taxes | 4.1436 | 0.9209 | 0.9596 |
| | Incentives for Charging point | 4.0904 | 0.9971 | 0.9986 |
| | Tax Deductions on EVs | 4.2181 | 0.8301 | 0.9111 |
| | Lower TCO | 4.3936 | 0.7068 | 0.8407 |
| | Lower Env. Impact | 4.4947 | 0.5372 | 0.7329 |
| | Emission Norms | 4.0745 | 0.9200 | 0.9592 |
| | V1G & V2G | 3.1543 | 1.2049 | 1.0977 |
| | Performances | 4.3351 | 0.7441 | 0.8626 |
| | Development of Charging Infrastructure | 3.7447 | 0.9986 | 0.9993 |
| | EV Offer | 4.1862 | 0.6834 | 0.8267 |

Table 10: Responses from Private Users

| RESPONSES FROM COMPANIES | | | | |
|---|---|---|---|---|
| | | AVERAGE | VARIANCE | STANDARD DEVIATION |
| | Employees | 12,776.97 | | |
| | Number of locations | 18.52 | | |
| **Typology of Acquisition** | Purchased | 7.58% | 3.64% | 19.07% |
| | Mid-term rent (<24 months) | 4.55% | 3.04% | 17.42% |
| | Long term rent (> 24 months) | 65.15% | 17.04% | 41.28% |
| | Leasing | 14.24% | 10.12% | 31.82% |
| | Other | 0.61% | 0.06% | 2.39% |
| **Typology of Engine** | Gasoline | 4.24% | 1.21% | 11.02% |
| | Diesel | 63.94% | 9.81% | 31.33% |
| | Hybrid | 7.27% | 0.99% | 9.93% |
| | Methane | 4.55% | 2.31% | 15.19% |
| | LPG | 0.00% | 0.00% | 0.00% |
| | PHEV | 7.88% | 1.56% | 12.49% |
| | BEV | 9.09% | 5.60% | 23.66% |
| **Typology of Usage** | Sharing | 20.00% | 6.48% | 25.47% |
| | Ad Personam | 72.73% | 9.35% | 30.58% |
| | Other | 6.06% | 3.33% | 18.25% |
| **Motivators for Choice of Engine** | Cost | 3.0909 | 2.0826 | 1.4431 |
| | TCO | 3.6667 | 1.8586 | 1.3633 |
| | Design | 2.4545 | 1.1570 | 1.0757 |
| | Performances | 3.2424 | 1.6382 | 1.2799 |
| | Fuel Consumption | 3.8485 | 1.4013 | 1.1838 |
| | Emissions | 4.1212 | 1.5005 | 1.2249 |
| | Reliability | 3.9697 | 0.9991 | 0.9995 |
| | Corporate Image | 3.4242 | 1.6988 | 1.3034 |
| **Motivators for Choice of Fleet Management Platform** | Real time Localization | 1.9091 | 1.9614 | 1.4005 |
| | Performances Monitoring | 3.1212 | 2.1065 | 1.4514 |
| | Real time Notifications | 2.4242 | 2.1230 | 1.4571 |
| | Optimization of Fleet | 3.1515 | 1.8861 | 1.3734 |
| | Optimization of Workforce | 2.0909 | 1.7796 | 1.3340 |
| | Integration with Apps | 2.4242 | 1.8200 | 1.3491 |

| | | | | |
|---|---|---|---|---|
| | Traffic Monitoring | 1.7576 | 1.2140 | 1.1018 |
| | Impact of pollution laws | 2.8485 | 2.0680 | 1.4380 |
| | Importance of sustainable mobility | 3.8125 | 1.4023 | 1.1842 |
| **Motivators for Choice of Vehicles** | Company Sustainability Goals | 4.0303 | 1.6051 | 1.2669 |
| | Promotion of Green Image | 3.9091 | 1.6584 | 1.2878 |
| | Reduction of Emissions | 4.1515 | 1.5225 | 1.2339 |
| | Reduction of Costs | 3.4242 | 1.9412 | 1.3933 |
| | Traffic Restrictions | 3.2424 | 1.5776 | 1.2560 |
| | Possibility to Install Charging Points at Work | 3.4545 | 1.6419 | 1.2814 |
| | Availability of Charging Points | 2.8788 | 1.8035 | 1.3429 |
| **Barriers for Choice of Vehicles** | High cost of Car | 3.3636 | 1.3223 | 1.1499 |
| | Inadequacy of Public Charing Infrastructure | 3.6667 | 1.5556 | 1.2472 |
| | High Cost for Installation of Charing Infrastructure | 3.2727 | 1.3499 | 1.1618 |
| | Complexity for Installation of Charing Infrastructure | 3.0000 | 1.8788 | 1.3707 |
| | Complexity in management of points | 2.8182 | 1.8457 | 1.3586 |
| | Low Autonomy of Vehicles | 3.9697 | 1.4839 | 1.2182 |
| | Lack of Models Available | 2.8182 | 1.2397 | 1.1134 |
| | Economic Impact of COVID-19 | 2.0303 | 0.9991 | 0.9995 |
| | Environmental Impact | 2.8485 | 1.3407 | 1.1579 |
| | Change of Habits required | 3.7273 | 1.4105 | 1.1876 |
| | Lack of Assistance | 2.7273 | 1.1680 | 1.0808 |

| | | | | |
|---|---|---|---|---|
| | Perception of Insecurity | 2.2121 | 1.2580 | 1.1216 |
| **Drivers for Choice of Provider of Charging Point** | Cost | 3.3636 | 1.7466 | 1.3216 |
| | Availability of Solutions | 3.3636 | 1.5647 | 1.2509 |
| | Integration of Services | 3.3333 | 2.0404 | 1.4284 |
| | Integration with Company Software | 2.6970 | 1.9688 | 1.4031 |
| | Availability of App | 2.8788 | 2.1065 | 1.4514 |
| | Availability of Personalized App | 2.3939 | 1.8145 | 1.3470 |
| | Provision of Fleet Management Platform | 2.5152 | 2.0680 | 1.4380 |
| | Access to Public Charging Points | 3.0000 | 2.4848 | 1.5763 |
| | Other | 1.3636 | 1.0799 | 1.0392 |
| **Major Changes in Mobility** | Higher Utilization of Vehicles in Urban Routes | 2.8485 | 2.3104 | 1.5200 |
| | Less Journeys for Employees | 3.7576 | 2.0624 | 1.4361 |
| **Knowledge about EV Influencing Factors** | Statal incentives | 3.3939 | 1.8145 | 1.3470 |
| | Local Incentives | 3.0606 | 1.9963 | 1.4129 |
| | Emission Taxes | 3.6364 | 1.6253 | 1.2749 |
| | Incentives for Charging point | 3.4545 | 1.9449 | 1.3946 |
| | Tax Deductions on EVs | 3.6667 | 1.6768 | 1.2949 |
| | Lower TCO | 3.5152 | 1.8255 | 1.3511 |
| | Lower Env. Impact | 3.9091 | 1.7796 | 1.3340 |
| | Emission Norms | 3.5758 | 1.7594 | 1.3264 |
| | V1G & V2G | 2.5758 | 1.8806 | 1.3714 |
| | Performances | 3.6061 | 1.3297 | 1.1531 |
| | Development of Charging Infrastructure | 3.2121 | 1.5005 | 1.2249 |
| | EV Offer | 3.7879 | 1.1974 | 1.0943 |

Table 11: Responses from Companies

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# 8. Acknowledgements

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