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E-CARS: a multi-perspective analysis to future scenarios for the Italian market.

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Per gli insegnamenti ricevuti;
per i sorrisi e le risate che hanno contraddistinto questi cinque anni;
per le lacrime versate, di gioia e di dolore, che mi hanno permesso di reagire, sempre;
per aver conosciuto la vera me;
per tutti gli amici che mi sopportano fin “da casa”;
per quelli che a Milano sono diventati la mia “nuova casa”;
per le telefonate infinite;
per tutto lo stress e la fatica accumulati;
per il non aver mai ceduto;
per gli obiettivi raggiunti;

GRAZIE

Ma soprattutto grazie a voi, Mamma e Babbo, per avermi insegnato e lasciata libera di imparare la cosa più importante di tutte: “lotta”, tenta, sbaglia ma non andare mai “contro cuore”.

Contents

ABSTRACT

The objective of my thesis is that of identifying how the EV Italian market will evolve in next years. Nowadays, it is difficult to make forecasts in a so dynamic environment. The complexity increases speaking about e-mobility.

For this market, the Italian uncertainty it's related to both the unpredictability about the success of this revolutionary technology and the level of backwardness of our country, in this sector.

This is the path I followed for my analysis:

1. Identification of Italian weaknesses through a multi-perspective analysis;
2. Identification of possible solutions;
3. Quantification of the impact of resolutive actions;

It was a multi-perspective analysis, comprehending exogenous and endogenous factors.

For the ***exogenous*** one, I analyzed:

- **Consumer side**: I tried to understand which are the elements that mostly impact on demand, the potential customers' awareness about EV technology and their level of trust. From this step, I came out with the main demand's drivers: price, range anxiety, charging time, gross domestic product.
- **Market side**: I tried to understand how Europe, European countries and the leading foreign countries are facing the revolution. So, I focused on their initiatives and on those demand's drivers on which these initiatives have an influence.

For the ***endogenous*** one, I began from the automakers that are leading the European market.

I analyzed each on them, with the objective of understanding on which elements they are concentrating their efforts and I derived the consequences on the development of the offer, of batteries and charging infrastructures.

In the end, I was able to individuate and describe three evolution's scenarios, for which the final results strongly depend on the adopted starting hypothesis:

1. **AS IS or PNIRE DOMINATED:** it looks to potential effects of the Italian PNIRE project, initiated in 2014;
2. **TOP-DOWN:** it looks at how a top-down approach, consisting in a precise and complete strategy adopted by Government, should impact on the final demand's level;
3. **OPTIMISTIC:** it looks at how the technological development and the strategic adoption of effective incentives' policy can act contemporary and can generate concrete results on demand;

ABSTRACT

L'obiettivo della mia tesi è quello di identificare come potrebbe evolvere il mercato italiano delle auto elettriche.

Oggi è sempre più difficile fare previsioni, in un ambiente cosi dinamico. La complessità aumenta quando si parla di e-mobility.

Il mercato italiano è affetto da due principali fattori di incertezza: uno legato alle difficoltà nel predire il successo atteso di questa tecnologia; l'altro legato all'arretratezza che caratterizza l'Italia in questo settore.

Questo è il percorso che ho seguito nella mia analisi:

1. Identificazione dei punti di debolezza del paese attraverso una analisi multi-prospettica;
2. Identificazione delle possibili soluzioni;
3. Quantificazione degli effetti di possibili azioni risolutive;

Come anticipato, questa è stata un'analisi multi-prospettica, comprendente l'osservazione di fattori esogeni ed endogeni.

Dal punto di vista ***esogeno,*** ho preso in considerazione:

- **La prospettiva dei consumatori**: cercando di capire quali sono gli elementi che influenzano maggiormente la domanda di veicoli elettrici, il livello di conoscenza di questa tecnologia, cosi come quello di fiducia. Da questo passaggio sono stati individuati quattro drivers principali, suddivisi in altrettanti "driver-figli": prezzo, "range anxiety", tempo di ricarica, prodotto interno lordo.
- **La prospettiva del mercato**: cercando di capire come l'Europa, i paesi europei più avanzati in questo settore e paesi come USA e Cina, stanno affrontando questa "rivoluzione". Dunque ho verificato quali iniziative stanno adottando e su quali driver della domanda tali iniziative stanno impattando.

Dal punto di vista ***endogeno*** ho iniziato dai produttori di auto che sono risultati i best seller europei, per il mercato dell'auto elettrica, nel 2017. Ho analizzato ognuno di questi, con l'obiettivo di capire su quali elementi stanno concentrando i loro investimenti e ne ho derivato le conseguenze in termini di offerta, di sviluppo delle batterie e delle strutture di ricarica.

Dunque, ho potuto delineare tre principali scenari evolutivi, i cui risultati finali, in termini quantitativi, dipendono fortemente dalle ipotesi iniziale adottate:

1. **PNIRE-DOMINATO:** guarda al potenziale effetto che il progetto PNIRE, avviato nel 2014, potrebbe avere sulla domanda;
2. **TOP-DOWN:** guarda alle conseguenze dell'adozione, a livello strategico, da parte del Governo di concrete forme di incentivo;
3. **OTTIMISTICO:** guarda all'effetto atteso di uno sviluppo naturale della tecnologia contemporaneo a politiche di incentivazione efficaci;

1 THE CONTEXT

1.1 E-MOBILITY AND ITS RELEVANCE

HISTORICAL FUNDATIONS [1]

Even if it is not so famed EVs were introduced more than 100 years ago. It's difficult to assign the invention of electric car to one inventor or country, as it is the output of a series of breakthroughs -from the battery to the motor- in the 1800s. In the early part of the century innovators in Hungary, Netherlands, France and England began toying with the concept of electric motor and building first small-scale electric cars. But the first successful vehicle made its debut around 1890 in US, thanks to William Morison, a chemist who lived in Des Moines, Iowa. His six-passenger vehicle with a top speed of 14 miles per hour was little more than an electrified wagon, but it helped spark interest in electric vehicles. At the point that by 1900 electric cars accounted for around a third of all vehicles on the road. Its popularity was linked with the development of personal vehicles and other available options.

At the turn of 20th century, the horse was still the primary mode of transportation, but Americans become richer and they passed to the newly invented motor vehicle -available in steam, gasoline and electric versions. Steam-cars required long start-up times and would need to be refilled with water, limiting their range.

Gasoline were the promise but had some faults like a lot of manual effort to drive and their noisy.

On the other hand, electric cars were quite easy to drive and didn't emit smelly pollutant, they quickly became popular with urban residents, especially women. Its success increased as more people gained access to electricity in the 1910s and it became easier to charge electric cars.

But with Henry Ford's mass-produced Model T, gasoline powered car widely available and affordable, the decline of the electric vehicles started soon and culminated in 1935 with its complete disappearance.

Fast forward to the late 1960 and the early 1970s, soaring oil prices and gasoline shortages created a growing interest in reducing the US's dependence on foreign oil and the Congress authorized the energy Department to support R&D in that sector.

At the same time, many small and big automakers began exploring options for alternative fuel vehicles and also NASA helped raise the profile of the electric vehicle. The electric cars produced at that time still suffered from drawbacks compared to gasoline-powered cars because of limited performances (for example a maximum speed of 75 km/h and a range of 64 km before the next recharge). With a booming economy, a growing middle class and low gas prices in the late 1990s, many consumers didn't worry about fuel-efficient vehicles.

[11] https://www.energy.gov/articles/history-electric-car

The true revival of electric cars happened at the begin of the 21st century and, depending on whom you ask, it was linked with the introduction of Toyota Prius or with the launch of a small Silicon Valley startup, Tesla Motors.

E-CARS

An e-car is a vehicle with an electrified automotive powertrain. There are different kind of EVs (the word that indicates all the vehicles with an electrified powertrain) and it is important to list them in order to clarify the EV's environment.

- **BEV:** battery electric vehicle without auxiliary sources of energy on board.
- **PHEV:** plug-in hybrid electric vehicles, driving with combustion engine and/or e-motor, plug-in to recharge battery
- **REEV:** range extended electric vehicle, driving with e-motor only, ICE & plug-in (or fuel cell) used to recharge battery
- **FCEV:** fuel cell electric vehicle, driving with e-motor only and storing energy in hydrogen.

In my analysis, I will focus on BEV models.

Basically, a BEV is composed of four main elements: batteries, BMS (battery management system), inverter, electric motor.

- **Batteries:** batteries are charged directly from the electric network.
- **BMS:** this system manages batteries and it takes care of charge and discharge phases, with the aim of avoiding the batteries' damage.
- **Inverter:** an inverter is put b/w the motor and batteries because batteries and motor use different kind of current. The batteries provide direct current (a current with constant intensity and direction along time) while the motor uses alternating current (in which the positive and negative poles invert themselves with a fixed periodicity).
- **Electric motor:** it is the primary source of propulsion. It can be used also as a generator, so it is possible to retrieve part of the kinetic energy from the slowing down-phase and part of the potential energy produced during the downgrades.

The main advantages and disadvantages [2]related to the electric vehicles will be listed in the following section.

[2] https://www.autoreporter.it/auto-elettriche-vantaggi-e-svantaggi-delle-automobili-con-motore-elettrico/ + https://www.energysage.com/electric-vehicles/101/pros-and-cons-electric-cars/

ADVANTAGES

1. **Higher motors' efficiency:** these cars are far more efficient than conventional gas-powered vehicles. BEV batteries convert 59 to 62 percent of energy into vehicle movement while gas powered vehicles only convert between 17 and 21 percent. It implies a lower utilization cost.
2. **Lower environmental impact:** the electric energy can be produced by renewable and not polluting sources. Additionally, reducing the usage of fuel means reducing the dependence from those countries providing fuel.
3. **Higher performance and lower maintenance:** BEV motors react quickly, are quiet and require less maintenance. They are overall newer than their gas-powered counterparts and often more digitally connected with charging stations. It means that drivers control charging from an app.

DISADVANTAGES:

1. **Lower autonomy:** on average EVs have a range that is shorter than gas-powered cars. This may be an issue when looking at EVs if you frequently take long trips. The same kind of drivers can find issues linked to the availability of charging stations.
2. **Longer recharging time:** even the fast-charging stations take 30 minutes to charge to 80% the capacity. The drivers must plan carefully their movements, this means also a higher effort from the user side. Additionally, not everyone has the possibility to install domestic recharging networks for technical and economic reasons.
3. **Price:** electric cars are more expensive, and the batteries' pack may need to be replaced more than once over the lifetime of the car. However, fuel cost savings, tax credits and state incentives (where active) can help to offset this cost.

E-MOBILITY AND ITS SOCIAL RELEVANCE [3]

The E-mobility [4]is that word through which we can refer to all those vehicles that use electricity as primary energy's source. As the mobility sector is one of the major responsible of pollution and CO2 emissions, it has to be subjected to environmental efficiency's improvements. The automotive industry considers this starting point as the basis for developing an opportunity for the business but also for the society and the environmental sustainability. Even if this theme was previously touched by some automakers, it gained its pick of attention during last years because of climate changes, increase in petrol's prices and the pressure for the introduction of new technologies in the automotive sector. This phenomenon looks at cars but also trucks, four-wheeled motor vehicles and motorcycles and needs the intervention of different actors, for this reason it can be defined as **cross-sectoral.**

[3] https://www.transportenvironment.org/news/electric-cars-have-significantly-lower-climate-impact-diesels-over-their-lifetime-–-study + file:///C:/Users/utente/Google%20Drive/TESI/1-%20THE%20PROBLEM/Scio%20ecoRUG01-002272400_2016_0001_AC.pdf https://www.energy.gov/eere/electricvehicles/reducing-pollution-electric-vehicles - https://onlinelibrary.wiley.com/doi/epdf/10.1111/j.1530-9290.2012.00532.x - http://www1.nyc.gov/html/ev/html/society/society.shtml -

[4] FIA e-mobility report

From the supply side, it involves authorities, automakers, batteries' developers and producers, energy's providers and it is counter-productive to define boundaries between them. In fact, e-mobility requires that all the actors act together in a complementary way on different fronts.

From the user side, it is necessary to conduct sensitization's campaigns on two fronts:

- making potential customers understand the new technology, trying to take them to overcome uncertainties linked to EVs limits like price, range anxiety and so on.
- Making potential customers to understand the advantages that this technology can provide to both users and the environment, reducing the social cost of the mobility sector.

The social cost is composed by:

- **Greenhouse gas emissions**
- **Atmospheric pollution**
- **Acoustic pollution**
- **Traffic congestion**
- **Accidents**
- **Energetic consumption**

All these elements can be associated to a social problem that has an impact on the environment, on people' s quality of life and on the security of citizens. Instead the E-car seems to be able to decrease the environmental and social impact of mobility, for the next reasons:

1. **CARBON EMISSIONs:** the "carburant" is only made of energy. Even when powered by the most carbon intensive electricity in Europe, an electric car will emit less. These emissions will decrease further as more renewable electricity is used, accordingly with the analysis conducted by the VUB university in Brussels for "Transport&Environment". Poland and Germany have more carbon intensive power generation, while the other countries have cleaner energy mixes with Sweden in the

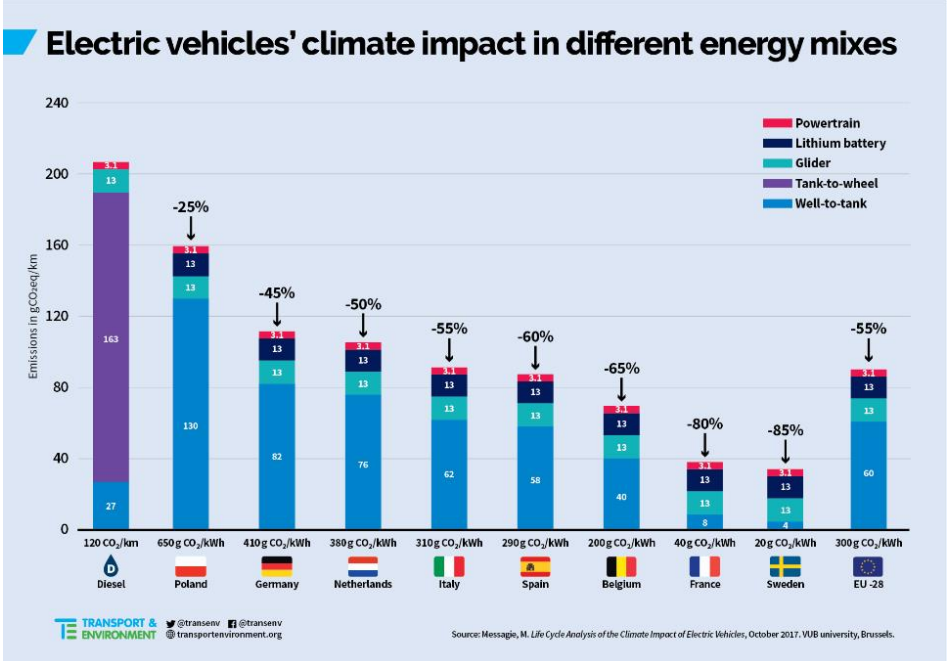


Figure 1 *The climate impact of electric vehicle depending on different energy mixes, by country.*

leading position. Looking at a comparison between electric and diesel cars, the average CO_2 emitted in Poland, it is 25% less than the diesel one. In Sweden it reaches the 85% less. The table on the right summarizes the climate impact of EVs in different energy mixes. Additionally, another forecasted result is that EVs' sustainability will improve further with battery technology advances.

2. **URBAN AIR QUALITY:** electric vehicles produce little or no tailpipe emissions, one of the major contributors to climate change and smog. There are two general categories of emissions: *direct and life cycle.* What is emitted through the tailpipe together with greenhouse gases (GHGs, primarily the carbon dioxide) is categorized as direct emission. Electric vehicles produce zero emissions, so are able to improve the air quality of urban areas. Instead, life cycle emissions are all the emissions related to fuel and to the complete life cycle of the vehicle, from the production to the recycling/disposal.
   All vehicles produce substantial life cycle emissions, that are difficult to be calculated. However, depending on the electricity mix and on the country, there is the possibility to strongly reduce the impact.
3. **ENVIRONMENTAL IMPACT OF MAINTAINANCE**: the electric motor does not need to be maintained through oils and lubricants, that are difficult to be disposed, so the impact is reduced.
4. **URBAN NOISE:** electric vehicles lack pounding pistons and for this reason, especially at the city speed, they emit an imperceptible noise. So, on one hand it means that the *acoustic pollution* of small and big cities is drastically reduced. On the other, EVs can barely be heard when they travel at a speed lower than 20 Km/h. It means that in urban areas with low speed limits the risk associated to the circulation of EVs increases, especially considering the pedestrians and cyclists who move listening music through headphones. This problem will be solved until July-2019, when a law will start to impose to all electric and hybrid models seeking approval in Europe to emit a noise, when travelling at low speeds. While, existing vehicles will be gradually retrofitted with devices. This is an important point, as from the article emerged that "EVs are 40% more likely to hit pedestrians than a conventional vehicle" and a related study suggest that the 93% of blind and partially sighted people have had difficulties with them.
5. **URBAN HEAT:** considering traditional cars, only the 15% of the energy gets converted into motion, the rest is lost as waste heat-one and this is a negative aspect for pedestrians' walking. Instead, electric vehicles use energy much more efficiently and so they create less heat.

For reaching all these benefits, there is a set of actions that should be put in practice and that, as I will describe later, are going to be implemented by automakers, authorities and other actors involved:

1. Incentives' policies promotion, able to support the e-mobility diffusion.
2. R&D investments in batteries' development.
3. Definition of standards for charging infrastructure in order to promote the competitiveness and avoid monopoly.

4. Concentrate efforts in the provision of services able to attract consumers.
5. Promote transparency and coherence in the CO2 emissions' evaluation.

1.2 THE ITALIAN CASE

Italy is the European country situated in the heart of Mediterranean Sea. It has 60.963.000 inhabitants (with a ratio of 1,65 inhabitants for each passenger car circulating on the Italian territory) and a total land area of 301.339 km2. It is one of the countries involved in the E-mobility revolution, but it still lingers in a backwardness' situation in comparison to the other countries. Between 2005 and 2016 the number of new registrations had a 41% growth, impacting on different forms of mobility, but Italy is still presenting diverse weaknesses.

Starting from the description of the current situation, I will proceed my analysis looking at the trend of BEVs' new registrations (in order to understand how Italy is positioning in terms of sales) and finally I will highlight which are the main Italian goals deriving from the EV revolution.

As emerged in the "*E-mobility Revolution – the European House Ambrosetti*" report there are six main points that States should consider as pillars for developing the right e-mobility strategy and that actually represent a deadlock.

I will present the elements that can be considered as success' keys[5] for this revolution and I will analyze how Italy is currently acting in these fields.

1. **NATIONAL STRATEGIC VISION FOR THE E-MOBILITY:** it is the starting point. In order to succeed there should be a SHARED and STRATEGIC vision of e-mobility at national level. It means that Government should define in its annual plans precise frameworks regarding e-mobility and specific KPIs for measuring and monitoring targets. A strategic plan can be concretized through national policy able to incentivize the adoption of EVs. Here Italy is for sure frail.
   Looking more in detail at Italy's incentives what I found out is that these are few and less effective than those adopted by other countries.
   In 2014, the Law n.134 was draft with the aim of providing purchase incentives to customers. During the parliamentary approval, the text of this law was changed, and the benefits extended to the whole family of environmentally friendly vehicles (electric, Hybrid, LPG, CNG). This meant that incentives finished until the end of 2015. These were substituted only by alternative measures such as:
   - the exemption of the circulation tax for 5 years from the date of the first registration and, once passed this timeframe;
   - a reduction of around 75% of the rate applied to traditional non-environment friendly vehicles;
   - the exemption from the payment of public park in some cities;

   What emerged is that "without a real purchase incentive nobody buys[6]", as stated by Vittorio Chiesa, professor at *"Politecnico di Milano"* who highlighted how the higher price

[5] E-mobility Revolution: the European House Ambrosetti
[6] https://www.agi.it/blog-italia/funding/incentivi_auto_elettriche-3410651/post/2018-01-25/

of EVs and the lack of an Italian strong incentive policy can be considered one of the main barriers to the EVs' diffusion.

In Norway a pure electric car receives around 20.000 € of incentives, in Holand 10.500 €. In Italy, summing up the previously mentioned facilitations, a consumer can gain a maximum of 3.000 € of rebate.

In the table are summarized the few incentive's initiatives adopted by Italy.

INCENTIVE CATEGORY	DESCRIPTION
Purchase Subsidies	Low local subsidies
Ownership Tax Benefits	Electric vehicles are exempt from the annual circulation tax (ownership tax) for a period of five years from the date of their first registration. After this five-year period, they benefit from a 75% reduction of the tax rate applied to equivalent petrol vehicles in many regions.
Infrastructure Incentives	Credit for charging infrastructure in non-residential buildings over 500m2

***Table 1 ITALY INCENTIVES' POLICY** - Categorization and description of Italian incentives' policy.*

2. **R&D efforts:** Italy should launch specific research programs exploiting its "scientific estate" and leveraging on the e-mobility cluster created by MIUR5 and composed of 12 main districts. As stated in the report "*this cluster should have the role of capitalizing on the scientific expertise and industrial know-how found on a regional and local level throughout the value chain, while working in synergy with other strategic clusters and promoting projects for the internationalization of research through scientific collaboration and technological exchange with partners which have competencies that complement Italy's".*

3. **SENSITIVIZATION AT URBAN LEVEL:** Italy should exploit its **non-economic incentives** to improve the sensitiveness of citizens in relation to this topic, highlighting the potential benefits that both EV users and society could gain.

   These measures comprehend:

   - *free access to LTZs and preferential lanes in urban centers;*
   - *reduction or exemption from paid parking;*
   - *freedom to circulate in closed traffic areas;*
   - *reduced tolls for highways and expressways;*
   - *target goals for electric vehicles in public transport fleets (including taking advantage of funds available on a national level);*
   - *promotion of vehicle sharing systems (car, motorcycle, bicycle) which would tend to have the effect of reducing vehicles in circulation;*

- *introduction of measures to discourage vehicles with polluting emissions, such as the adoption of road pricing and congestion charges for access to urban centers;*

Sensitization could represent also a mean for homogenizing Italy at regional and metropolitan level. In fact, an additional problem that Italy is facing is the diversified diffusion of EVs region by region and city by city.

Florence, Milan and Rome are the most evolved cities, from *European House Ambrosetti.*

4. **LAUNCHES OF PILOT PROJECTS AND COLLABORATIONS**: Italy can exploit the existence of numerous Universities and research centers as well as numerous competences that play a key role in the value chain of e-mobility.

   Italy is leader in the following sector:

   - **Body shell and interior design:** it has a solid and prestigious tradition in these sectors.
   - **Electronic components:** Italy is the second country in the World that exports the highest number of electric conductors with a voltage higher than 80.
   - **Recharging technologies:** Italy has a leading position in the design and production of recharging equipment – to be mentioned operators as Enel, Ducati Energia, ABB.
   - **Electric network:** Italy is one of the pioneering countries looking at the smart grid field and is developing projects and collaboration about Smart Charging technologies as well as Vehicle-to-Grid also at international level.

   Leveraging on synergies between all the previously mentioned actors should represent one of the turning points for reaching defined system goals.

5. **CHARGING INFRASTRUCTURES DIFFUSION:** it represents one of the most discussed themes. Often associated to the highest limit that EV Italian drivers are facing when buying an electric car, the opinions about Italy and its status seem to diverge.

   In fact, looking only at PUBLIC charging [7] what emerged is that Italy is the fifth in the classification, after Germany, UK, Netherlands and Norway, with 4.207 public charging points (at the end of 2017). The relation between Italian [8]electric vehicles and charging points is also good, 2,23 against Malta that is the first in the list with 1,62 cars per point. What does it mean? On one hand, that electric vehicles are not diffused in Italy; on the other, that in Italy the current infrastructure could be potentially able to sustain an increase in circulating EV for some years.

   The project **EVA+** coordinated by Enel and dedicated to the enlargement of fast charging network, will for sure improve the current status.

   Instead, looking at the total number of charging points the situation seems to get worse. It is enough to look at private charging points which cover the 80% of Italian current infrastructure and are mainly concentrated in urban areas and cities.

[7] https://it.motor1.com/news/221467/colonnine-di-ricarica-auto-elettriche-chi-vince-e-chi-perde-in-europa/

[8] elaborazione OmniAuto.it su dati Open Charge Map, European Alternative Fuels Observatory, EV Sales

As first consequence of the European DAFI (that I will introduce more in detail later in my analysis), in 2014 the Italian government launched the PNIRE program (Piano Nazionale per la ricarica di veicoli alimentati a Energie Elettrica or National Plan for Electric Charging Infrastructure) through which it defined guidelines for developing in a unitary way the recharging service and related infrastructures. It was subsequently updated in 2016, highlighting two main phases to be completed until the end of 2020:

1. **Settlement and development** (2013-2016), in which were prepared the basis for granting e-mobility in cities and metropolitan areas.
2. **Consolidation** (2017-2020), aiming at completing the infrastructural network in order to cover the entire national territory.

The development and promotion of charging stations can be divided in three main types:

a. **Development of new stations**
b. **Financial support for building local infrastructure through public and private programs**
c. **Validation of pilot projects** with a particular focus on infrastructure technologies, business models, logistics, and the interaction with EVs.

After the Directive Alternative Fuel Initiative (DAFI) and the Legislative Decree for the reception of 2014/94/UE, was defined a national strategy based on the following pillars:

- **4,500 ÷ 13,000 slow/accelerated** charging points and **more than 2,000 ÷ 6,000 fast** charging stations on the national territory until 2020, giving priority to urban areas which belong to metropolitan cities and, successively, suburban areas, extra-urban roads, state roads and highways;
- "**Technology neutral" approach** is used as a total strategic vision, able to appreciate the contribution of each fuel type for realizing environmental targets;
- Mandatory provision of methane or natural gas and installation of charging stations for new fuel stations – or those under renewal;
- Mandatory purchase of at least 25% methane, natural gas or electric vehicles, for Public Administration, when substituting their fleets;
- Mandatory updates of building regulations to meet the requirements of the provision on alternative fuels. Starting from June-1st 2017, new buildings or the ones under significant renovations must provide connections to install charging stations;

Additionally, Enel was charged by the Italian Ports Association [9]to install 300 public EV charging stations in the areas managed by Italy's 15 port authorities. A declaration of intent was signed by Enel X, the subsidiary company responsible for EVs and the Assoporti association. The charges will have different capacities depending on the traffic model they will face: inner cities will have 22 kW stations, while "extra-urban" areas will receive 50 and 150 kW charging stations.

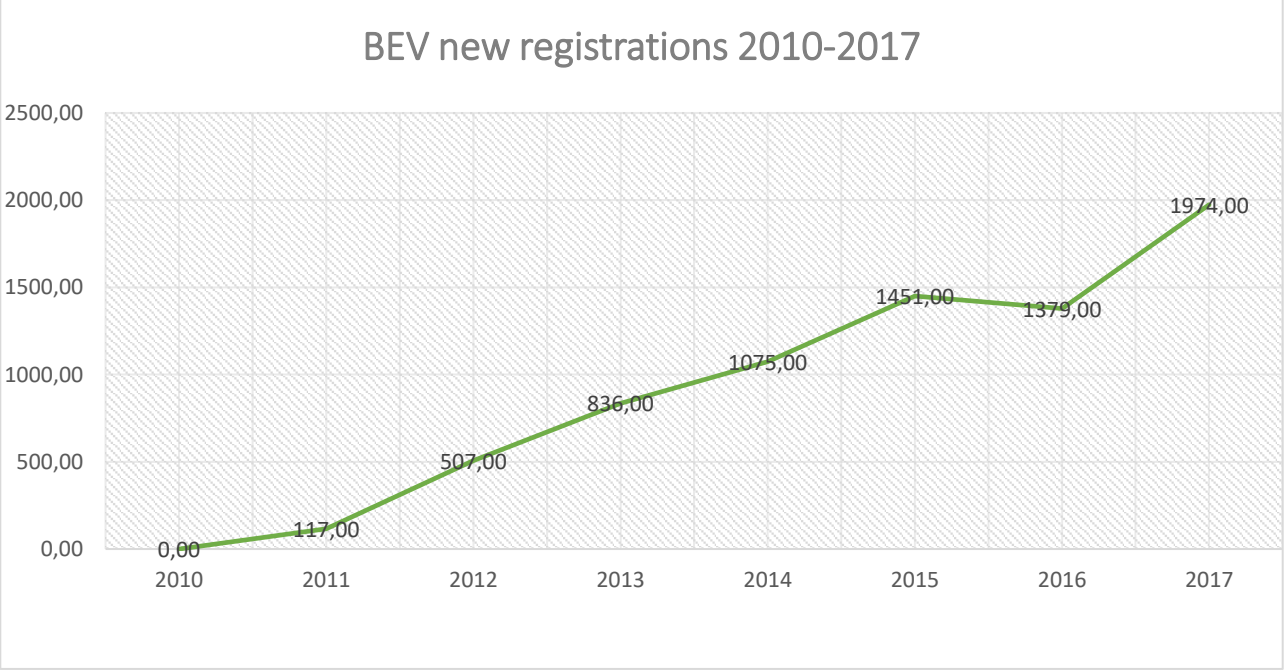
[9] https://www.electrive.com/2018/07/24/enel-to-construct-public-charging-stations-in-italian-ports/

6. **PROMOTION CAMPAIGN:** increasing the level of awareness about EV mobility, advantages and limits (that different actors are trying to overcome).

Combined actions on these six main fields can represent the winning choice for this State.

EVs NEW REGISTRATIONs

For Italy I relied on data coming from www.eafo.eu. Numbers are lower than other States, but they simply mirror the backward situation of Italy in comparison to other European countries. Even if it is a slow growth, it presents a positive trend that overcome the one thousand units in the same year in which some incentives were introduced and the Government launched the PNIRE program. I think there could be a possible correlation between these "events".



Graph 1 ITALIAN BEV NEW REGISTRATIONS *- in this graph is presented the Italian trend of BEV registration from 2010 to 2017*

FUTURE GOALS

- By 2020, between 4.500 and 13.000 charging points will be installed and between 2.000 and 6.000 charging stations
- By 2022, one million electric vehicles on the road. While the target is ambitious – if successful it would set Italy on top of the list for EV adoption in Europe. This ambition may send a strong signal to both the car as well as the charging infrastructure industry so that they may accelerate electric car adoption in Italy

2 THE METHODOLOGY

ESTIMATION's ISSUE

The dynamism of the today environment increases day by day and so making forecasts and estimations about potential developments of a market become more difficult. The EV market is one of the most affected by uncertainty. It involved a variety of factors (like the level of CO2 emissions, the future sales, the future purchase prices and total cost of ownerships) impacting one each other and so it's not possible to determine a single evolution path, but it is necessary to define different scenarios.

For example, the table below reports the results from literature study, conducted by EAFO, on the ZEV/EV share in new car sales 2020 – 2050. The dots represent the forecasted ZEV+PHEV sales, the 3 lines represent the ZEV only sales using the low – average – high forecast values, excluding the PHEV sales. Data points received from BNEF (2017) but not taken into account are: 2025 (8%), 2030 (24%), 2040 (54%).[10]

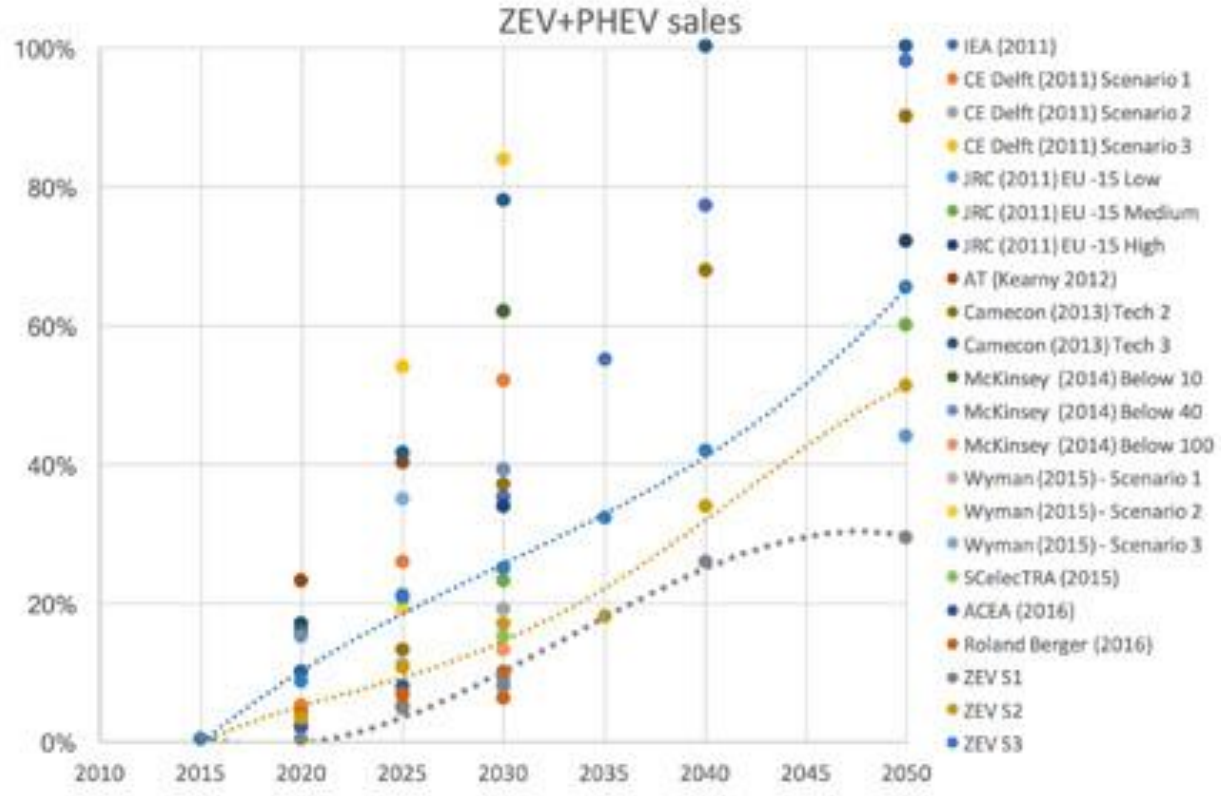


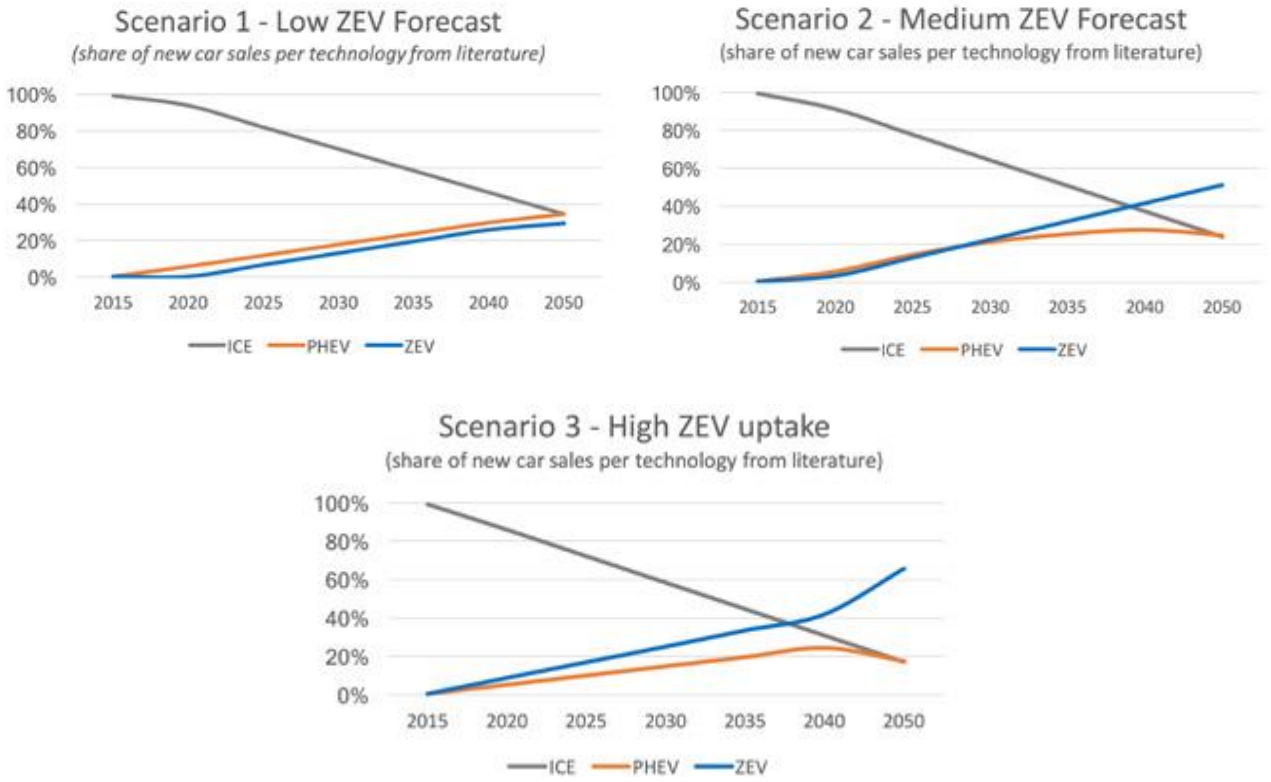
Figure 2 ZEV and PHEV FORECAST *- this figure groped all the different forecasts and scenarios draft by different experts starting from 2011, looking at time horizon and market share. It highlights how opinions were (and are) different year by year and so it mirrors the high uncertainty of this market.*

Even if this image is not definite, I thought it was interesting to show how differently experts interpret forecasts. EAFO developed three scenarios representing different ratios of ZEVs to ICEVs (the kind of ICEV were grouped under a single acronym for simplify the analysis) for and PHEVs.

[10] The transition to a ZEV fleet for cars in EU by 2050 EAFO – report

The trend observed is that the more recent the sources are, the more optimistic they are about the ZEV penetration level.

Following the scenarios EAFO found out.



***Graph 2 EAFO SCENARIOS** - In these graphs are described the three scenarios captured by EAFO. These are classified as LOW, MEDIUM of HIGH, depending on the estimated market share of ZEVs.*

As highlighted, even in the best case EVs' share is not expected to reach the 100%. The main obstacles are linked to the inhomogeneity of adopted policies. Despite the objectives listed in the European "White Paper for Transport (2011)" (that I will deepen later), each country autonomously defined its targets and incentives' policy, implying a higher forecasts' difficulty. Looking at main active countries, French government aims at banning the traditional cars sales by 2040, the Dutch one has a similar objective but by 2030. Norway is targeting the 2025 for the same goal, while China has put a ZEV mandate in place to take effect in 2019.
Speaking about incentives' policies Germany, France, Norway and Netherlands seam to provide the best mixes of measures, but the final result is that sales are unevenly distributed.

Following the conclusions highlighted by EAFO from the literature review on ZEV sales forecasts:[11]

• *Even the most optimistic forecast evaluated in this study will not result in 100% ZEV car sales by 2050. Reaching a 100% ZEV car fleet by 2050 is something which is not considered likely to happen.*

[11] The transition to a ZEV fleet for cars in EU by 2050 EAFO – report

• *Expert forecasts of sales data for the coming decades is much lower than the current ambitions of ZEV leader countries, as well as the stated targets for ZEV sales by OEMs.*
• *Policymakers and other decision makers would be prudent to prepare for significantly faster ZEV market growth than experts predict will happen. The risk of being too pessimistic may be bigger than the risk of being too optimistic.*

As a proof of this uncertainty I also reported the information published by different source.

ING, DUTCH BANK PREDICTION (2017) – ELECTRI CARS TO ACCOUNT FOR ALL NEW VEHICLES SALES IN EUROPE BY 2035[12]

In 2017, a Dutch bank has predicted that all new cars sold will be electric by 2035. From this bank perspective, thanks to a decrease in prices and an increase in charging infrastructure and range capabilities expected between 2017 and 2024, the EV will become the rational choice of consumers.
This forecast expects also an EV's TCO equal to that of traditional cars in 2024.

A quite optimistic opinion, considering the fact that from EAFO perspective EV's prices should equal those of fuel cars between 2022 and 2026 and the TCO should reach the same result in subsequent years.

It presented other positive expectations looking at ranges but also automakers' actions. In fact, it expected that in the next decade the carmakers will begin to focus only on electric models.
A negative aspect highlighted by the bank refers to the competitive advantage that European automakers gained in past years. From its perspective, their strength in internal combustion engine sector, will disappear shifting to electric vehicle. Why? For the "new" comer China. China entered in this new market aggressively, exploiting the opportunity to cover the gap related to its backwardness in traditional combustion engine.

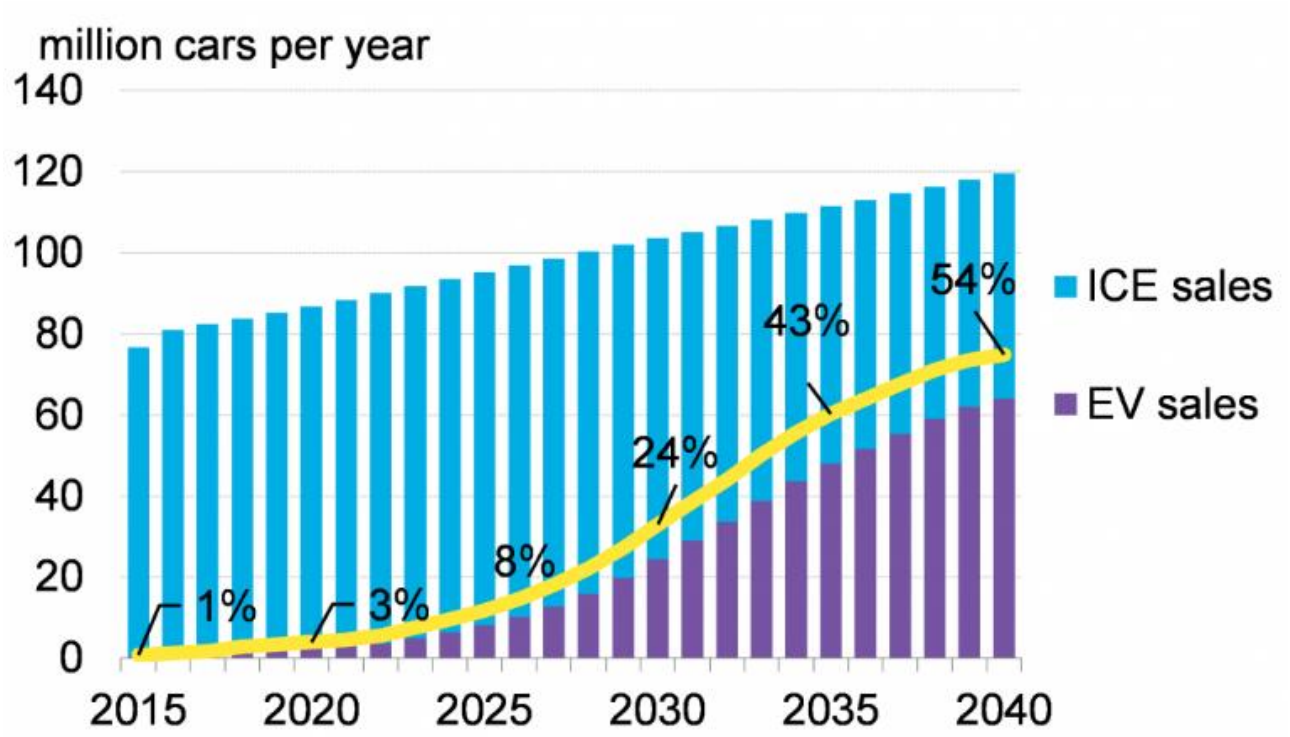
Stanford University economist Tony Seba, through a diverse report on EVs, made a similar forecast for worldwide adoption.
"Our findings clearly indicate that essentially all vehicle miles travelled will be electric by 2040 [worldwide]," he told The Guardian. "The car industry faces an imminent technology disruption by AEVs [autonomous electric vehicles] in the early 2020s. Even without autonomous technology, the internal combustion engine car industry will have been long decimated by 2040."

BLOOMBERG -ELECTRIC VEHICLES TO ACCELLERATE TO 54% OF NEW CAR SALES BY 2040 (July 2017)[13]

Bloomberg has a different opinion. From its perspective the majority of new sales worldwide will be electric until 2040 and will account for the 33% of light-duty vehicles on the road.

[12] https://www.theguardian.com/environment/2017/jul/13/electric-cars-to-account-for-all-new-vehicle-sales-in-europe-by-2035
[13] https://about.bnef.com/blog/electric-vehicles-accelerate-54-new-car-sales-2040/

Bloomberg assumed that current policies will continue to push EV adoption until its scheduled expiry but didn't expect any new measures. A reduction in battery costs and other components was individuated as major impacting elements, together with a rising EV commitments from customers' perspective and an increasing offer. Final result: Bloomberg modified the previously published forecasts passing from the past 35% of new sales until 2040 to the 54% of new sales until the same year. Segmenting this finding by geographical areas BNEF stated that there will be a 67% of new car sales in Europe by 2040, and a 58% in of sales in the U.S. and 51% in China by the same date.
From BNEF point of view, those countries that made early progress in EV sector are expected to be among the leaders in 2040, including Norway, France, and the U.K.
In the figure below the BNEF's projection:



Graph 3 BNEF PROJECTIONS *- in this graph from BNEF are highlighted the ICE and EV sales forecasts.*

Comparing with scenarios of EAFO and ING, BNEF forecasted new car sales counting for the 67% in 2040, while EAFO expected the same percentage a decade later. Again, the most optimistic appears ING, with 100% EV new sales until 2035.
I notice a higher agreement on the period in which the upfront costs of EV will fall below those of conventional vehicles: from the second half of 2020s, as affirmed by EAFO and ING.

These examples could provide to the reader the proof of difficulties in establishing which will be the EV market evolution at global level but also at country one. For this reason, to come out with Italian evolution scenarios I had to conduct the analysis explained below.

ADOPTED APPORACHES

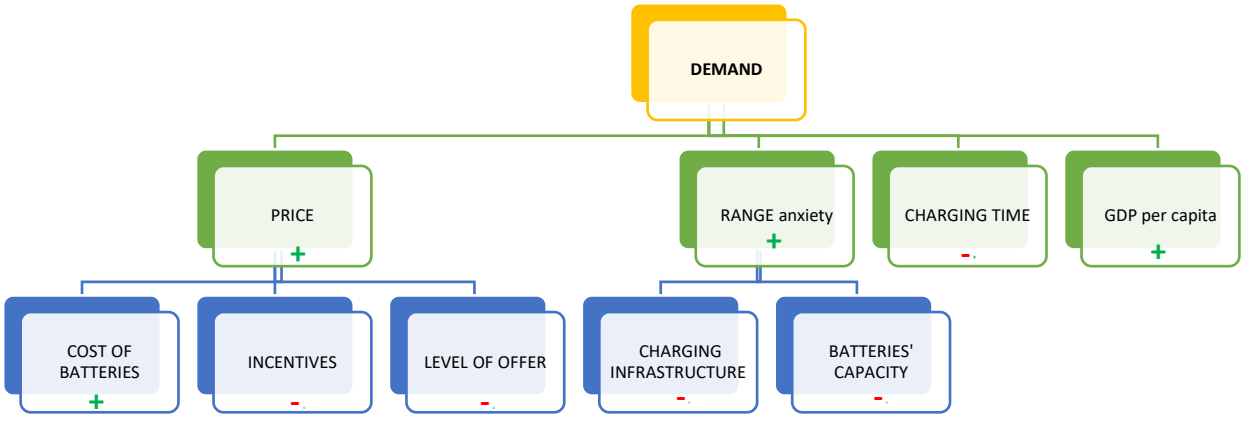
The aim of this session is to present the E-mobility topic and related aspects, to increase readers' awareness about the argument. In the following paragraphs I will conduct a deeper analysis, under three different perspective:

1. **DRIVERS ANALYSIS:** this chapter will be divided in two macro areas. On one hand, I will analyze consumers' perceptions of this market and its evolution (as well as limits and advantages). Starting from different surveys I will summarize my understandings through a conceptual tree, showing the relationships between demand and customers-choices' drivers. On the other, I will analyze the market under a geographical perspective, looking at pioneering countries, with a focus on European leading States, USA and China. I will describe how different States managed and are managing the EV revolution defining their point of view, their goals and their level of trust on the technology that is shaping the mobility-paradigm.
2. **ENDOGENOUS ANALYSIS:** I will analyze leading automakers and how they are facing this revolution. Here I will consider the eight main actors of the industry, looking at their strategies in terms of *offer and price, infrastructures' development, batteries' development and market dimensions.* The aim of this session is to map different competitors and to understand their positioning, trying to draw a final classification.
3. **UNDERSTANDING THE POSSIBLE INCENTIVATING ACTIONS FOR THE ITALIAN MARKET AND POSSIBLE DERIVING SCENARIOS:** integrating the findings coming from the previous chapters, I will develop my view of scenarios that will potentially affect the Italian EV market.

3 DRIVERS ANALYSIS

3.1 THE CONSUMER SIDE – THE DEMAND AND ITS DRIVERS

As defined in the "APPROACHES" paragraph, this session will be dedicated to the analysis of different drivers that are able to positively or negatively influence the demand of EVs. The scheme is the summary of my research about customers' attitudes toward electric mobility.



I integrated what I found out reading online articles and some surveys (related to different years). Finally, I mapped in this tree the main results and relations. As you can see, I put a sign ("**+**" = direct correlation, "**-**" = indirect correlation) indicating the kind of relationship between drivers and demand or "son-drivers". For example, looking at the price it is positively correlated with the cost of batteries. It means that the price increases when the cost of batteries increases. While it is negatively correlated with the incentives and with the level of offer, so it means that at an incentives' growth (= increasing number of provided incentives as well as improved quality of incentives) corresponds a decreasing price. Similarly, the price has a negative relation with the demand because when its increases, the demand decreases. For each driver I will describe its importance and characteristics and I will finally highlight its evolution in customers' priorities list.

Following the list and the description of considered surveys:

a) **"Attitude of European car drivers towards electric cars: a survey"** (2012): the survey was distributed in six European countries (at that time) with the aim of understanding drivers' behaviors. Completed interviews per member state were: **France** - 623 interviews, **Germany** - 606 interviews, **Italy** - 613 interviews, **Poland** - 548 interviews, **Spain** - 617 interviews, **UK** - 716 interviews.

   The methodology the authors followed can be divided into two main parts: the first related to the knowledge assessment (where drivers were asked to estimate their knowledge about electric mobility, their opinion about the relevance of incentives' policies) and the second with the aim of defining the features that mostly impact customers' behaviors. Specifically, in the second part the procedure was the following: starting from a comparison between a generic conventional and a generic electric car based on key variables as car purchase price, operating costs (i.e. the cost needed to run the car for 100 km), the range of the car, the time needed to re-fuel/re-charge the car, the maximum speed and the level of well-to-wheel emissions, drivers were asked to provide a probability for them to purchase the electric car rather than the conventional car. Then, repeatedly, they were asked to imagine having an additional amount of money available for modifying one of the features and to choose which variable to improve (each time they could choose a different feature). In this way the authors were able to define a classification of the most important drivers of choice.

   RESULTS:

   1. The possibilities of decreasing the price or increasing the range were equally distributed, gaining a 32% of preferences.
   2. The 25% looks at the possibility of charging at home.
   3. The 9% was interested in decreasing the recharge time.
   4. Only few individuals were interested in increasing the maximum speed.

   These were similar in all countries but with some differences. In Italy and Spain, the most important was the price, while in Germany and UK the range. While in Poland people mainly looked at the possibility of recharging at home.

b) **"Public attitudes towards electric vehicles"** (2016): This report summarizes people's attitudes towards electric vehicles. It is based on a survey module, which was included in the Office for National Statistics' (ONS) February 2016 Opinions and Lifestyle Survey (formerly the Omnibus Survey). The questions were commissioned and designed by the Department for Transport in Great Britain.

RESULTS:

1. Recharging time was considered the first barriers for not buying an EV (45%).
2. The range was second positioned in the list of barriers (39%) [it somehow confirms what emerged in the previously mentioned report].
3. The third influencing element was the price (28%).

c) **"Green Party / Comhaontas Glas - E.V. Owners Survey Report 2017"** [14](2017): this survey was carried out by Green Party and the Irish Electric Vehicle Association between the 14th and the 18th June 2017, interviewing 231 EV owners.

RESULTS:

1. The lower running costs were seen as one of the main reasons for buying an EV.
2. The main disadvantages listed were linked to lack of charging points. It meant lack of an appropriate charging infrastructure and a limited range issue. When asked how to encourage the adoption, the majority of them suggested to increase the number of chargers or to increase the fast chargers (focusing on the recharging time).

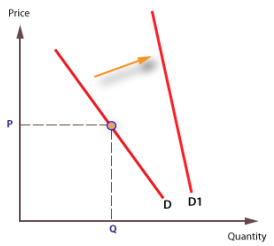
Even if these surveys focused on different countries and on different years, main results don't seem to change over time. What emerged from surveys is supported by the fact that:

1. Incentives' policies (that I will deepen later) are mainly focusing on these elements (for example, the stimulation of construction of charging infrastructure and the reduction of price).
2. All the automakers focused and are focusing on the development of new batteries through which they can decrease the price but also increase range capacity and so decrease the range anxiety.

Now let's analyze in detail the different drivers and their "son-drivers".

PRICE

The price is the upfront element that a potential customer faces when dealing with a product or service. It is determined by the producers and essentially it contains information about the demand and the supply. It can be also considered as an indicator of the quality of products and is used at strategic level for introducing and maintaining products on the market during their lifecycle. The relation between price and demand is



[14] https://greenparty.ie/news/new-survey-shows-electric-vehicle-drivers-love-the-cost-savings-but-want-more-charging-stations/

defined as the price elasticity. It is the measure of change in the demanded quantity in relation to its price's change.

The price in EVs market is considered as one of the most influencing factors in purchase decisions and is actually seen as a limit, because it still results higher than traditional vehicles. In the scheme I considered it as negatively correlated with the demand, because the demand decreases if the price increases, especially in those countries with lower income and lower sensitivity to environmental issues. It is not by chance that most of incentives' policies focus on the reduction of perceived price.

Speaking about this factor is important to make a distinction between the *purchase price* and the *total cost of ownership.* Both concern the cost a customer has to sustain buying a car but have different time orientation and composition.

- **Purchase price:** it is the cost sustained in the moment in which the customer becomes the owner of a product. Looking at the case of EVs it is usually higher than traditional cars
- **Total cost of ownership:** it is the total cost a customer has to pay until the moment in which he is the owner of a product. Considering the case of a vehicle, it will comprehend the maintenance costs, the insurance, price of fuel, etc. UBS, a swiss financial company, forecasted that the total cost of ownership of electric cars will equal that of conventional vehicles during 2018, other sources are opting for he period between 2024 and 2026

The price is obviously influenced by other factors that can have a positive or negative impact on it. Specifically, there are three main elements that can be defined "son-drivers" of the price: cost of batteries, incentives and level of offer. These are not explicitly considered by customers during the purchase process but influence one of the main drivers taken into consideration.

COST OF BATTERIES

The battery is the principal component of an electric vehicle, both in terms of costs and importance (in fact it defines the range dimension, one of the first features at which customers look). The impact it has on price is high and so is important to put R&D efforts on this field in order to decrease its costs and consequently the purchase price.

In 2017, a study published by McKinsey [15]& Company described batteries economics as one of the highest barriers to profitability. Even if these costs dropped off from 2010 to 2016 they stated they don't see automakers making a profit between 2025 and 2030. According to McKinsey the lower costs could bring base versions as Chevy Bolt below $30,000 and that of Tesla Model 3 below $40,000 after the application of tax subsidy. However, the unsubsidized price of these EVs is still above the average price of around $35,000 for a new vehicle purchase in the US (~$29,500 in Europe, ~$24,000 in China).

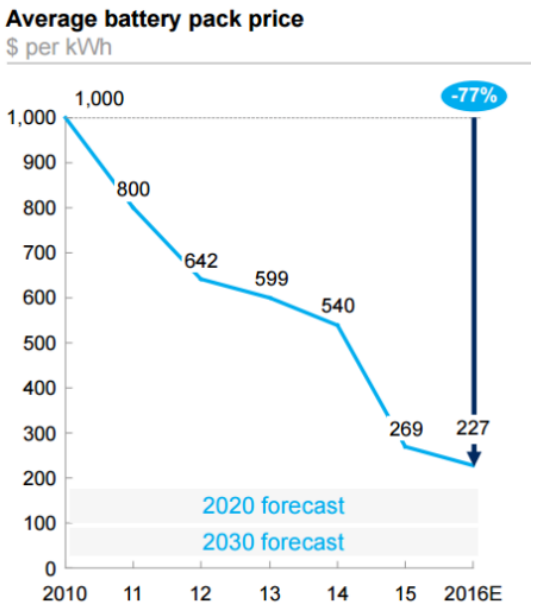
[15] https://www.sicurauto.it/news/batterie-auto-elettriche-costi-in-picchiata-le-previsioni-taglia-prezzi.html

From the report:

> *"Despite that drop, battery costs continue to make EVs more costly than comparable ICE-powered variants. Current projections put EV battery pack prices below $190/kWh by the end of the decade, and suggest the potential for pack prices to fall below $100/kWh by 2030"*

NOTE: This sentence is related to the entire battery pack and not just battery cells.

On the right the projection [16]of battery pack costs from 2010 to 2017. As we can see the cost of batteries was subjected to a 77% reduction in six years, decreasing of a good percentage year by year. The expected result is that price will fall under 100 $ per kWh until 2030.



Graph 11 *FORECAST ABOUT BATTRY PACK PRICE*

Ward's Auto [17]report dated Feb-2017 expressed a different opinion. In the report was stated that EV battery prices could be lower than the magic $100 per kWh by 2020. In an article published, firstly, by Gas2 the author reported the information gained during the Consumer Electronics Show in Las Vegas. Here several experts told him the costs will be under $100 before 2020 and that no longer after that they will go down to about $80.

Even if there is a divergence between the two opinions in terms of time horizon, what is sure is that the $100 per kWh is the limit under which electric cars will gain a competitive price in comparison to traditional ones.

As defined in the three a decrement in batteries' cost will generate a decrease in price and so a positive effect of the demand.

INCENTIVES

Incentives are one of the most effective instruments for decreasing the price and increasing the demand. These are applied at strategic level for increasing the level of attractiveness customers perceived in front of EV cars. As we see in the previous chapter, actually most of countries are adopting incentives' policies, with different mixes, but the most effective ones are those that impact on the purchase price. Why? These have the power to diminish the cost sustained by customers during the purchase. To be noted that countries not pushing on this direction are actually the most underdeveloped in terms of EVS' diffusion. But this instrument can't be exploited forever. For this reason, countries as

[16] https://electrek.co/2017/01/30/electric-vehicle-battery-cost-dropped-80-6-years-227kwh-tesla-190kwh/
[17] https://cleantechnica.com/2017/02/13/electric-vehicle-battery-prices-falling-faster-expected/

China are gradually decreasing the subsidies in order to arrive to the point in which EVs will be independent and the market will grow autonomously.

LEVEL OF OFFER

The level of offer is another element influencing the price and so the demand. As happen in traditional market's mechanisms, an offer's increase stimulates a decrease in the price. In fact, different competitors have to fight for shares, aiming at being attractive for customers and so they opt for reducing the purchase price. An increment in the number of automakers producing EVs, but also in the kind of EVs produced by each producer (enlarging the addressed segments) will lower the price and will increase the demand.

RANGE anxiety

The range is the equivalent of the amount of km that a vehicle is able to run with a complete charge. It depends on the kind of batteries that are installed on the car and it is the "generator" of the so called *"range anxiety".* With this word we can define the phenomenon that the majority of EV drivers face: the fear of not being able to reach the next charging infrastructure with the current charge. The result is that drivers don't feel secure guiding an EV and often they prefer traditional vehicles.

In order to decrease this feeling, producers should increase the number of charging stations (increasing the availability of charging points) and improve batteries' capacity. Let's have a more detailed look on "son-drivers".

CHARGING INFRASTRUCTURE

Charging infrastructures are key elements for increasing the market penetration of EVs and are indirectly correlated with range. In fact, an increase in number of charging infrastructure means a decrease in range anxiety. The usage of infrastructure can be influenced by customers' behaviors and habits: it can happen during the night at home or during the day at work or at the shopping centers as well as public parking area. Charging infrastructures present different combinations of:

1. The kind of locations
2. The kind of charging points (generally normal, usually associated with offers of free electricity to attract demand or fast/ultra-fast, more profitable as customers are willing to pay a higher price for charging rapidly their vehicles)
3. The owners
4. The operators
5. The payment methods

Different combinations of these elements require different business models that can be deployed under three main schemes:

1. **As marketing investment:** generally sustained by manufacturers to support sales of its brand
2. **Private-public partnership**
3. **As part of the regulated asset base of electricity network operators**

Charging electric vehicles means the usage of cables, connectors and communication protocols between the vehicles and the EVSE (electric vehicle supply equipment). The equipment can be classified on the basis of three main features:

1. **Level:** the power output
2. **Type:** depending on the socket and connector used for charging
3. **Mode:** kind of communication protocol between vehicle and charger

These characteristics are defined through standards that are fundamental for spreading EVs' adoption. In this standardization process are involved different entities like International Organization for Standardization (ISO), International Electronical Commission (IEC), Society of Automotive Engineers (SAE) of United States. Also, CHAdeMO, an association of car manufacturers and utilities, became active in this field since 2009 developing the DC quick-charging and giving its name to the fast charger. Another association was the CharIN, born with the aim of developing and promoting a global charging standard. Now it promotes the combined charging system (CCS) and the combo connectors used in Europe and US.

In addition to them, Tesla developed its own standard to support all level and modes through a unique connector, but it can't use it in Europe where Tesla has to comply with the mandatory usage of standards for socket and connectors for normal and high-power recharging points.

Following a table from Outlook 2017 that summarizes the classification of chargers in China, Europe, Japan and North America.

<table>
<tr><th rowspan="2">Classification in use here</th><th rowspan="2">Level</th><th rowspan="2">Current</th><th rowspan="2">Power</th><th colspan="4">Type</th></tr>
<tr><th>China</th><th>Europe</th><th>Japan</th><th>North America</th></tr>
<tr><td></td><td>Level 1</td><td>AC</td><td>≤ 3.7 kW</td><td colspan="3">Devices installed in private households, the primary purpose of which is not recharging electric vehicles</td><td>SAE J1772 Type 1</td></tr>
<tr><td rowspan="2">Slow chargers</td><td>Level 2</td><td>AC</td><td>> 3.7 kW and ≤ 22 kW</td><td>GB/T 20234 AC</td><td>IEC 62196 Type 2</td><td>SAE J1772 Type 1</td><td>SAE J1772 Type 1</td></tr>
<tr><td>Level 2</td><td>AC</td><td>≤ 22 kW</td><td colspan="4">Tesla connector</td></tr>
<tr><td rowspan="3">Fast chargers</td><td>Level 3</td><td>AC, triphase</td><td>> 22 kW and ≤ 43.5 kW</td><td></td><td>IEC 62196 Type 2</td><td></td><td>SAE J3068 (under development)</td></tr>
<tr><td>Level 3</td><td>DC</td><td>Currently < 200 kW</td><td>GB/T 20234 DC</td><td>CCS Combo 2 Connector (IEC 62196 Type 2 & DC)</td><td>CHAdeMO</td><td>CCS Combo 1 Connector (SAE J1772 Type 1 & DC)</td></tr>
<tr><td>Level 3</td><td>DC</td><td>Currently < 150 kW</td><td colspan="4">Tesla and CHAdeMO connectors</td></tr>
</table>

Table 2 *Overview of level and type of EVSE used in China, Europe, Japan and North America. Sources: IEA elaboration based on AFDC (2017), Bohn (2011), CHAdeMO (2012), CharIN (2017a), CharIN (2017b), EC (2014), Electric Vehicle Institute (2017), HK EMSD (2015)*

The following image is helpful for visualizing the differences between AC and DC charging solutions.

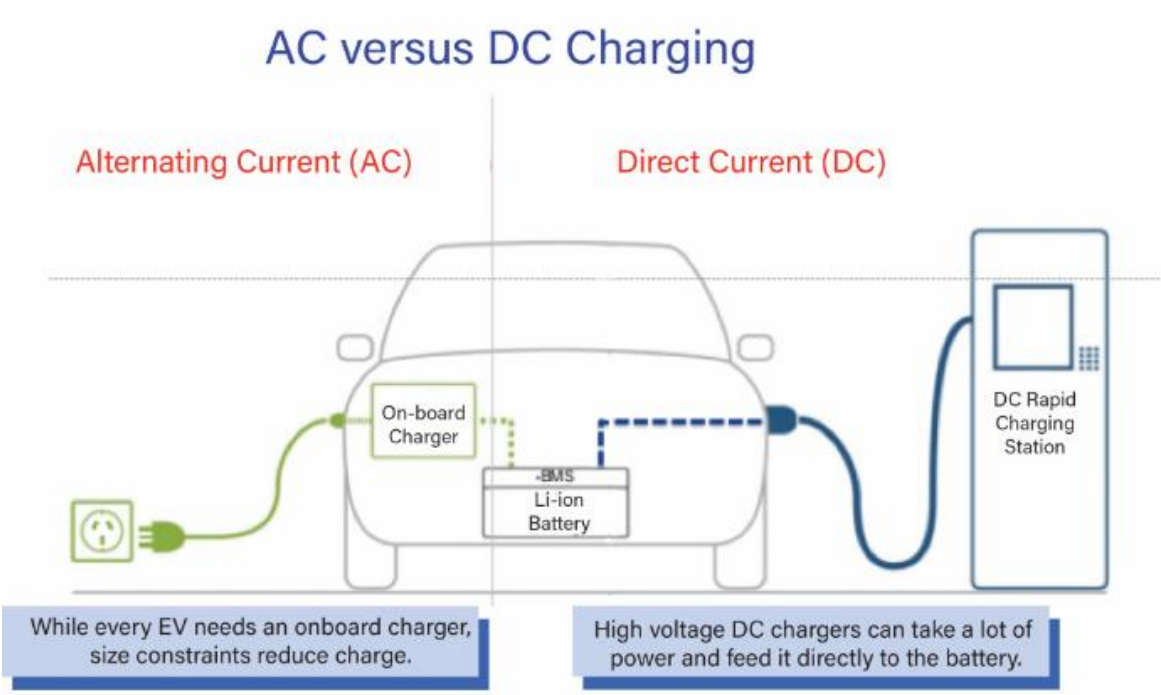


Figure 3 *Visual difference between AC and DC charging solutions*

I think it is interesting also to have a look on the stock and charging infrastructures by country and type, in order to begin entering into the topic that I will treat in the next chapter.

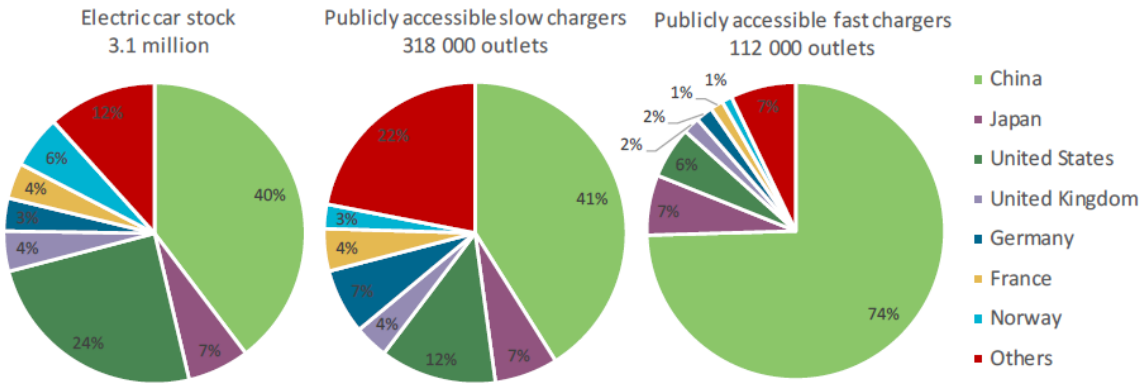


Figure 4 *Comparison between stock and charging type distribution by country. Source: IEA analysis based on EVI country submissions, complemented by EAFO, 2018b.*

The main considerations listed by IEA were the following[18]:

a) *China and Japan tend to have a higher reliance on fast chargers, coherently with constraints that apply to access to private chargers in densely populated cities and the low numbers of EVSE per EV observed for private chargers in the case of China. Several large charging stations have been built in China to serve the needs of various vehicle*

[18] OUTLOOK 2018

modes. The charging station is populated by taxis (50%), LCVs (30%), passenger cars (10%) and buses (10%), highlighting the diversified use of the chargers.

b) *China's high EVSE/EV ratio for publicly accessible fast chargers can also be explained by the high utilization rate of non-private vehicles, such as government fleets and taxis, likely to be more dependent on fast charging to fulfil their daily trips (Ou, 2017). Another element corroborating this is the relatively low range of BEVs in China, compared with BEVs marketed in other countries.*

c) *Norway, the market with the highest electric car sales share globally in 2017, achieved its leadership role despite a rather low share of publicly accessible charging infrastructure compared with the electric car stock. This is consistent with survey results indicating a strong consumer preference in Norway for home charging (IEA, 2018b).*

Finally, an element that should be taken into consideration is the development of a good digitalized charging network, able to provide important advantages to both supply and demand side. Looking at suppliers, a good digitalized charging infrastructure decreases the range anxiety and increases the demand. The supplier will be able to collect a lot of useful data used for improving the service level, on the basis of customers' behaviors. Looking at buyers, lower range anxiety means higher propensity to buy an EV and better customers' experience.

BATTERIES' CAPACITY

Batteries' capacity is improved putting R&D efforts in the development of new technologies. This factor is mainly managed by automakers and for this reason I will deepen the discussion in the "***Endogenous Analysis***" chapter. What I can anticipate is that batteries' capacity is negatively correlated with range anxiety, because the range anxiety decreases when it increases.

CHARGING TIME

The charging time is the amount of time a vehicle needs for being completely charged. It is one of the major limits of EVs as it is, of course, longer than traditional cars. It depends on the kind of charging points that are exploited and can go from a maximum of 6-8 h to 1 h - 30 minutes. Depending on customers behaviors, habits and necessities it can be considered as an important disadvantage or not, but actually it is in the first positions of list of perceived limits. Even if it depends on the kind of technology installed in charging points and not on specific features of vehicles, it is one of the main factors mentioned by drivers as a weakness. A demonstration of this can be the fact that some years ago, when certain charging technologies were not already on the market the global demand of EV was lower. So, the correlation between the charging time and the demand is negative. When the charging time decreases the demand should increase.

GROSS DOMESTIC PRODUCT PER CAPITA

Even if not directly mentioned during surveys, the economic conditions of those countries where EVs are mainly diffused seem to have an impact on EV diffusion. As EVs have actually a higher purchase price than traditional, customers with higher willingness to pay for an electric vehicle will

be those with higher level of income. GDP per capita can be a good approximation. So, I thought it was important to mention also this factor in the group of demand's drivers.

3.2 THE MARKET SIDE

In the following section I will analyze the most relevant countries and how they faced and are facing the e-mobility transformation. In so doing, I will take as starting point the IEA's (International Energy Agency) report (Global EV Outlook 2018) and its analysis of the EV's market in different countries. With the aim of using it in the most reliable and coherent way possible, I will take the majority of data from this report (especially when speaking about market shares or EVs registrations). When the source will be different, I will specify it.

Starting from Europe, as the central continent of my analysis, I will focus on those countries that reached a BEV market share higher than 0.5% during 2017: Norway, France, Germany, Netherland, Sweden and Portugal.

Subsequently, I will analyze the cases of two giants like China and USA, that are actually the leading countries in this sector, considering the sales volume.

For each country, in the first part I will shortly introduce its main characteristics and its general approach to E-mobility. Secondly, I will focus on the two demand's drivers on which a country can act: incentives and charging infrastructures.

> **NOTE**: for the incentives session, as done by EAFO (for European countries) I will group all the initiatives within a table where they will be categorized in one of the following classes (not necessarily all):
>
> - **Registration Tax Benefits**: benefits coming from the registration of new vehicles
> - **Ownership Tax Benefits:** benefits coming from the property of an electric vehicle
> - **Company Tax Benefits:** benefit for companies that equip their car-fleet with the electric or plug-in ones
> - **VAT Benefits**
> - **Other Financial Benefits**
> - **Local Incentives:** those related to the urban transportation
> - **Infrastructure Incentives:** incentives to the contraction of charging stations
> - **Purchase subsidies:** subsidies that incentivize customers to buy electric of plug-in hybrid cars

Thirdly I will provide a view of the EVs new registration from 2010 to 2017, in order to understand what kind of trend each country is facing. In the end, I will list the summary of main future goals each country set about electric mobility and related topics (as climate changes).

The final objective of this section is that of comparing successful States' initiatives with the Italian one, in order to understand Italian weaknesses and the points on which the Government and main Italian actors should focus for getting better the current scenario.

UE[19]

Considering the temporal order, the first document to be mentioned at European level is the "*White Paper for Transport (2011)".* The European Commission adopted 40 initiatives for the next decade to build a competitive transport system that will increase mobility, remove major barriers in key areas and cut carbon emissions in transport by 60% by 2050.

By 2050, key goals will include:

- No more conventionally-fueled cars in cities.
- 40% use of sustainable low carbon fuels in aviation; at least 40% cut in shipping emissions.
- A 50% shift of medium distance intercity passenger and freight journeys from road to rail and waterborne transport.
- Reduction of the dependence on the import of fossil fuels for transport
- Reduction of GHG emissions from transport by 60% relative to 1990 emissions
- Stronger focus on problems related to air quality and congestion
- Improvement of competitiveness of EU industry

In 2014, EU established the "*Deployment of Alternative Fuel Infrastructure* of October,2014 (DAFI)", giving to different States basis for the development of their own policies. The types of fuel included in the directive were: Biofuels, Liquefied Petroleum Gas, Liquefied Natural gas (LNG), Compressed Natural Gas (CNG), Hydrogen, Electricity. Concentrating on the electricity one, the two main points that the Commission highlighted were: the need of having the adequate charging network in urban and other areas (with a minimum of one charger for ten vehicles) and the need to standardize the recharging connectors (Combo 2, EN 62196-3). Trying to face the main challenges related to alternative fuels, in Jan-2013 it proposed the Directive, asking to Member States to adopt specific and personalized policy frameworks for developing the alternative fuels market.

Below is listed what the commission asked to each State:

1. Construction of a defined minimum of charging points (one point for each ten electric vehicles) by the end of 2020 (at least the 0% publicly accessible).
2. Ports equipped with shore-side electricity supply for vessels by end-2015.
3. Construction of right number of hydrogen-refueling points, no further than 300 km apart by 2020, for those States that already have introduced this technology.
4. LNG supply should be available for navigation along the core Trans-European Transport network in maritime ports (2020) and inland ports (2025).
5. LNG refueling points should sustain heavy-vehicle road transport along the TEN-T core network (refueling points at least every 400 km by 2020).
6. By end-2020, Member States should ensure sufficient CNG refueling points are set up (at least every 150 km) to support CNG vehicles across the EU.

[19] https://epthinktank.eu/2014/04/11/deployment-of-alternative-fuels-infrastructure/

Even if my focus will be only on e-mobility, it was important to mention all the main points of this Directive.

As I already explained, the alternative fuels vehicles are a mean through which different countries can face the problem of climate changes. So, it is important to mention also another initiative taken by the UE: the **Paris Agreement.** [20]

In Dec-2015, during the Climate Conference (COP21) 195 countries adopted the "*first-ever universal, legally binding global climate deal".* With this agreement they set-up a sort of bridge between today's policies and climate-neutrality before the end of the century.

It treated six main points:

- **Mitigation: reducing the emissions**→ *a long-term goal of keeping the increase in global average temperature below 2°C above pre-industrial levels* (reducing the risks and impacts of climate changes); *on the need for global emissions to peak as soon as possible, recognizing that this will take longer for developing countries*; *to undertake rapid reductions thereafter in accordance with the best available science.*
  All the countries defined during the conference their **national climate action plans.**
- **Transparency and global stock take**→ with the objective of tracking progresses and communicating results and status of targets each other
- **Adaptation**→ strengthening the society to deal with impact of climate changes and providing support to developing countries
- **Loss and damage** → *it recognized the importance of averting, minimizing and addressing loss and damage associated with the adverse effects of climate change; it acknowledged the need to cooperate and enhance the understanding, action and support in different areas such as early warning systems, emergency preparedness and risk insurance*.
- **Role of cities, regions and local authorities**→ it recognized the role of non-party stakeholders in addressing climate changes including cities and private sector that have to put efforts in the emissions' reduction challenges.
- **Support**→ The EU and other developed countries will continue to support climate action and to carry on their existing collective goal to mobilize USD 100billion per year by 2020 and to extend this until 2025.

Now, let's analyze in detail how EU initiatives impacted singularly the States that faced and are facing e-mobility with highest success.

NORWAY

TOTAL LAND AREA (km2): 323.805 km2

CAPITAL: Oslo

POPULATION: 5.194.000

PASSENGER CARS: 2.500.000

[20] https://ec.europa.eu/clima/policies/international/negotiations/paris_en

GDP (per capita): 98.895 €

Norway is a unitary sovereign State, whose territory comprises the western portion of the Scandinavian Peninsula plus the remote island of Jan Mayen and the archipelago of Svalbard. It is leading the way of transition to zero emission cars, reaching in 2017 the 21% of market share for BEVs.

INCENTIVES[21]

Norway is considered as one of the strongest nations in terms of incentives. Its incentives policy is really effective and is the result of a long-time work that took the nation to become one of the countries with the highest penetration of EVs in the world. In 1989, pushed by Bellona Foundation [22](an independent non-profit organization that aims to meet and fight the climate challenges, through identifying and implementing sustainable environmental solutions) Norway started the promotion of EVs through the famous pop group A-ha.

Figure 5 A-HA *- Norwegian pop group*

In the mid-nineties it cut the annual registration tax and exempted EVs from road tolls. Climate-change policy has been a driving force behind the Norwegian commitment to EVs, reinforced by the strong support received by all the parties in the Parliament. In 2012 Norway adopted a legislation that set the goal of achieving a carbon-neutral transport sector until the end of 2030. It introduced a car import tax on the basis of CO_2 emissions, NO_x emissions, effect and weight and aimed at ensuring the rewarding of low-carbon emissions and a penalization for the more polluting cars. It summoned up the *"polluter pays principles"* exploited in the tax system: higher taxes for high emissions cars (through which incentives for zero emissions will be financed). It's interesting to have a look on a survey conducted by the Norwegian EV Association in 2017, in which customers were asked to select the first three most important incentives according to their perspectives.

The mainly selected are those that make EVs price competitive at the time of buying the car. The research highlighted the ***upfront cost as a more influencing factor*** than the total cost of ownership in the purchase process.

[21] https://elbil.no/english/norwegian-ev-policy/ + https://wpstatic.idium.no/elbil.no/2016/08/EVS30-Charging-infrastrucure-experiences-in-Norway-paper.pdf + https://wpstatic.idium.no/elbil.no/2016/08/EVS30-Norwegian-EV-policy-paper.pdf

[22] http://bellona.org/assets/sites/3/BellonaBrief_EV-Norwegian-Success-Story.pdf

Another important point is the "***incompatibility, lack of re-charging points and limited driving range***". This factor took the government to improve the consumers' confidence regarding this technology offering free recharging from thousands of points along the country or providing subsidies amounting to up to 6000 €/ per year per vehicle for the installation of home-charging points.

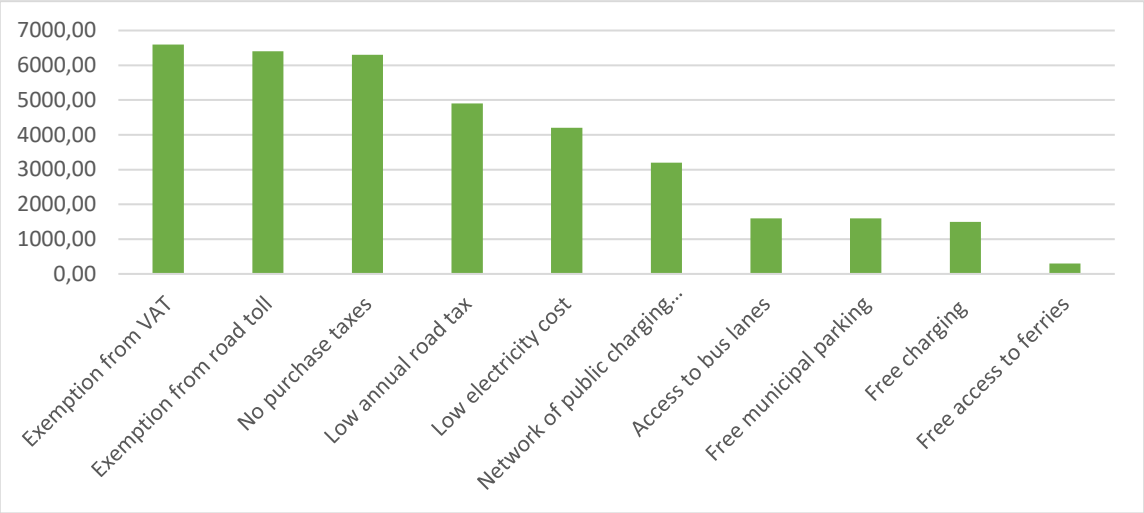


Table 3 SURVEY's RESULTS *- in this table are summarized the results emerging from the survey mentioned above. results are ordered in a degrowing order, from the most selected*

The success of Norway is mainly due to the contemporaneous adoption of a ***push and a pull strategy***. An "EV-friendly" car taxing system with the possibility to drive EVs cheaply was combined with the fast development of an effective charging infrastructure. The main points of EV policy are listed here, but while looking at them, we should remember that all of them will be revised and adjusted in parallel with market development during the coming years.

INCENTIVE CATEGORY	DESCRIPTION
Registration Tax Benefits	Purchase Tax exemption for BEV's/FCEV's, reduction for PHEV's (Up to 10.000€)
Ownership Tax Benefits	Tax reduction
Company Tax Benefits	Tax reduction
VAT Benefits	No VAT tax (BEV / FCEV)
Other Financial Benefits	No import Tax - Purchase tax/import tax is the same in Norway
Local Incentives	- Urban toll exemption - Highway toll exemption - Free Parking - Bus lane use - Funding in some cities for normal charging stations in shared apartment buildings, shopping centers, parking garages etc
Infrastructure Incentives	Public funding for fast charging stations every 50 km on main roads

Table 4 NORWAY INCENTIVES' POLICY *- Categorization and description of Norwegian incentives' policy*

CHARGING INFRASTRUCTURE

In 2015, Norway was not entirely prepared for the exponential growth of EVs. For an average 72.000 EVs on the road, there were less than 10.000 charging points. All of that is now changing. Most of consumers are charging at home and manage without fast charging daily. But for longer trip, a good and fast charging infrastructure is needed. They are willing to pay three times more than they pay for electricity at home, for that kind of re-charging network. The European Clean Power for Transport directive recommends that there should be one public available charging point for every 10 electric cars by 2020. With an increasing market share from 22% in 2015 to 30% in 2020, the Norwegian EV population may reach 250.000 by 2020. This shows that there should be around 25.000 public charging points available by 2020 and in 2015 there were only approximately 1.350 charging points complying with EU standards.

The good news is that the Norwegian government has launched a program to finance the establishment of at least two multi-standard fast charging stations every 50 km on all main roads in Norway. Additionally, a new network of 180 EV charging stations is currently being constructed. It runs all the way from Italy to Norway and is funded by the European Union (EU).

Norway's charging networks can be divided into two main kind of infrastructures: normal and fast.

- ➔ **NORMAL:** different Norwegian governments supported the development of basic charging infrastructure. The first governmental scheme started between 2009-2010 as a consequence of a 2008-initiative that funded 100 % of the installation cost for normal chargers. The total support was around 5.243.064 € and it resulted in 1800 Schuko-points spread all over the country. Many of them can still be used, but the majority become obsolescent because of the cost of maintenance. Today public charging stations are mostly Type 2.
- ➔ **FAST:** the governmental support schemes for fast charging stations run from 2010-2014 at the same cost of normal ones, with the only difference that this had been addressed ONLY to installation costs and not also to operating ones.
  From 2015 the state enterprise Enova introduced a support scheme which aims at covering the Norwegian main roads with fast charging stations every 50 km. It also defined the kind of installation: at least two multi standard fast chargers (CHAdeMO and CCS) and two 22 kW Type 2 points. The road network is divided into several smaller segments and operators compete for public funding. All the stations are owned and/or operated by charging operators. Actually, the construction of charging infrastructure is gaining a purely commercial nature as the largest cities operators started to build stations without the public supports. Charging operators are also responsible of the payment's methods introduced in their own stations.

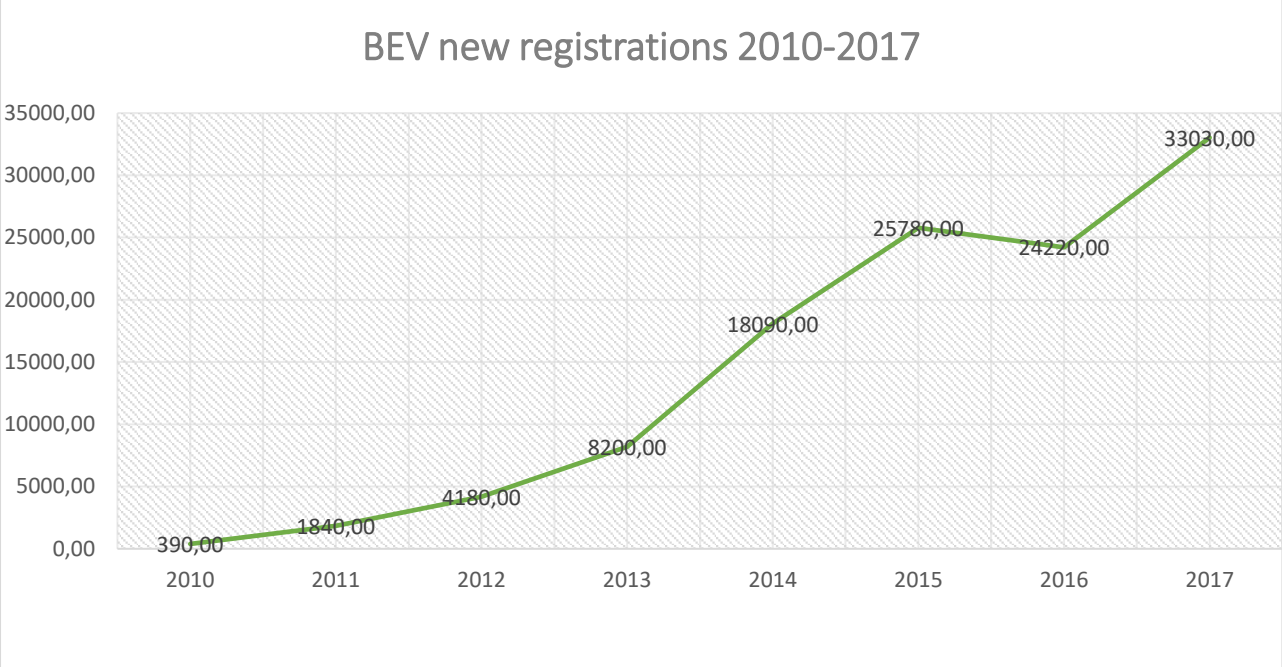
  As of June 2017, the fast charging infrastructure in Norway according to the NOBIL (Norwegian Charging Station Database for Electromobility) database:

  - 648 CHAdeMO points
  - 595 CCS points

- 47 AC Type 2 43 kW points
- 246 Tesla Superchargers

EVs NEW REGISTRATIONs

Its strong positioning can be concretely seen in the table below, where are summarized all Norwegian BEV new registration from 2010 to 2017. After 2013, the number of BEV overcame 10.000 units and started its continuous growth. I think it can be associated with the parallel development of an official incentives' policy and with the increasing focus on the installation of charging points.



***Graph 12 NORWEGIAN BEV NEW REGISTRATIONS** - in this graph is presented the Norwegian trend of BEV registrations from 2010 to 2017*

FUTURE SUSTAINABILITY GOALs[23]

- By 2025, all new cars sold should be zero (electric or hydrogen) or low (plug-in hybrids) emission.
- By 2025, shore side electrical power and charging power are to be available for ships in major ports
- By 2026, have emissions-free vessels in Fjordsan near harbors
- By 2030, new heavy vans, 75 % of new long-distance buses, and 50 % of new lorries are to be zero-emission vehicles
- By 2030, 40% of all ships in local shipping are to run on biofuels or be low-/zero emission vessels
- By 2030, goods distribution in major urban centers are to be almost emission free

[23] https://www.innovasjonnorge.no/en/start-page/invest-in-norway/industries/electric-mobility/

- By 2030, as transport, including maritime transport, accounts for a large part of Norway's greenhouse gas emissions so the National Transport Plan aims for a 50 % reduction of emissions from transport
- By 2040, all short-haul flights to be 100% electric

FRANCE

TOTAL LAND AREA (km2): 551.500 km2

CAPITAL: Paris

POPULATION: 67.063.000

PASSENGER CARS: 32.244.000

GDP (per capita): 42.175 €

It is an European State situated in Western part of Europe and it is composed of a metropolitan part as well as different overseas regions and territories. Starting from 2009 the French Government spent 120 million € in R&D concerning the environmental and sustainability topics, with a long-term goal about the electrification of French transportation. It mainly focused on batteries' sector. Numerous automakers (like Renault) started to build partnerships with other battery makers aiming at developing new technologies. France gained 273 patents in that sector and the 15% of them was assigned to Saft, a French company working since 1918 in this field. Additionally, in 2010 the "*Investissments d'Avenir"* (Investments for the future) was created under the National loan plan, with the objective of providing French companies the support needed for the experimentation and validation of new technologies.

INCENTIVES[24]

The majority of laws and regulations are related to tax incentives and to the construction of charging infrastructures. The Grenelle II legislation is the set of laws deriving from the European initiatives. This new legislation covers a variety of topics such as climate and energy, biodiversity, public health and defined, implicitly, the French sustainable-development strategy for the coming years.

In the past the incentives' policy addressed both electric and hybrid models but starting from 2018 the Government decided to exclude the hybrid ones from those providing purchase benefits. The reason is mainly related to the fact that hybrid-powered cars produce emissions higher than 20 g CO2/km. For those owning a PHEV there will be a bonus of 2.500 € for buying a new BEV. This kind of initiatives will help in pursuing strategic goals listed below.

Considering local initiatives, it's interesting to mention the peculiarity of Paris[25] that has launched an own EV program, announcing additional grants for the procurement of electric buses (around 9.000 €) and EVs (around 6.000 €) used by schools.

[24] https://www.autovistagroup.com/news-and-insights/french-government-introduce-incentives-new-low-emission-vehicles + http://www.ieahev.org/by-country/france-research/

[25] http://oecdobserver.org/news/fullstory.php/aid/5305/Paris_leads_the_way_in_electro-mobility.html

INCENTIVE CATEGORY	DESCRIPTION
Purchase Subsidies	-Electric and hybrid electric vehicles emitting 20 g/km or less of CO 2 benefit from a premium of € 6,000 under a bonus-malus scheme. -For vehicles emitting between 21 and 60 g/km, the premium is € 1.000. -Diesel Scrappage Scheme: Switching a 11 year or more diesel for a new BEV grants an extra 4.000€ (Or 2.500€ in case it is a PHEV). -The "L" category (Quadricycles, Motorbikes, Scooters...) also has a purchase subsidy (Lead battery vehicles excluded), with €250 per kWh, with a limit of € 1.000 or 27% of purchase price
Registration Tax Benefits	Road Tax Exemption / Reduction
Ownership Tax Benefits	Road Tax Exemption / Reduction
Company Tax Benefits	Electric vehicles are exempt from the company car tax. Hybrid vehicles emitting less than 110 g/km are exempt during the first two years after registration.
Local Incentives	Local subsidies

***Table 5 FRANCE INCENTIVES' POLICY** - Categorization and description of French incentives' policy*

CHARGING INFRASTRUCTURE [26]

The French first move to electrification was a Government's investment for the construction of public and private infrastructure with the deadline in 2015. It was part of a national installation strategy for ensuring a sufficient driving range and was focused on three main groups:

1. **Enterprises:** regarding the installation of charging stations for corporate fleets but also for providing to employees the possibility to charge their own cars.
2. **Public domain:** deployed in public areas such as parking garages and roadways and also suitable for vehicles used in the sharing economy.
3. **Residential sector:** available to individual users.

In 2017, France established 12.000 charging points, being the leader of installation for that year in comparison to the other European countries.

The French strategic roadmap put in place different challenges that evolved differently depending on three main variables:

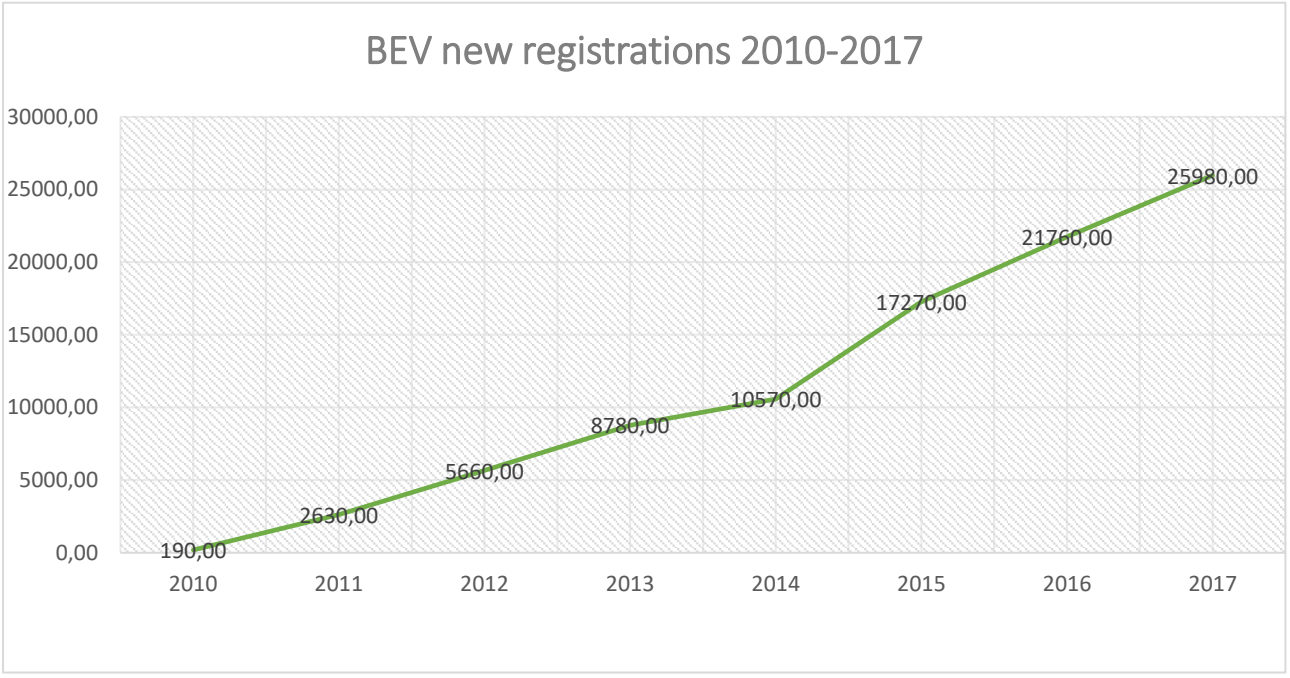
1. **Standards:** the question of standardization was treated at both national and European level. In fact, initially it was possible to find a variety of charging methods. But in the end, the introduction of standards was the winning choice for facilitating interoperability, safety, cost-competitive infrastructure and the management of electricity's demand.

[26] https://uk.motor1.com/news/229029/france-charging-points-2017/ + http://www.ieahev.org/by-country/france-research/

2. **Entire market-system:** this definition looks at the business models that will govern the entire charging infrastructure ecosystem, including vehicles, batteries, the installations and operations. The business model is surly the long-term success factor. Challenges include changing the financing model for vehicles, batteries, and infrastructure, and how to use batteries once they can no longer power a vehicle.
3. **Match infrastructure supply with demand:** the third element is the interaction between vehicles, users, and the charging for matching the demand with the supply. Infrastructures are one of the most influencing elements because of their impact on the "range anxiety". By 2020, France has the objective to gain equilibrium between these two parties and is conscious that will reach it only through a strong commitment of the Government. Instead, the future 2050-goal is that of being independent from Government through new economically and industrially viable business models.

EVs NEW REGISTRATIONs

Initially France was more focused on the diffusion of PHEV vehicles, this is the reason why looking at the following table the starting numbers are low. After 2014, the new registration started to growth with a so positive trend in comparison to the first 4 years. If I think about the fact that purchase benefits started to address only BEVs at the beginning of 2018, France can expect a faster growth.



***Graph 13 FRENCH BEV NEW REGISTRATIONS** - in this graph is presented the French trend of BEV registrations from 2010 to 2017*

FUTURE SUSTAINABILITY GOALS [27]

The goals listed below are mainly taken from the Grenelle II legislation.

- By 2020, 20% of reduction of region-wide emissions → this goal can be potentially transformed into 30% reduction
- By 2020, 40% reduction of the average energy consumption of buildings. They provided some parameters to be respected during the construction of new structures and for the renovation of old ones. The final objective is that builds must be "**energy positive**" in the sense that they have to produce more energy than that they consume
- By 2020, 23% of France's energy must come from a mix of renewable energy sources - most likely from hydropower (the nation's largest renewables source so far), wind power, and biomass
- By 2025, make the circular economy a central feature of the energy transition in order to reduce the amount of waste and achieve 100% plastic recycling
- By 2040, hydrocarbon exploration plans will be prohibited, and France will no longer produce any oil, gas or coal
- By 2040, take greenhouse gas-emitting vehicles off the market: stopping sales of petrol or diesel cars will encourage car manufacturers to innovate and take the lead on this market. Around 100.000 vehicles will be eliminated from French roads.
- By 2050, achieve **carbon neutrality**: government will seek a balance between man-made emissions and the ability of ecosystems to absorb carbon. In world terms, only France, Sweden and Costa Rica have made this a requirement to be met
- By 2050, 80% emissions' reduction. It means 3% of reduction per year. This project has been divided into four parts and for this reason has been defined "Factor 4"

GERMANY

TOTAL LAND AREA (km2): 357.121 km2

CAPITAL: Berlin

POPULATION:81.276.000

PASSENGER CARS: 43.851.000

GDP (per capita): 47.594 €

Germany is situated in the central part of Europe and is the second most popular country for migration in the world. The German government assigned a high importance to electromobility to the point that in 2007 it was included in the *Energy and climate program* as a mean to reach its climate targets. For Germany electromobility has the power to be *environmentally friendly and to fit for the future.*

[27] https://www.gouvernement.fr/en/climate-plan

From the German perspective these are the main reasons considered looking at the potentiality of EVs:

1. Climate and environment protection (by reducing emissions of CO2 and other pollutants).
2. Future-oriented nature of this industry that can provide more than one million jobs in Germany (particularly in small- and medium-sized companies).
3. Higher independence from oil-based fuels.
4. Higher exploitation of renewable sources of energy.

INCENTIVES[28]

The German incentives' strategy has been initiated in 2008 during the "*National Strategic Conference on Electromobility"* through a discussion that involved different stakeholders of the industry, researchers and politicians. The result was a set of measures grouped in the *National Development Plan for Electric Mobility.*

The initial target was that of reaching one million EVs on the road by 2020. So, R&D national projects as well as projects in model regions have been launched with an initial budget of 500 million euro for the period between 2009 and 2011.

On 3 May 2010, after a high-level meeting, the creation of a National Platform for Electric Mobility (NPE) and the adoption of a Joint Declaration were announced. Through these initiatives Germany aims at becoming a leading provider in the sector.

During 2016, the purchase subsidies were introduced with the aim to add 300.000 EVs on its road by 2019 and even if initially the slope about applications had a positive trend, it subsequently declined. So, in order to incentivize the acquisition and to reach the goal until 2019 the purchase benefit (previously dedicated only to those cars with a price lower than 60.000 €) was extended to more expensive vehicles (like Tesla) at the beginning of 2018.

INCENTIVE CATEGORY	DESCRIPTION
Purchase Subsidies	- For pure electric cars, there is a grant of 4,000 euros. For hybrids, it is 3,000 euros. - Rewards are only for cars with a list price of a maximum of 60,000 euros (base model). - The promotion lasts for a maximum total of 400,000 cars. - The federal government contributes a total of 600 million euros. The cost should ever share federal and automakers half. Overall, the funding is therefore EUR 1.2 billion. - The promotion ends in 2020.
Ownership Tax Benefits	Exemption for the first 10 years for cars registered until Dec 31, 2015, 5 years from then on to Dec 31, 2020

[28] http://www.ieahev.org/by-country/germany/

Company Tax Benefits	Tax deductions on company cars
Other Financial Benefits	- Transport companies are paying reduced electricity tax for the operation of their electric or hybrid buses (11.42€/MWH instead of 20.5€/MWH)
Local Incentives	BEV benefits: - Free Parking - Reserved Parking spots - Bus lane use

***Table 6 GERMANY INCENTIVES' POLICY** - Categorization and description of German incentives' policy*

CHARGING INFRASTRUCTURE[29]

Starting from the "Electric Mobility in Pilot Regions" program the first goal related to charging infrastructure was that of realizing 2.000 charging stations by 2011.

Looking at the analysis of a research group of NPE (previously mentioned), is interesting to understand how they described the undersupplied situation of infrastructure and the subsequent range anxiety. The resulting scenario: during those years the majority of users were used to charge their vehicles at home (during the night) or at the workplace (during working hours) and there were additional user groups that required a publicly accessible charging infrastructure. The low utilization rate caused a poor cost-efficiency ratio and so, as is explained in the report, the ramp-up of vehicles was much stronger than the development of publicly accessible points. To solve this problem the NPE planned a staggered approach to develop a **nationwide fast charging network.**

[29] http://nationale-plattform-elektromobilitaet.de/fileadmin/user_upload/Redaktion/AG3_Statusbericht_LIS_2015_engl_klein_bf.pdf + http://www.ieahev.org/by-country/germany/

Following I attached the short version of the plan[30].

Stage 1 *(around 1400 points, up to 2017):*

- *Preparing the grid supply capacity to several times ≥ 150 kW at central intersection points and important transport links*
- *Building some 1,000 charging points with a charging capacity of 50 kW on main traffic arteries*
- *Plus, building some 400 charging points, mostly with a 50 kW charging capacity, in major cities*

Stage 2 *(from 2017):*

- *Increasing the number of DC charging points towards the 7,100 DC fast charging points that are required by 2020*
- *Simultaneously increasing the output of individual charging points at traffic intersection points and important transport links to ≥ 150 kW*
- *Installing 150 kW charging stations at several hundred locations on motorway arteries and a correspondingly high grid supply capacity for simultaneous fast charging at several charging points, each with a 150 kW charging capacity*
- *Increasing the density of the fast charging network at important transport links and in major cities with 150 kW and 50 kW charging points in preparation for Stage 3 (also beyond 2020)*

Stage 3 *(from 2020):*

- *By 2025, it is anticipated there will have been a significant improvement in battery performance and thus in the range that electric vehicles can cover. This will require higher charging capacity*
- *Depending on the availability of vehicles with the corresponding battery technologies, individual charging points on main traffic arteries will prospectively be configured with a charging capacity of up to 350 kW – with a corresponding improvement in grid connection/expansion*
- *In terms of power generated from renewables, legislation stipulates an increase to a share of 40 to 45 percent by 2025.*

This was the strategic approach adopted by NPE, but at the same time other external and somehow unsuspected actors intervened.

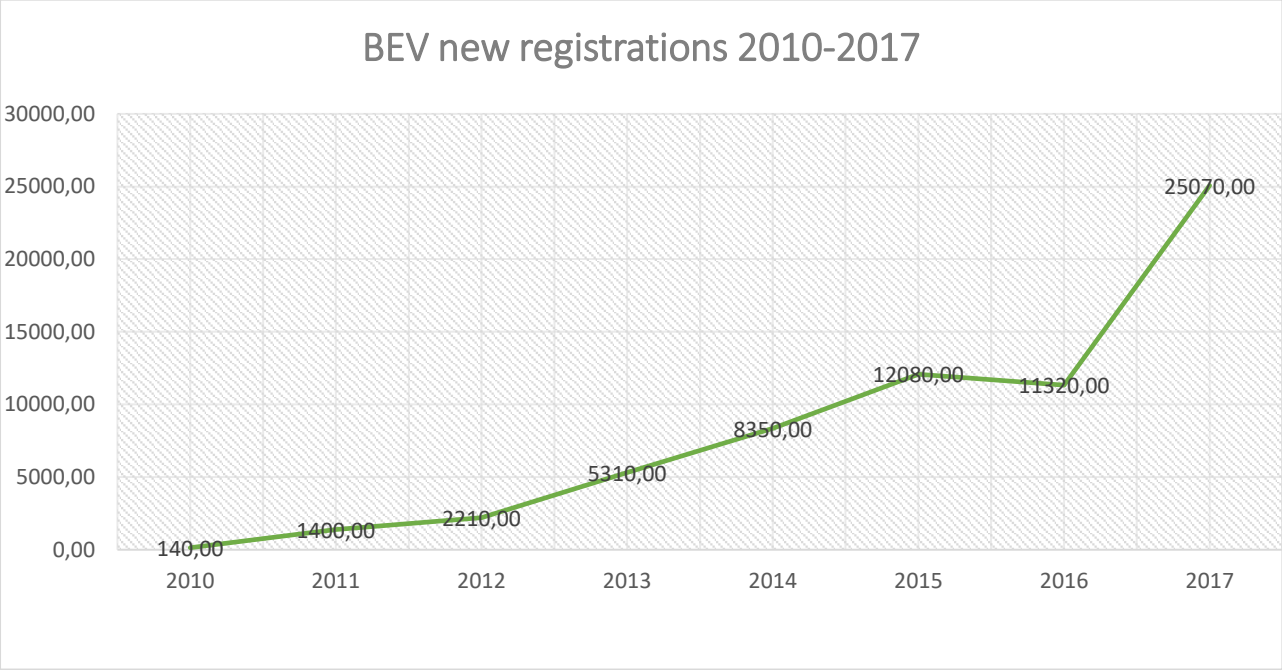
For example, the case of Telekom, an European telecommunications company, headquartered in

[30] http://nationale-plattform-elektromobilitaet.de/fileadmin/user_upload/Redaktion/AG3_Statusbericht_LIS_2015_engl_klein_bf.pdf

Germany that confirmed its efforts to put in place a massive plan with the aim of doubling the current electric car charging stations, **by converting 12.000 of its distribution boxes.** This plan alone would double the current charging infrastructure in the country.

EVs NEW REGISTRATIONs

As is visible in the table below, BEV new registration had a positive trend until 2015 and a little decrease in 2016 that was recovered during 2017.



***Graph 21 GERMAN BEV NEW REGISTRATIONS** - in this graph is presented the German trend of BEV registration from 2010 to 2017*

FUTURE SUSTAINABILITY GOALS

The listed goals are mainly taken from the German Sustainable Development Strategy 2016.

- By 2020, one million electric vehicles and a further 500,000 fuel-cell-powered vehicles operating on the nation's roads.
- From 2008 to 2050, increased the energy productivity by 2,1% per year
- By 2020, reduction of 20% of primary energy consumption and 50% by 2050
- By 2050, an incremental increase of share of renewable energy sources in gross final energy consumption→ 18% by 2020, 30% by 2030, 60% by 2050
- By 2050, an incremental increase of share of renewable energy sources in gross electricity consumption → 35% by 2020, to at least 50% by 2030, to at least 65% by 2040 and to at least 80% by 2050
- By 2050, incremental reduction of greenhouse gas emissions (in each case compared to 1990)→ 40% by 2020, by at least 55% by 2030, by at least 70% by 2040 and by 80% to 95% by 2050

NETHERLANDS

TOTAL LAND AREA (km2): 41.543 km2

CAPITAL: Amsterdam

POPULATION: 16.933.000

PASSENGER CARS: 8.000.000

GDP (per capita): 51.297 €

Netherlands is situated in the Western Europe and together with three island territories in the Caribbean, it forms a constituent country of the Kingdom of the Netherlands. In 2009 it started the *Action Plan for Electric Driving* that was implemented until 2011 with the aim of making Netherlands a sort of mentor for electric mobility. Policies and Legislation are mainly focused on CO2 and NOx emission reduction, as well as improving the air quality. From its perspective, electric mobility has the possibility to succeed but only through a joint collaboration between different stakeholders like NGOs, social institutions, knowledge centers and group of other authorities.

INCENTIVES[31]

The *Action Plan*, as mentioned, comprehends the support of both Central Government and other stakeholders for a total amount of 500 million € in expenditures. The Central Government contribution consist in three main pillars:

1. **Formula E-team's establishment:** a robust group of stakeholders, coming from different industries, with the objective of introducing and implementing a successful development-strategy**.**
2. **Implementation:** focused on starting the practical testing projects, on launching charging and energy infrastructures, R&D activities and on drawing ancillary policy
3. **Market introduction**

Another interesting fact sponsored by the Dutch government was a dedicated communication program based on the concept of **eco-driving** for drivers of all type of vehicles. For pursuing the goal of this project, the government set a training course to earn a car operator's license. They saw this initiative as a way for improving the fuel economy as well as the EV's range of adoption.

In the table below, you can find a summary of all the incentives. Is important to highlight that in 2016 the PHEV incentives were suspended.

INCENTIVE CATEGORY	DESCRIPTION
Registration Tax Benefits	Zero emission cars are exempt from paying registration tax. For other cars the system is progressive, with 5 levels of CO2 emissions that pay different amounts of registration tax. Plug-in hybrid cars go to level 1,

[31] http://www.ieahev.org/by-country/the-netherlands-policy-and-legislation/

	1-79 gr CO2/km and pay € 6 per gram. For level 2, 80-106 gr CO2/km the tariff is € 69 per gram CO2. The final level is € 476 per gram for 174 gr CO2/km or over.
Ownership Tax Benefits	- Road tax: Zero emission cars are exempt from paying road taxes. Plug-in hybrid cars (< 51 gr CO2/km) pay 50% of the road tax for a regular car.
Company Tax Benefits	- Surcharge on income tax for the private use of company cars: In the Netherlands, income tax has to be paid on the private use of a company car. This is done by imposing a surcharge of 4-25% of the catalogue value on the taxable income. For zero emission cars this percentage is 4%. For most plug-in hybrids the percentage is 15% (< 51 gr CO2/km), the next level (51 – 106 gr CO2/km) is 21%. Over that, 25% is imposed. - Tax deductible investments: The Netherlands has a system of facilitating investments in clean technology, by making these investments partially deductible from corporate and income taxes. Zero emission and plug-in hybrid (and not with a diesel engine) cars are on the list of deductible investments, as are the accompanying charging points.

***Table 7 NETHERLAND INCENTIVES' POLICY** - Categorization and description of Dutch incentives' policy*

CHARGING INFRASTRUCTURE [32]

Most of initial effort put in the construction of charging infrastructure comes from the E-laad, a consortium initiated in 2010 by six national network operators that spent around 25 million € for covering all costs and that is continuing to maintain and upgrade about 3.000 stations around country.

Another huge investment was covered directly by the Government that provided 16 million € through its "*Electric Mobility Gets Up to Speed"* program. The aim of this plan was to reach 200.000 EVs on the road by 2020, but an important condition for this growth was a sufficient number of charging stations. It was based on 3 pillars:

1- **Concentrate on focus areas:** looking firstly to those cities with stronger issues in terms of air quality and aiming at implementing it in other regions after successful results in the focus ones.
2- **Stimulate promising market segments**
3- **Support consistently the electric mobility** as it can contribute to a sustainable economic growth

[32] https://www.google.it/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&ved=2ahUKEwjpuvzo6MPcAhXyzIUKHTlJDeUQFjABegQIARAC&url=https%3A%2F%2Fdspace.library.uu.nl%2Fbitstream%2Fhandle%2F1874%2F347179%2FMaster%2520thesis%2520Roland%2520Torensma.pdf%3Fsequence%3D1%26isAllowed%3Dy&usg=AOvVaw0HjRcVo5YroBTq_b65k8Yc + file:///C:/Users/utente/Desktop/EV-charging-best-practices_ICCT-white-paper_04102017_vF.pdf

Recently (2016) they introduced the "*Green Deal*", another initiative focused on the promotion of charging infrastructures, that includes also a strong network of partnership. It is an agreement between Government and other stakeholders to support the development and implementation of sustainable initiatives, so it is linked with energy, climate, water, mobility and building topics.

From 2010 to 2016 more than two green deal were signed and the last (dated 2016) was really focused on the Electric Mobility topic. It aims at preparing the market, making it independent from further public support by 2020.

The result of these policies is an infrastructure divided into **public, semi-public and fast charging,** that are highly concentrated in four main cities (Amsterdam, Rotterdam, The Hague and Utrecht):

- **Public:** installed with public money, is opened 24/7 and is built on public ground.
- **Semi-public:** it is privately installed on a private property but can be accessed by public. An example can be a multi-story car park location.
- **Fast charging:** for this kind of stations is used a different technology

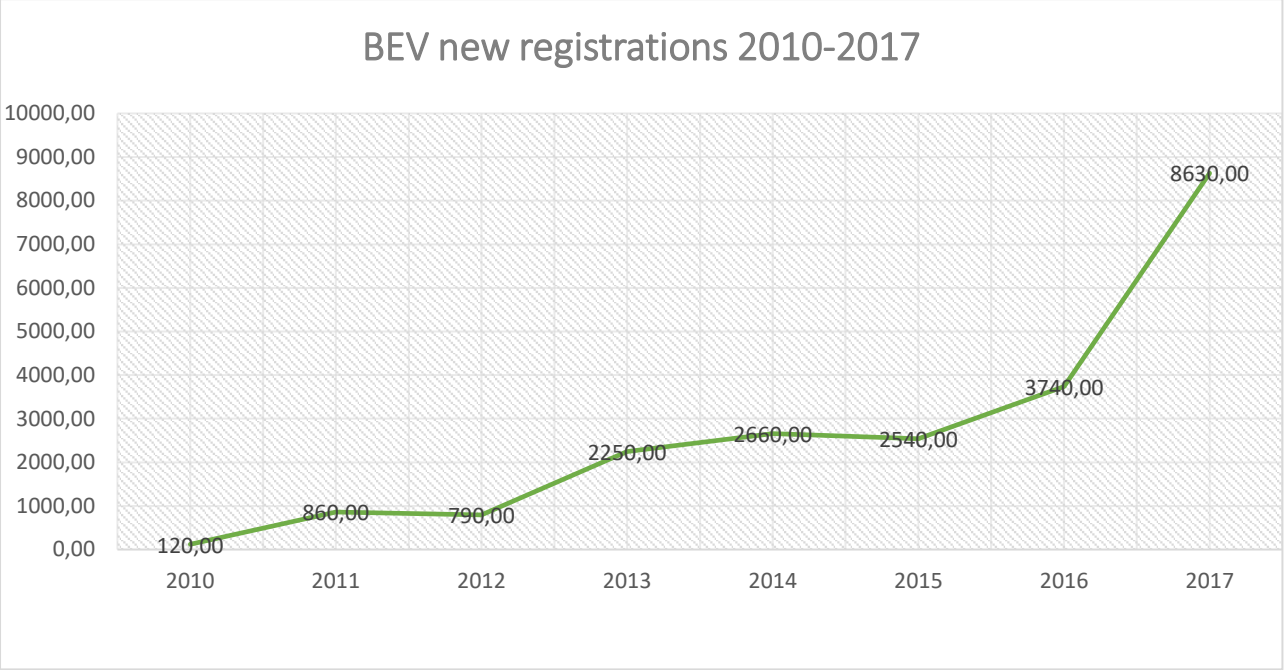
Following two examples of different initiatives adopted also at local level for supporting e-mobility:

- **Noord-Brabant** initiated a smart charging trial project in 2014 and has announced tenders for the installation of 2.000 new smart charging stations starting in 2017.
- **Amsterdam**, **Utrecht and The Hague** in partnership with utility Nuon, will install curbside chargers on demand.

EVs NEW REGISTRATIONs[33]

Netherlands is considered one of the leaders in the EV sector and this is mirrored by its market share that was around 6,4% at the end of 2017. In 2016 the PHEV have been excluded from incentives' policies and so while this category saw a 50% decrease, the EVs rose 47%.

[33] Outlook 2018



***Graph 22 DUTCH BEV NEW REGISTRATIONS** - in this graph is presented the Dutch trend of BEV registration from 2010 to 2017*

FUTURE GOALS

- By 2020, electric vehicles have to reach the 10% of new vehicles
- By 2020, 20% of CO2 emissions' reduction in comparison to 1990. The coalition b/w the Butch government and several leading parties is actually pushing for a more aggressive goal (49% reduction by 2030)
- By 2025, electric vehicles have to reach the 50% of new vehicles
- By 2025, 100% electric public bus sales and 100% electric public bus stock by 2030.
- By 2030, all new cars will be zero-emissions as stated by the coalition b/w the Dutch government and several leading parties
- By 2030[34], ban new petrol and diesel cars
- By 2030, called for the closure of all coal plants and for increased use of carbon capture
- By 2050, passenger vehicle fleet only made of EVs

SWEDEN

TOTAL LAND AREA (km2): 449.964 km2

CAPITAL: Stockholm

POPULATION: 9.816.000

PASSENGER CARS: 4.495.000

GDP (per capita): 58.290 €

It is a Scandinavian country situated in the Northern Europe and it is the third largest country in the European Union by area. This country has put a lot of effort in last decades in order to push

[34] https://arstechnica.com/cars/2017/10/dutch-government-wants-all-new-cars-to-be-emissions-free-by-2030/

customers to adopt hybrid or electric vehicles and the result was that in 2016 Sweden had the third largest market share of BEVs. Since 2006 they started to introduce the concept of *Green car,* through which they specified certain criteria that gave the possibility to owners to receive some benefits, like tax reliefs. In June 2017, they introduced a new progressive Climate Law [35]that reflected the national strategy and was focused on three key areas:

1. **Transport efficient society**
2. **Use of renewable fuels**
3. **Electrification of vehicles**

Actually, Sweden is part of the Nordic electricity market already almost decarbonized.

INCENTIVES

The incentives' policy was slowly adopted by the government. It started to associate *Green cars* to a granted purchase rebate, between 2006 and 2009. Continuing to focus on this kind of vehicles, they provided an exemption from annual vehicle taxes for the first five years of circulation. The main objective was to encourage the acquisition of energy efficient or powered by renewable fuels vehicles.

The evolution of this initiative was the *Super Green Car rebate* "*Supermiljöbilspremie*[36]*"* that was introduced in 2012 and is actually considered the backbone of Sweden EV policies. It reached its target at mid-2014 but was extended in 2015 and 2016. In 2016 it changed, granting the rebate to new sales vehicles with tailpipe emissions lower than 50 g CO2/km. Both private and company cars were impacted by the Super Green.

Starting from July-1st 2018[37] it decided to replace the Super Green with a bonus-malus system for new light vehicles. Regular petrol vehicles will receive increased taxation and plug-in vehicles will receive an increased bonus under the new scheme. By doing so, the proportion of EVs will increase and the oil dependence of transport sector as well as the climate impact will mutate positively.

Considering the public transportation in 2016 was introduced a subsidy through which both battery and plug-in hybrid buses can be granted a variable rebate. The regulation determines the size of rebate that varies depending on the maximum transport capacity. For buses classified as electric and for trolley buses is granted the maximum rebate.

INCENTIVE CATEGORY	DESCRIPTION
Purchase Subsidies	Super green car premium new cars: A so called "Super green car premium" (Supermiljöbilspremie) of SEK 20,000 for PHEV and SEK 40,000 for BEV is available for the purchase of new cars with CO2 emissions of maximum 50 g/km
Ownership Tax	Five-year exemption from paying annual circulation tax

[35] http://www.ieahev.org/by-country/sweden/
[36] https://www.theicct.org/blog/staff/lessons-learned-sweden-EV-rollercoaster
[37] https://gas2.org/2018/05/03/new-policies-expected-to-boost-ev-sales-in-sweden/

Benefits	
Company Tax Benefits	Reduction of company car taxation

Table 8 SWEDEN INCENTIVES' POLICY - Categorization and description of Swedish incentives' policy

CHARGING INFRASTRUCTURE [38]

The Sweden Government started to concentrate a higher effort on e-mobility in 2015 when it launched two investment support schemes: *Climate Leap* and *Urban Environment Agreements.*

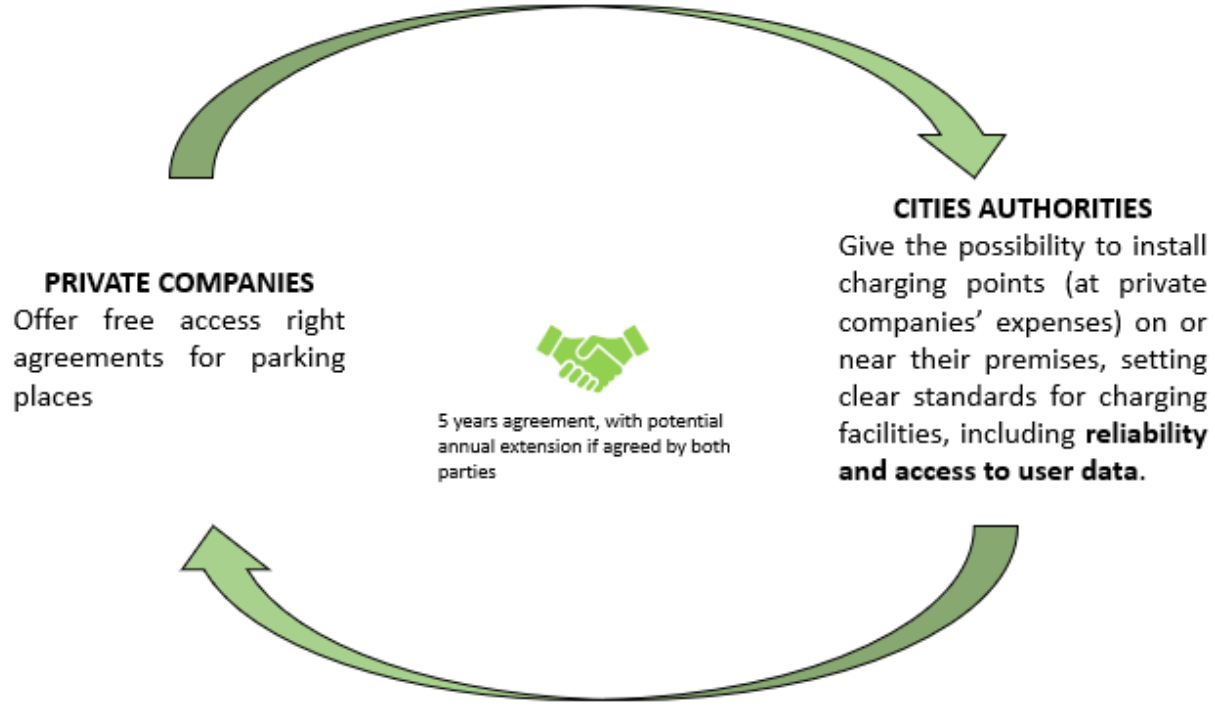
The first aimed at granting investments support to GHG's emissions reduction, but it specifically encouraged investments in charging infrastructures. The time horizon is between 2015 and 2020 and until July 2017 around 8.800 charging points have been granted support. The two-thirds of them are normal charging points (following the EU definitions it means that they are <22 kW) and are distributed between public and non-public. While the remaining are the fast ones and will be installed as public points.

NOTE: in Sweden the two categories used are <23 kW and >23 kW

The second aimed at promoting the sustainable environments through the creation of right conditions for an efficient and effective public transport service. The new measures adopted should lead to energy efficient solutions and to an improvement in the air quality.

Considering the local case of Stockholm,[39] it aimed at becoming the leading city in this sector. In 2014 it started a program focused on the installation of 10 fast points and 100 normal ones for public usage and on the development of a future expansion strategy.

Here a scheme about the adopted business model:



[38] http://www.ieahev.org/by-country/sweden/

[39] http://www.eltis.org/discover/case-studies/stockholm-implementing-public-electric-vehicle-charging-network-sweden

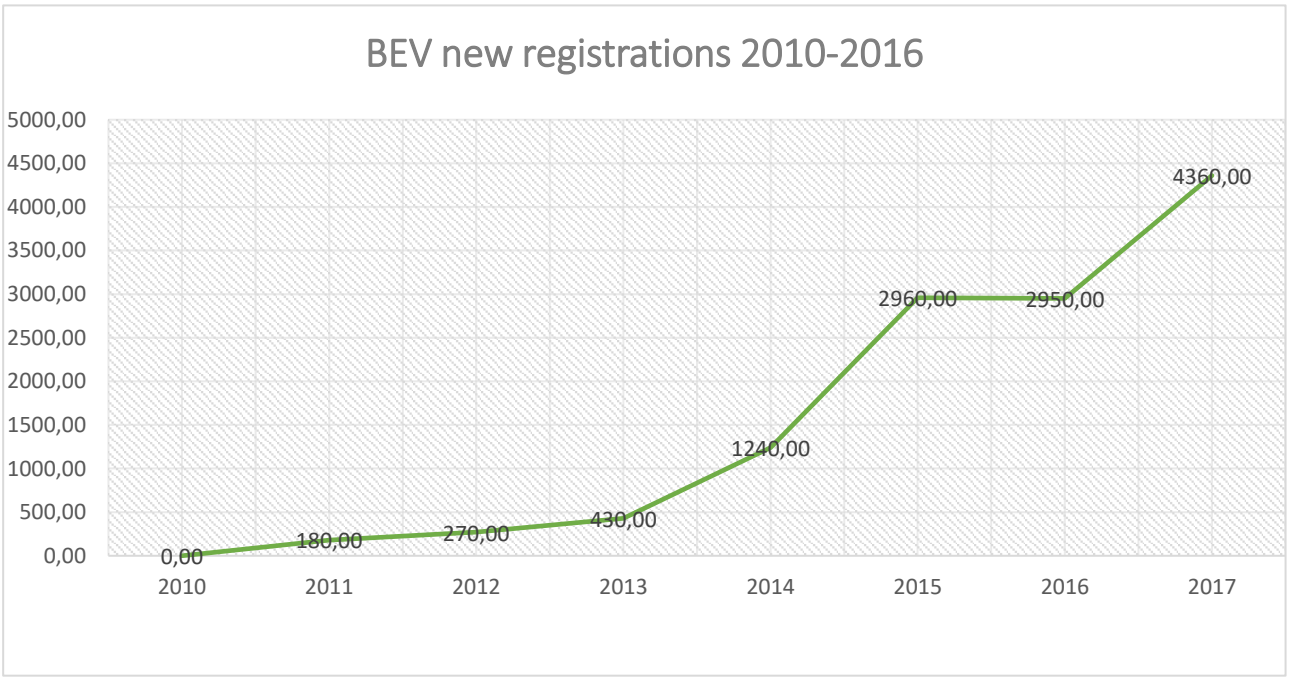
During 2017 they installed both normal and fast charging stations.

- ➔ **Data from normal charging stations shows that**:
  - more used on weekdays so they are linked to work and they depend on the location
  - Their usage doubled during each quarter of the project's evaluation period (May 2014 – October 2015) as the number of charging facilities
  - Charging time exploited: 1 - 5 hours
- ➔ **Data from fast charging stations shows that**:
  - Most users are commercial EV drivers.
  - Charging time exploited are of two different natures: a "top-up" of up 10 minutes and longer charging sessions of 10-30 minutes.
  - The charging location has an impact on users' behavior
  - Fastest charging stations are located in Stockholm's inner city

The south part of Sweden is currently well developed and able to link together all part of the region. The charging stations' structure is the result of the well-coordinated efforts of both public and private actors. By the end of August-2017 it counted around 3.600 charging points.

EVs NEW REGISTRATIONs

As we can note from the table, from 2015 to 2016 the growth was quite stable. The higher growth was registered in 2015 and I think it can be linked with the increased effort put in building the right infrastructure in those years.



***Graph 23 SWEDISH BEV NEW REGISTRATIONS** - in this graph is presented the Swedish trend of BEV registration from 2010 to 2017*

FUTURE GOALS

- By 2020, 600.000 electric vehicles and 140.000 publicly accessible infrastructure stations by 2020
- By 2030, reduce its GHG emissions by 70%
- By 2045, become **fossil-free**

PORTUGAL

TOTAL LAND AREA (km2): 91.568 km2

CAPITAL: Portugal

POPULATION: 10.311.000

PASSENGER CARS: 4.327.000

GDP (per capita): 22.379 €

It is situated mostly in the Iberian Peninsula in Southwestern Europe and is characterized by not very frequent commuting, except in large urban areas. The Portuguese government has taken e-mobility's measures starting from 2008, for reducing its high dependence (in 2007 it counted for around 81% on foreign oil) on foreign states, in terms of energy and other sources. The initial goal of Portugal was that of being the first country to inaugurate a national network of charging stations and it started pursuing it through the set-off of the *Mobi-E* program.

The MOBI.E electric mobility model was developed by INTELI, a Portuguese think tank, as a fully integrated and totally interoperable system of electric vehicle charging infrastructure, service providers, and intelligent electric grid management. It smartly integrates mobility and energy systems, resulting in using vehicles as a "decentralized mega-battery". The mega-battery can store excess renewable energy for return to the grid during periods of high electricity demand and charge the vehicle batteries during periods of low demand, when the electric grid is supplied by renewable energy. With a single card, a user may charge the battery of any electric vehicle at any charging point around the country, with electricity supplied by any retailer.

Additionally, is important to speak about the MOBI SUMMIT an event organized by the Global Media Group and national electricity company EDP, in partnership with car manufacturers Volkswagen and toll managers Via Verde, that aims at becoming "an essential part of the framework for mobility". This event has been divided into two parts (the first in January-2018 and the second in September-2018) in which the World's leading experts have been and will be brought to Portugal to discuss transports trends and debate the future of e-mobility.

It aims to showcase the main trends in sustainable and ecological transport and explores solutions such as car-sharing, renewable energies, and electric vehicles.

During the Warm Up event they brought people and families to try out new forms of transportation and permitted them to experiment futuristic vehicles and innovative transport solutions.

INCENTIVES

Portugal most important initiatives in the E-mobility field is the introduction of a program aiming at the implementation of a national mobility network based on MOBI.E model. It is the result of synergies between different actors as Office for Electric Mobility and Ministry of Economy (with a direct involvement of Prime Minister's Office) that in 2010 were able to develop a framework for electric mobility touching the following points: actors and roles, high-level specifications, and a comprehensive set of incentives for vehicle purchase and operation, circulation and parking, infrastructure installation. One of the main objectives was that of creating a transparent and full integrated structure that could provide to investors a clear view of the environment and of potential returns.

More recent is the Law 7-A/2016 (March-30th) that defines the State Budget and rules for the year 2016. With this law all the previous defined measures were maintained and only the fiscal benefit under the End-of-Life incentive was changed. The incentive for new electric vehicles when an old vehicle is delivered for the End-Of-Life dismantling is actually 2.250 € for BEV and 1.125 € for PHEV. It also establishes that the incentives could be maintained until the end of 2017, but with a further 50% reduction. Therefore, after Jan-1st 2017, the fiscal incentives decreased to 1.125 € for a new electric vehicle and 562,50 € for a hybrid plug-in.

Additionally, Portugal adopted other direct and indirect incentives that solely addressed fully electric vehicles (BEV) in order to coherently maximize the effectiveness of measures.

INCENTIVE CATEGORY	DESCRIPTION
Purchase Subsidies	National Subsidy for BEV's: 2.250€ and PHEV's: 1.125 €
Ownership Tax Benefits	Tax reduction / exemption - CO2 based tax
Registration Tax Benefits	Tax reduction / exemption - CO2 based tax
Company tax benefits	VAT is deductible for companies (With acquisition cost <€ 50,000)
Local incentives	- Free parking in Lisbon - Local utility company gives 1-year discount in electricity for BEV buyers

***Table 9 PORTUGAL INCENTIVES' POLICY** - Categorization and description of Portuguese incentives' policy*

CHARGING INFRASTRUCTURE[40]

The current infrastructure is mainly the result of MOBI.E vehicle electrification project, inaugurated in 2009, that aimed at equipping 25 municipalities with the right charging networks. Actually, there are two kinds of stations: normal and fast charging.

- **Normal:** at home, for fleets on street and off-street parking
- **Fast:** on main roads and highways, in service stations and other strategic locations

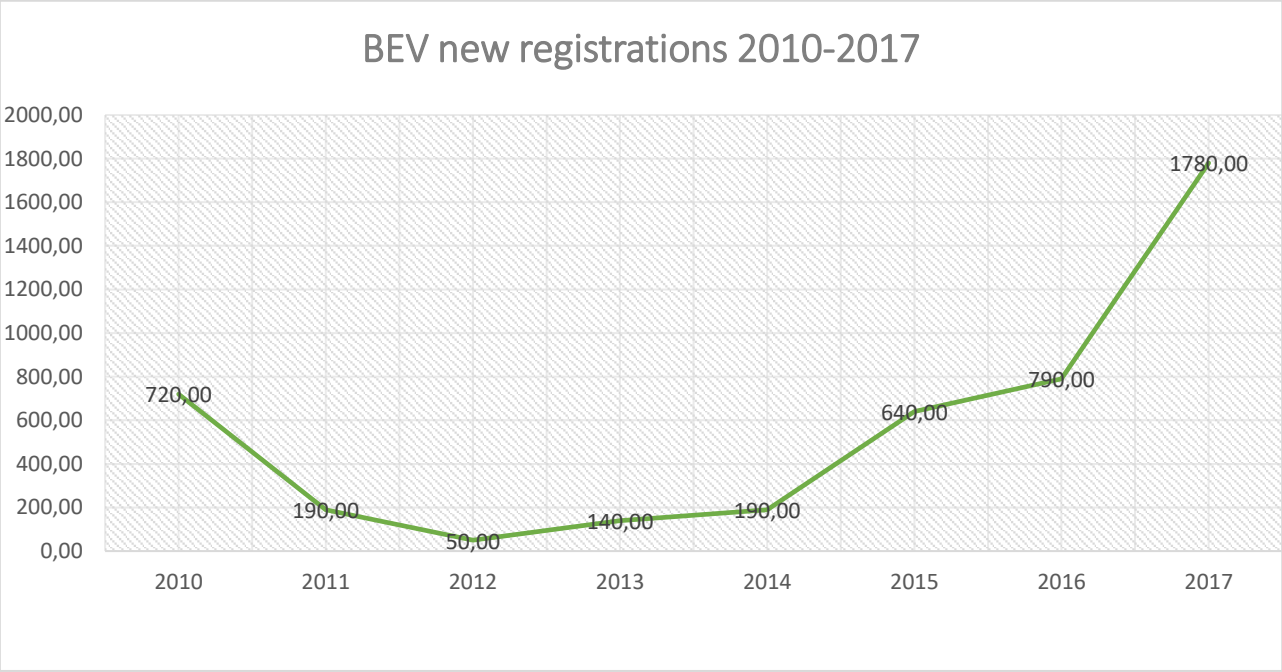
[40] https://pushevs.com/2017/07/11/portugal-will-soon-fully-covered-electric-car-charging-stations/

This project received different kind of funding. It was divided in different phases and decided that the initial one must be publicly funded, with the intention to extend it to private funding later. So, the chargers' distribution can be grouped as follows.

	NORMAL	FAST
PUBLIC FUNDED	404	39
PRIVATE FUNDED	156	19

Before arriving to this point, the charging investments topic was one of the most discussed. In fact, in 2011 José Sócrates of the Socialist Party was the Prime Minister and he considered this issue as a top priority for his program, in order to make Portugal the leading country in the electric car revolution. But everything changed after the Debt Crisis, when Pedro Passos Cohelo of the right-wing party was elected Prime Minister in the same year. In that moment Environmental issues were not considered as a problem but as a personal ambition of the previous Prime Minister. The result: automakers interrupted their support-plans, the charging network was abandoned and left without maintenance. It became difficult to have an electric car in Portugal. In 2015 the destiny of electric mobility changed again. Antonio Costa from the Socialist Party in alliance with Communist Party, Anti-capitalist Left Bloc and Greens was elected. He took back to priorities the e-mobility as a mean to reduce external dependence on foreign oil. Now, repairing and upgrading the charging network is on top of the list. Currently, the charging network is still very concentrated in biggest cities and is mainly composed of slow chargers.

EVs NEW REGISTRATIONS



***Graph 24 PORTUGUESE BEV NEW REGISTRATIONS** - in this graph is presented the Portuguese trend of BEV registration from 2010 to 2017*

What I described in the previous paragraph is mirrored in the EVs new registration trend that I'm showing in this table. In fact, in 2011 Portugal was subjected to a decreasing path that started to be recovered in 2015, when the government had the possibility to demonstrate to potential users a real interest and effort in this direction. Numbers are still low, but from 2016 to 2017 it registered a successful growth.

FUTURE GOALS

- By 2020, 200.000 circulating electric vehicles and 12.000 publicly accessible infrastructure stations
- Construction of electric car charging stations in each municipality

CHINA

TOTAL LAND AREA (km2): 9.596.961 km2

CAPITAL: Peking

POPULATION: 1.403.500.365 (estimated)

PASSENGER CARS: 310.000.000

GDP (per capita): around 6265,64 €

China is a state in East Asia and is the world's most populous country. In 2016, 509.000 EVs and PHEV were sold in China and this number took the country to become the first global market for the e-mobility, with the highest number of vehicles sold. China is pursuing the e-mobility revolution thank to a governmental top-down approach, that considers the electric transport as the only mean for contemporary providing cars to citizens and not jeopardizing the air quality. It is how they transform a big problem into a big opportunity. But China has favorable conditions from different points of view:[41]

- **Electric technology**: it is an opportunity for entering in the World's market without suffering of the Know-how gap existing with the traditional automakers.
- **Perfect environment of Megalopolis:** these provide the ideal conditions for this new technology and for its positive impact on air pollution and citizens' health.
- **Most populous country:** it means that the demand will be higher than other countries (additionally, China electric car market is highly protected with stringent trade restrictions for the foreign players and so domestic players account for majority of electric car sales in the country) and China will quickly exploit economies of scale.
- **Large high-income customer base:** high-income class in China is higher than the Italian one and this means major willingness to spend high amount of money for buying vehicles that will improve environmental conditions.
- **Developed electric batteries manufacturing sector:** there are around 150 electric vehicle battery manufacturers in China. As the battery is the key component for EVs and is also the most impacting on price, having so many batteries' manufacturers

[41] https://www.psmarketresearch.com/market-analysis/china-electric-car-market

increase the independence from imports and permits the definition of a competitive price.

- **Government's support:** it provided easy licensing and subsidies that were able to improve consumer concerns on creating a better environment. In 2009, the Chinese government subsidized the purchase of EV for public vehicles and in 2013 it extended the program to passenger cars, reaching between 2013 and 2016 the booming period for electric market. Now, the government has plans to stop the subsidy in the coming years and to make the market self-sustained.

The market is actually so fragmented because of the presence of foreign players that aim at investing in China to set up plants and at building joint ventures to serve the domestic market.

INCENTIVES[42]

The most diffused opinion about the EV Chinese incentives' policy is that it was responsible of the booming it reached three years ago. Probably it is not by chance that EVs started their highest diffusion in the same year in which China extended the subsidy program to passengers' cars.

Is interesting to note how the Chinese government did not concentrate only on the demand side but also on the supply side, providing incentives like energy credits to manufacturers. Initially the manufacturers received financial incentives, but after a huge group of them adopted an opportunistic behavior (lying on the sales volumes in order to get more subsidies) the government decided to transform them into non-financial one.

During the first semesters of 2018, sales dropped because of the reduction of subsidies, but analysts said that EV producers are still poised to benefit from favorable policies and larger scale of production in the longer term.

Let's have a deeper look on the incentives' initiatives taken by China.

INCENTIVE CATEGORY	DESCRIPTION
Purchase benefits	-Purchase tax exemption: renewed until 2020 -Subsidy program: starting from 2010 it is renewed every two or three years, decreasing the subsidies and raising the eligibility threshold. In 2016 it concerns a maximum of RMB 55,000 ($8,736) for each BEV and RMB 30,000 ($4,765) for each PHEV. It will decrease by 20 percent in 2017 and 2018 based on 2016's standard, and by 40 percent in 2019 and 2020 based on 2016's standard. **China plans to phase out the subsidy entirely by 2020**
Company Tax Benefits	-Producers' incentives: "**dual-credit policy**" started in April 2018, imposing compulsory targets for vehicle manufacturers starting from 2019. To obtain these new energy credits, manufacturers will need to produce a minimum number of EVs, and the credit will be proportional

[42] http://www.eesi.org/articles/view/comparing-u.s.-and-chinese-electric-vehicle-policies

	to driving range and EV weight. It mandates that 1 0%of a vehicle manufacturer's total credits must consist of new energy credits in 2019 and 12% in 2020 (equivalent to about four to five percent of actual vehicle sales). Manufacturers failing to meet the requirements will be fined or must buy credits from other manufacturers (only those selling at least 30,000 conventional vehicles annually will be affected).
Ownership Tax Benefits	Circulation and ownership tax exemption
Local Incentives	Possibility of local subsidies to provide the 50% of the amount subsidized by the central government [this limitation was because vehicle manufacturers, being attracted by the generous subsidies coming from both government and local government, lied about their sales and registered ineligible vehicles in order to get more subsidies. In 2015, five vehicle manufacturers defrauded the central government of RMB one billion ($158 million)].
Non-financial incentives	-In seven major urban centers, exemptions from license plate access restrictions -Locally, access to bus lanes, exemption from access restrictions at peak times, free charging, free parking -EV drivers in some Chinese provinces and cities can get their license plates without paying the typical fees and more quickly than conventional vehicle drivers [for example, Shanghai has waived EV drivers' license plate fee, which is about RMB 100 thousand ($15,900)].

***Table 10 CHINA INCENTIVES' POLICY** - Categorization and description of Chinese incentives' policy*

CHARGING INFRASTRUCTURE [43]

One of the main challenge China is facing in the EV mobility field is related to the development of charging infrastructure. According to the recent report by Xinhua, China has 214.000 NEV public charging points, gaining the World's top position. Even if they are currently expanding the network, aiming at 500.000 public charging stations by 2020, the development of infrastructure and facilities is still lagging.

Chinese charging problem encompasses three main issues:

1. **High cost for charging vehicles:** in fact, the majority of charging stations is actually located in commercial centers and transportation hubs. It means that drivers have to pay for charging services but also for parking (that has exorbitant fees).
2. **Long pay-back time:** the initial up-front investments can take years to be recovered. Although the government is stimulating the private sector to build infrastructures, the price of charging services is too low and implies too long time for gaining significant returns.
3. **Unavailability of business models:** there are no validated business models for running charging stations.

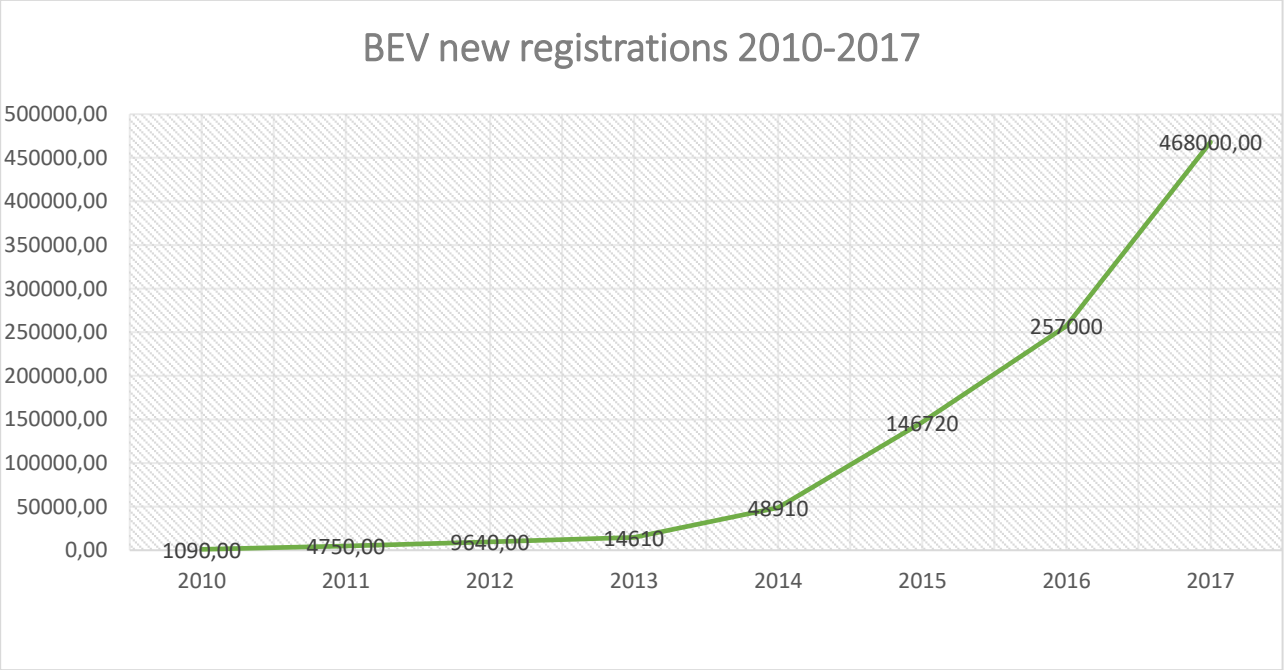
[43] http://www.sixthtone.com/news/1001403/the-race-to-build-chinas-ten-million-car-charging-stations

The government has recently sent an ultimatum to electric companies saying: "*evolve or die*". This is the reason why a company like X-Charge developed a smart, easy-to-use, highly functional typology of charging stations that is six time better in terms of efficiency and has already complied an impressive list of domestic and international partners.

Another innovative kind of charging infrastructure has been invented by Envision Solar: a solar-powered parking space called EV ARC that can be installed by businesses in parking lots, on streets or by municipalities. These advancements will boost the EVs' adoption over the next years.

EVs NEW REGISTRATIONs[44]

As anticipated the real EVs' boom in China happened in 2016. In the table we can see that since the beginning BEV new registrations had a positive trend, but the highest pick was reached in that year.



***Graph 25 CHINESE BEV NEW REGISTRATIONS** - in this graph is presented the Chinese trend of BEV registration from 2010 to 2017*

FUTURE GOALS

- By 2019, introduction of new energy vehicle
- By 2020, China has a goal to sell 2 million new energy cars a year
- By 2020, NEVs should be 7-10% of total vehicle market demand→ 15-20% by 2025 and 40-50% by 2030
- By 2020, will be built 12.000 new centralized charging and switch station and > 4.8 million charging spots
- By 2020, 5 million EVs, including 4.6 million PLDVs (passenger light duty vehicle), 0.2 million buses and 0.2 million trucks

[44] Outlook 2018

- By 2025, NEVs should be 20% of Chinese auto sales
- Phase out diesel and petrol cars by a not yet determined year

USA

TOTAL LAND AREA (km2): 9.372.614 km2

CAPITAL: Washington

POPULATION: 323.127.513

PASSENGER CARS: 112.961.266 (in 2016 from www.statista.com)

GDP (per capita): around 45.419,59 €

It is a federal republic composed of 50 states, a federal district, five major self-governing territories and various possessions. The interest in e-mobility field started officially in 2011 when the President Obama called for putting on the road one million EVs by 2015. US supported actively the R&D activities through the Department of Energy (DOE), searching for innovative technologies related to all different field touched by the value chain of electric vehicles.

US effort in R&D was mainly focused on the batteries, that make up the largest cost of BEVs. Additionally, it provides financial support to government, private companies, universities, non-profit organizations to conduct research on zero-emission public transportation through the Public Transportation Innovation Program and the Low or No Emission (Low-No) Vehicle Program. Another different program, the Advanced Research Project Agency-Energy (ARPA-E) (a U.S. Department of Energy agency), has funded many EV projects, including batteries, automotive controls and efficient EV chargers.

Following the list of guiding programs run by three main offices, as descripted in the www.ieahev.org:

1. **Office of science:** *based on finding enabling materials for batteries through the Energy Frontiers Research Centers*
2. **Applied Research Projects Agency - Energy (ARPA-E):** *research focused on "game-changing" energy storage technologies. EDV-related projects include metal-air, lithium sulfur, magnesium ion, advanced lithium-ion, and solid-state batteries, as well as ultracapacitors.*
3. **Vehicle Technologies Program (VTP) Advanced Energy Storage Technologies research programs:**
    a. ***Research portfolio is focused on battery module development and demonstration of advanced batteries to enable a large market penetration of EDVs within 5 to 10 years***
        i. *Participating national labs: Argonne National Laboratory, Lawrence Berkeley National Laboratory*

ii. *Government-industry partnerships: U.S. Advanced Battery Consortium (USABC), working with Ford Motor Company, General Motors, Chrysler, and several companies in the battery supply chain*

b. VTP also manages research programs in other technologies that are relevant to EDVs. These include:

i. *Vehicle systems research is focused on improving the way various new components and systems affect fuel efficiency. Work also aims to reduce parasitic losses.*
ii. *Lightweight materials R&D aims to significantly reduce automotive vehicle body and chassis weight without compromising other attributes such as manufacturability, cost, and safety. Priority lightweight materials include aluminum, magnesium, titanium, and carbon fiber composites.*
iii. *Advanced power electronics and electrical motors (APEEM) research develops power electronics, electric motors/generators, and thermal control of inverters and motors with advanced cooling technologies, among other topics*.

Until 2015 it was the leader in electric sector but in that year, China stole its top position and US became the second largest player of electric mobility. USA is highly dependent on oil, so electric mobility represents a mean through which it can reduce its petroleum dependence and contemporary also the GHGs emissions.

INCENTIVES[45]

Actually, policy support is the main element on which countries should leverage in order to increase the development and deployment of E-mobility. In fact, the high upfront price is still perceived as a disadvantage by potential customers and so they need to be incentivized in order to increase their willingness to adopt electric vehicles. A proof of this: in 2016 the EVs' price was still 15.000 $ higher than a traditional car. A possible match between traditional and electric vehicles' price is expected by 2025. But the price is only one of the different elements that are actually slowing the adoption of EVs.

Looking at incentives, the most significant incentive provided by US through the American Recovery and Reinvestment Act of 2009 was the "*Tax credit*". Way back in 2005, Congress enacted a tax credit that expired in 2009 and was replaced by a similar program to increase the purchase of PHEV and BEV. It's important to understand that it is not a tax deduction (that reduces a person's taxable income), but a credit against the tax owed after all the figuring and calculating are done. So, if you owe the IRS 7.501 $ in federal income tax and you bought a qualifying electrified car during the year, you only have to send the government a check for a buck. While, if your tax bill is

[45] http://www.eesi.org/articles/view/comparing-u.s.-and-chinese-electric-vehicle-policies

less than 7.500 $, your credit is limited to what you owe, and any excess cannot be carried over to subsequent years. For example, if you purchase a car that is eligible for the full 7.500 $ credit but you only owe 3.897 $ in federal tax, the total benefit you will get from the law is 3.897 $ not 7.500 $.

This tax credit involves also manufacturers and considers a limit of 200.000 vehicles sold. After this number is reached, the size of tax credit will be reduced gradually, as explained in the table.

I will take into consideration an example extrapolated from a CleanTechnica's article, published in July-5th to make readers understand the tax credits' dynamics:

Let's assume by June 30, 2018, Tesla sold 199.990 electric cars in total since December 31, 2009. That means it won't reach the tax credit cutoff until the third quarter, which ends September 30, 2018. And that means it can sell all the electric cars it can manufacture during that quarter and the following quarter and all of them will qualify for the full 7.500 $ tax credit.

The fleet procurement is another field touched by US initiatives. Los Angeles, Seattle, San Francisco, and Portland, plan to purchase 24.000 EVs for their municipal fleets, according to their joint Request for Information (RFI). The city of New Bedford, Massachusetts, has procured 23 EVs from Nissan using 7.500 $ in state incentives and a federal tax credit of 7.500 $. The U.S. Department of the Navy also proposed a purchase of 400-600 EVs from Ford Motor Company using a federal tax credit.

INCENTIVE CATEGORY	DESCRIPTION	States
Purchase benefits	Purchase Directives, Promotion Directives, or Mandates	DC and all states (except for Arkansas, Colorado, Florida, Georgia, Maryland, Michigan, Nebraska, Pennsylvania, and Virginia)
Ownership Tax Benefits	Tax credit [46]that ranges from $2,500 to $7,500 for each vehicle based on its battery capacity and gross vehicle weight rating (a vehicle's maximum weight, including cargo and passengers). It is available until a manufacturer sells 200,000 EVs, at which point the credit begins to phase out over time for vehicles sold by that company. The credit halves for the six months following the sale of the 200,000th vehicle, and then halves again for the next six months, and finally disappears entirely	DC and 40 states
Local Incentives	-Rebates offered by California to light-duty zero emission vehicles and plug-in hybrid electric vehicles	

[46] https://cleantechnica.com/2018/07/05/the-federal-ev-tax-credit-and-you-cleantechnica-explains-it-all/

	- Washington and New Jersey exempt EVs from motor vehicle sales and use taxes - Louisiana and Maryland provide tax credits of up to $2,500 and $3,000 per vehicle, respectively	
Non-financial incentives	-High occupancy vehicle (HOV) lane exemptions and expedited license plate acquisitions have been offered -Exemption from parking fees	Arizona, California, Colorado, DC, Florida, Georgia, Hawaii, Iowa, Maryland, Minnesota, Nebraska, New Jersey, Ohio, Tennessee, and Virginia

***Table 11 USA INCENTIVES' POLICY** - Categorization and description of American incentives' policy*

CHARGING INFRASTRUCTURE

The American charging infrastructure represents a challenge for the country. In 2008 these were 430 and grew to 465 in 2009. There was a clear necessity of adopting new measures for developing the network. At that point the American Recovery and Reinvestment Act of 2009 (ARRA) acted in order to support the construction of more than 22.000 electric charging points in more than 20 cities across the U.S. The number of outlets really started to take off in 2012 when the total count nationwide hit 12.000. By the end of 2017, the number had surpassed 47.000 (including 6.270 fast charging outlets), with an increase of 18% since 2016.

Recently, three US states announced huge investments [47]in charging infrastructure:

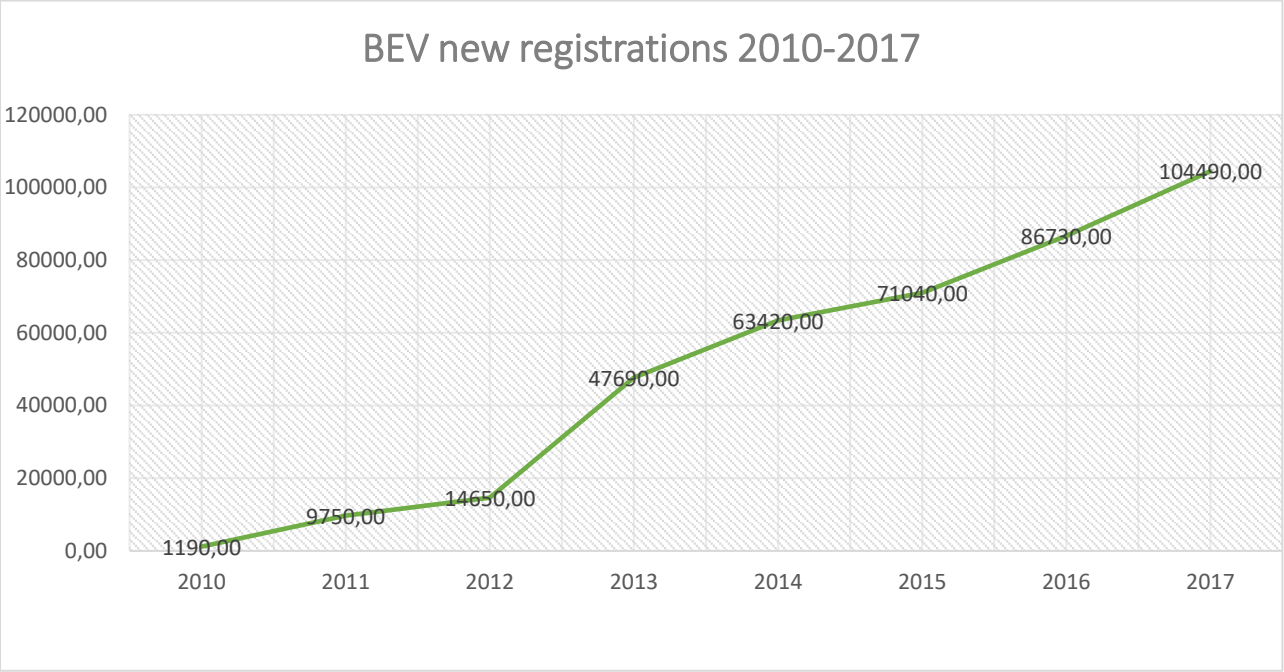
- ➔ **CALIFORNIA:** California's Public Utilities Commission approved up to **738 million $ worth of projects over the next five years**. Some partnership will take place like that of Southern California Edison and the Pacific Gas and Electric Company (PG&E) that will invest 343 million $ and 236 million $, respectively, to build charging infrastructure at around 1.500 locations throughout the state. PG&E will spend another 22 million $ for building 234 DC fast-charging stations at around 50 different sites.
  Additionally, after having understood that the 80% of EV charging still happen at home, the Californian focus will be on that field. For example, San Diego Gas and Electric will spend up to 137 million $ on its "Residential Charging Program".
- ➔ **NEW YORK:** the governor's office announced a pledge of maximum 250 million $ for its electric vehicle expansion initiative, *EVolve NY*. The synergy b/w New York Public Authority and private sector will be exploited to install up to 200 DC fast chargers, with the goal of making them available every 30 miles.
- ➔ **NEW JERSY:** New Jersey's biggest utility owner Public Service Enterprise Group (PSEG) announced a 300 million $ pledge to build out up to 50.000 charging stations along highways, in residential areas, and at workplaces.

These are the biggest investments these States have committed for EV charging infrastructure. Even if these will not directly affect the other 47 states, the impact on the adoption path of EVs is expected to be positive.

[47] https://www.theverge.com/2018/6/1/17416778/california-new-york-electric-charging-investment-stations

EVs NEW REGISTRATIONs

Since the beginning the EV registrations presented a positive trend and took US to be the leader until 2015. During this year it was overcome by China, reaching the second World's positioning.



Graph 26 AMERICAN BEV NEW REGISTRATIONS *- in this graph is presented the American trend of BEV registration from 2010 to 2017*

FUTURE GOALS

- By 2025, New York with other states agreed with other seven states to get 3.3 million zero-emission vehicles on the road
- By 2025, ZEV5 mandate in ten states6: 22% ZEV credit sales in passenger cars and light-duty trucks
- By 2025, California 1.5 million ZEVs and 15% of effective sales and 5 million ZEVs by 2030.
- By 2030, California will generate half of its electricity from renewable sources
- The long-term aim is to develop technologies that will provide Americans with greater freedom of mobility and energy security, with lower costs and lower impacts on the environment.

THE COMPARISON

I would like to summarize the kind of incentives adopted by different European and non-European countries analyzed in order to highlight the correlation between them and each country's market share. I took into consideration the 2017 market share being coherent with data extrapolated by the Global EV Outlook 2018 and inserted in my discussion.

	N	F	D	NL	S	IT	P	CN	USA
Registration Tax Benefits	X	X		X			X		
Purchase subsidies		X	X		X	X	X	X	X
Ownership Tax Benefits	X	X	X	X	X	X	X	X	X
Company Tax Benefits	X	X	X	X	X		X	X	
VAT Benefits	X								
Other Financial Benefits	X		X						
Local Incentives	X	X	X				X	X	X
Infrastructure Incentives	X					X		X	
EV Market share by country (2017)	**20,8 %**	**1,3%**	**0,7%**	**2,1%**	**1,34 %**	**~ 0,1%**	**0,8%**	**1,8%**	**0,6%**

***Table 12 SUMMARY TABLE** - in this table are sum up the incentives' strategy adopted by each country. The rows correspond to the different categories of incentives mentioned in the previous chapter, while columns correspond to different States.*

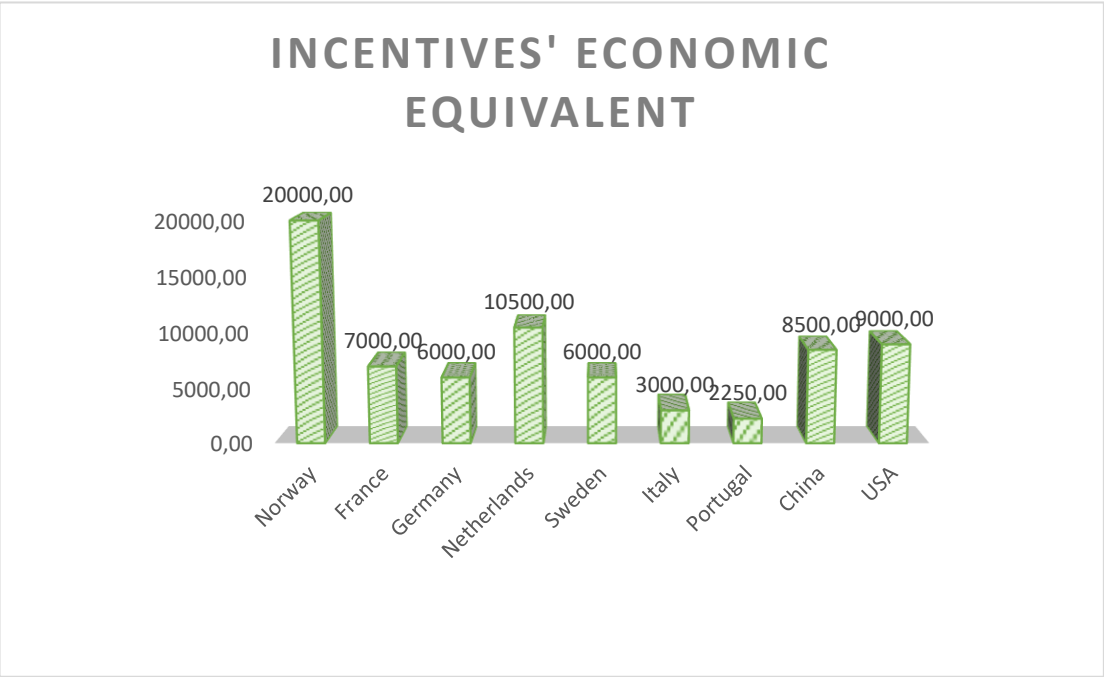
As we can see from the EV market share by country, Italy is in the last position with a share of 0,1%. It is not surprising considering the fact that the Italian incentives' system is clearly more fragile.

INCENTIVES

A 2016-estimation that took into consideration the total financial value of incentives, considering both those directly related to the purchase phase and those related to the utilization phase of the vehicles, provided a broad result.

Considering a BEV with an average cylinder capacity and a price of 30.000 €, the economic equivalent [48]is reported in the table.

[48] https://www.infobuildenergia.it/approfondimenti/futuri-sviluppi-mobilita-elettrica-infrastrutture-ricarica-macchina-314.html



Graph 27 INCENTIVES' ECONOMIC EQUIVALENT *- in this graph are reported the economic equivalent of different incentives policy adopted by European countries*

Italy and Portugal have similar incentives' equivalent, but the Portuguese market share is so far from the Italian one. Looking at the mix of measures adopted, Portugal was more complete and covered different fields. It mirrors a good Government strategy linked to EV market development. I found the same link between Government's strategy and EV market development in Norway[49], where it aims at a transaction that maximizes the renewable sources' utilization, becoming the primary source of energy. Again, in China[50] the choice to invest in EV market represents a geo-political decision (it is contemporary a way for entering in the global automobile market, from which it has been excluded because of its backwardness in term of "know-how" and as a mean for improving environmental conditions).

A high-level strategy is what currently Italy misses.

Norway and Netherlands with the highest incentives' equivalent had the highest market share. Netherlands' policy seems to cover less domains than the Norwegian, however it is effective.

For the remaining countries, France, Germany and Sweden, I noted that with similar incentives' equivalent Germany is the State with lower market share. The same happens for USA, in comparison to China.

Now let's exclude Norway, that represents an exception and is considered the example [51]of a country where, when BEV and ICEV are available at a similar price, BEVs are preferred.

If I look at measures adopted by all those countries with a market share higher than 1%, I find out that all of them provide company tax incentives, a missing element in the Italian incentive policy. So, it could be an additional reason behind the backwardness of Italy in comparison to other countries.

[49] https://www.consorzioesperienzaenergia.it/approfondimenti/E-mobility-Italia-ricarica-auto-elettrica.html
[50] https://www.consorzioesperienzaenergia.it/approfondimenti/E-mobility-Italia-ricarica-auto-elettrica.html
[51] The transition to a ZEV fleet for cars in the EU by 2050 EAFO study-Nov 2017

CHARGING INFRASTRUCTUREs

I'm going to present in the following table the number of positions [52] (that is not the equivalent of points) existing, by European country and by typology.

COUNTRY	CHARGING POWER	KW	NUMBER OF POSITIONS
NORWAY	Normal power	<= 22	8774
	High Power	> 22	2421
	Totals		**11195**
FRANCE	Normal power	<= 22	22308
	High Power	> 22	2019
	Totals		**24327**
GERMANY	Normal power	<= 22	22213
	High Power	> 22	3218
	Totals		**25431**
NETHERLANDS	Normal power	<= 22	34929
	High Power	> 22	946
	Totals		**35875**
SWEDEN	Normal power	<= 22	2731
	High Power	> 22	2762
	Totals		**5493**
ITALY	Normal power	<= 22	2582
	High Power	> 22	542
	Totals		**3124**
PORTUGAL	Normal power	<= 22	3221
	High Power	> 22	256
	Totals		**1578**

Italy and Portugal are in the last position, with the lower numbers both in terms of total charging positions and high-power charging positions. The richest is Netherlands with a total of 35.875 positions, but only the 2,6% is high-power. France, Germany and Norway rebalance their "total positions" with a number of high-charging that overcomes the 2.000 units. While Sweden collected more high-power charges than normal ones, even if in the last positions.

COUNTRY	PUBLIC CHARGING POINTS
NORWAY	7.855
FRANCE	3.016
GERMANY	22.708
NETHERLANDS	10.219
SWEDEN	3.693
ITALY	4.207
PORTUGAL	1.124

[52] www.eafo.eu

The situation varies a little bit, considering only the public charging points[53], at 2016. Here Germany gains the first position, followed by Netherlands and Norway. Italy overcame France and Sweden.

Even if later than other countries, the PNIRE will be responsible for the infrastructure development of Italy with the target to build 4.500 - 13.000 normal power points until 2020 and 2.000 – 6.000 high power points until 2020.

TO SUM UP

The aspects [54] that can represent a positive signal for our country are:

- **New Mandants' composition:** considering their composition, it passes from being totally linked to Public Administration to being extremely variegated. It means that there is an increasing interest on this field, from different perspectives. Between 2012 and 2013 the 95% of projects had the Public Administration, as mandant. Between 2014 and 2016 this percentage decreased to 57%. In 2017, companies focused on fuel's management appeared for the first time in the group of interested actors. This is the signal of possible growth's expectations. The same for mandants coming from the "Corporate's world".
- **Evolution of business models**
- **Expected evolution of charging infrastructure**

While the negative ones [55]are:

- **Absence of an unitary vision at government level**
- **Low capability of attracting private financing**
- **Lack of interoperability:** that is able to facilitate EV drivers' life and so their purchase's propension
- **Sort of inertia** that is characterizing Italy in comparison to other countries.

[53] https://it.motor1.com/news/221467/colonnine-di-ricarica-auto-elettriche-chi-vince-e-chi-perde-in-europa/
[54] https://www.infobuildenergia.it/approfondimenti/futuri-sviluppi-mobilita-elettrica-infrastrutture-ricarica-macchina-314.html
[55]https://www.infobuildenergia.it/approfondimenti/futuri-sviluppi-mobilita-elettrica-infrastrutture-ricarica-macchina-314.html

4 THE ENDOGENOUS ANALYSIS – THE AUTOMAKERS SIDE

In the following chapter will be analyzed the main electric cars producers. The selection of the producers has been conducted with reference to an article from www.cleantecnica.com where were listed the main EV models sold in Europe in 2017. As the majority of data reported in this document referred to the year 2017, this list is coherent with the entire analysis. From the catalogue of best EV seller models [56](PHEV + BEV), I filtered the only BEV models and I selected their producers, focusing on the following elements:

1. **General automaker's description:** with focus on the foundation, headquarter and main characteristics.
2. **Electric Gamut:** as the majority of models present different variants, I take into consideration data coming from an article written on www.tuttogreen.it/auto-elettriche-listino-completo/. This article selects the Italian gamut of different producers and provides to readers the Italian price-ranges. So, after a brief description of models I generated a first classification, producer by producer, on the basis of range and starting price. For each automaker, I calculated the approximated average price[57] and range (on the basis of its existing models) and I built the different categories (I considered as primary font www.tuttogreen.it). All the calculations will be reported at the end of the paragraph.
3. **Market:** where possible, I looked at sales trend of main EV models, considering a single source in order to be as much coherent as possible (www.carsalesbase.com).
4. **Batteries:** I analyzed how automakers faced and are facing one of the most important limit and feature to be considered when building an EV, the batteries' development.
5. **Charging infrastructure:** I described the efforts put in the construction of charging stations and the kind of stations built. So, I categorized their initiatives as follows. The "fast efforts", indicates the investments and solutions related to fast charging networks; the "slow efforts", indicates the investments and solutions related to slow charging networks and finally the "digital efforts" that describes the digital solutions developed for increasing the service level.

[56] https://www.gruppoacquistoauto.it/vendite-auto-elettriche/vendite-ev-in-europa-nel-2017-vince-renault-zoe /

[57] (the average was calculated considering the lower starting prices when mentioned more than one price)

Especially for what concerns *the vision, the battery session and the charging infrastructure,* important sources of information were both the annual reports and sustainability reports that I analyzed, for each producer, starting from the year 2010. The definitive list of automakers is the following: Nissan, Renault, BMW, Tesla, Volkswagen (e-Golf), Hyundai, Kia, Daimler (Smart).

Graph 28 2017 EURPEAN EV BEST SELLER MODELS *– in this graph are presented BEV and PHEV European best seller models and in green are highlighted the BEV ones that helped me in the selection of automakers.*

In the second section of this chapter I will summarize what automakers did in terms of offer and batteries and infrastructures' development, trying to define which could be the effects and consequences of their actions on EVs' diffusion.

THE AUTOMAKERS IN DETAIL

NISSAN

Founded in 1933 Nissan Motor Company Ltd is[58] a Japanes multinational car manufacturer, headquartered in Nishiku (Yokohama). Nissan has established itslef as a company operating and selling automotive and marine equipment with the following mission: **"***To provide unique and innovative automotive products and services that deliver superior measurable values to all stakeholders*".

Nissan uses a segmentation based [59]on demographic and geographic variables to satisfy the needs and wants of customers and potential ones in more than 150 countries. In this way Nissan captured respectable proportions of market share, it reached the 6,5% and aims at the 8%.

[58] wikipedia

[59] https://www.marketing91.com/marketing-strategy-nissan/

For what concerns the price, Nissan is known for offering a reasonable and logical price that works with direct correlation with the product function. The varied price catalogue is able to attract and appeal customers.
It has a very nominal promotion plan, which combines promotional advertisement, mediums and publications. In addition to traditional campaigns Nissan organizes rallies and outdoor events for its customers and specialized club based off road events for customers from its SUV portal, attracting further customers.
Nissan have and had a strong focus on the electric mobility, that concretly evolved in 1999 with the estabilshment of an alliance[60] between Nissan and Renault. It was enlarged in later 2013-2014 through the insertion of Mitsubishi and reconfirmed in Sept-2017 under the name of "*Alliance 2022"*, with the ambition of overcoming the 14 million of sold vehicles and of saving money, exploiting synergies between different brands.
Most automakers for the electric-car market set targets of 20-30% of their total business until 2025 or later, Nissan looks at a shorter-term vision. Gareth Dunsmore, Electric Vehicle (EV) Director for Nissan Europe, stated that by 2020, where the market conditions are right, Nissan will be selling up to 20% of its volume as zero emissions vehicles and this will only grow. Some experts consider this as a quite ambitious goal considering the fact Nissan's electric-offer is limited to two models, one of which represents less than 5% of its European sales. They affirmed that probably it is linked with the high trust in the new Nissan Leaf. But for them is clear that Nissan needs to introduce new models in order to succeed.

GAMUT

Analyzing the offer, it was possible to identify two main categories on the basis of *range* and *starting price.*

- **RANGE > 190 km and STARTING-PRICE < 27.000 €**
  NISSAN LEAF[61]: launched in 2009, it was the first *mass-market affordable zero emission vehicle* and thanks to its performance and price it was able to reach the title of *world's best-selling all-electric vehicle* in 2014 and 2016 (more than 200.000 cars sold cumulatively at the end of May). The *"natural evolution"* of this model was launched in Dec-2017 based on the *Nissan Intelligent Mobility concept* grounded of three pillars: **intelligent driving** (which aim at making the vehicle a more reliable partner for the driver); **intelligent power** (represented by the EV technology); **intelligent integration** (creating a nexus of cars and surrounding society). Nissan hopes to persuade even more drivers to switch to electric thanks to a *greatly-improved range capability* and a host of *new technology*. A new design hides more **powerful battery, 40 kWh** rather than the previous one (30kWh), and a **range** that jumped **to 250 km.** Is interesting to note that they are planning to launch a more power generation in 2019. For this model there are eight available options.

[60] https://www.researchgate.net/publication/271884082_Global_Strategy_The_Case_of_Nissan_Motor_Company
[61] https://www.express.co.uk/life-style/cars/923544/Nissan-Leaf-2018-review-electric-car-price-range-battery

- **RANGE < 190 km and STARTING-PRICE ~ 27.000 €**

  e-NV 200 EVALIA[62]: it is comfortable and ample 7 seats car with optimal performances and an autonomy of 167 km. Recharging time goes from 30 minutes with a traditional recharging station to 4 hours with the Wall-box and 10-12 hours through the domestic charge. The price goes from 28.218 € to 40.100 €, it depends on the choice of renting or not the battery.

  e-NV 200: [63]the commercial electric vehicle, Van and Combi, combines the reliability of the traditional Nissan's commercial vehicle with the technology of Nissan Leaf. With recharging times similar to those of the previous model, it has an autonomy of 163 km and two different driving-modalities, ECO and B, that give the driver the possibility to increase the range, through the accelerations' management and the regenerative ability of the braking system. The starting price goes from 30.950 € to 39.300 € depending on the six-different set-ups.

In addition, at the recent Tokyo exhibition, Nissan announced the debut of **Nissan IMx concepts**

IMx[64]: it is actually a concept. At Nissan's design center in London, the executive said: *"The interior is notably bigger than a conventional vehicle and there's much more usable space, thanks to the totally flat floor allowed by the [underfloor] battery pack. The dashboard is also pushed right back [towards the windscreen] because the HVAC [heating, ventilation and air-con] unit is under the bonnet."*

The exterior of the car is quite innovative too and very Japanese in its details – "*expressive but with purity and an expensive feeling*". The most of functionalities are managed through eyes' and hands' movements.

It is equipped with the Pro-Pilot, level 4, able to move and manage the vehicle in an autonomous way, without passengers on board. So, the car will have the possibility to reach alone the recharging stations and will exploit the modalities vehicle-to-home or vehicle-to-building.

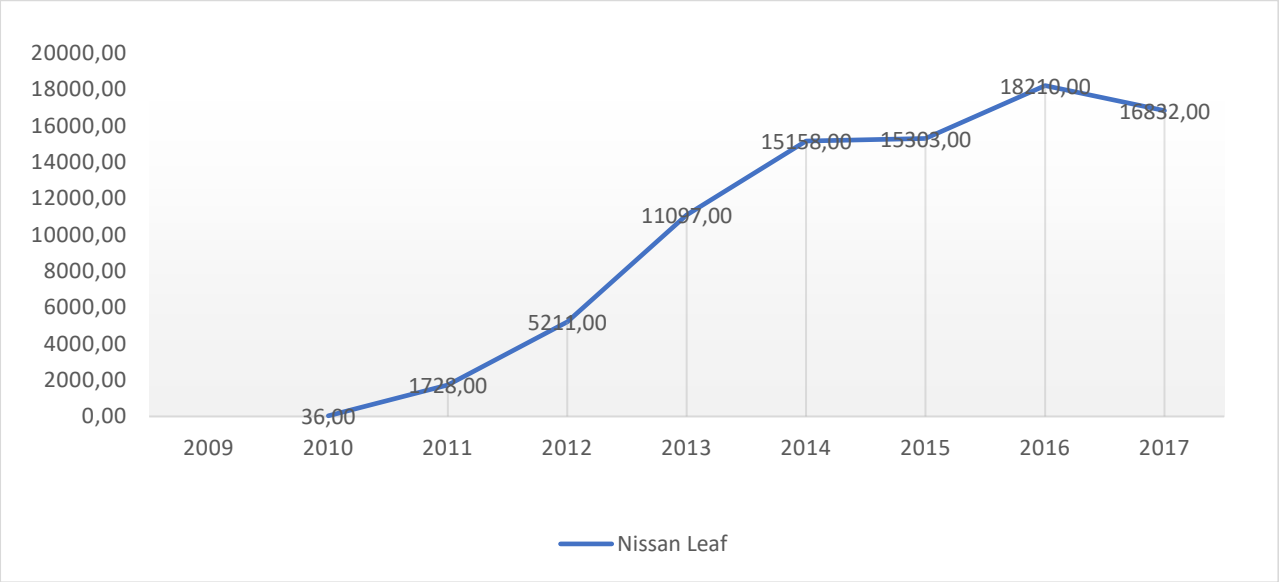
The final result is a vehicle endowed of a 600 km autonomy, for which the final price is still unknown.

MARKET

With reference to what was stated in www.carsalesbase.com Nissan was one of the few automakers to gain increasing trend both in sales and market share during the last period and hit a new European general sales record in 2017. The best seller electric model was the Leaf that started with a slow growth and increased year by year until 2017, before the arriving of the new generation Nissan Leaf. The first generation was the first EV to surpass the 10.000 annual sales but lost its lead in 2015 (as we can see in the graph) because of the Renault Zoe. In 2014, they introduced the model **e-NV 200** available in both the commercial version and the family version

[62] https://www.tuttogreen.it/auto-elettriche-listino-completo/
[63] https://www.tuttogreen.it/auto-elettriche-listino-completo/
[64] https://www.digitaltrends.com/cars/design-informs-innovation-with-the-nissan-imx-concept/ + http://www.motori.it/concept/674016/nissan-imx-concept-crossover-elettrico-autonomia-600-km.html

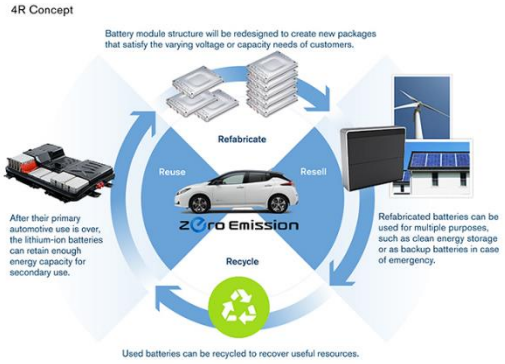
(called COMBI or the plushier EVALIA). Since the introduction, its European sales volume reached around 15.000 units, making this model one of the leaders in its sector, with an always increasing yearly trend.



Graph 29 *NISSAN LEAF EUROPEAN SALES by year*

BATTERIES' DEVELOPMENT[65]

Nissan always put a great attention on batteries, as these are key elements for the development of electric cars. In 2010 they launched a **joint venture company with NEC Corporation** for the development and production of lithium-ion batteries, NEC and NEC TOKIN brought their expertise in cell-technology and electrode production, while Nissan contributed from its long experience in real-world vehicle application. During the same year they built a Joint Venture to promote the **second-life use** for batteries with **Sumitomo Corp**, under the name of **4R Energy Corporation** (based on the *reuse, resell, refabricate and recycle principles)*. In 2013 Nissan was so sure about its batteries that they strategically offered to customers the possibility to change for free batteries if in five years these had lost their original performances, guaranteeing the investment made by clients. Today the new Nissan Leaf's battery is covered by a guarantee for eight years or 160.000 km. It has currently a capacity 40kWh and so it is able to provide a greater autonomy. Is recent the decision to close the battery business[66], comprising operations and production facilities, and sell it to Envision, a Chinese company specialized in the production of sustainable energy.



Finally, Nissan is one of the disapprovers of solid-state batteries. As reported in an article by INSIDEEVs Nissan's senior vice president for research and advanced engineering, Takao Asami

[65] Annual-reports from 2010 to 2017 + https://www.nissan-global.com/
[66] http://www.thedetroitbureau.com/2018/08/nissan-selling-electric-vehicle-battery-business/

affirmed that this technology "still need several breakthroughs". Instead he sees future progresses in the near-term with traditional lithium ion batteries for which they have a precise goal in mind.

INFRASTRUCTURE' s DEVELOPMENT [67]

As described in the introduction, I will divide this section on the basis of the kind of solutions considered.

- **"FAST" EFFORTS**

  Nissan launched its quick chargers in 2011, working with companies in the energy industry, such as **Circutor, DBT, Efacec, Endesa, Siemens**, and others in order to accelerate the diffusion and compliance with the **CHAdeMO** protocol and to provide tens of thousands of QCs by the end of 2015. Quick chargers, able to charge batteries from a minimum up to 80% in around 30-40 minutes, are a key element for the growth of this market and for giving the possibility to EV drivers to use their car for longer journeys. Another project, **Fast-E**, was launched in later 2016, in collaboration with the EU, with the aim of establishing 278 charging points 80 km apart along Germany and Belgium's main motorways, with 241 in Germany and 37 in Belgium.
  Finally, they announced in Dec-2017 the future expansion of about 20% of outdoor charging network, passing from 4.600 QCs, at the end of 2017, to 5.600 over the next 18 months.

  The company is working with different partners across Europe with focus on providing the maximum convenience to its drivers with different kind of installations. This investment will help to make the technology a more viable mainstream option than ever before, leading to changes in driving and purchasing habits.

- **"SLOW" EFFORTS**

  It is mainly linked with the concept of domestic charger and is based on the exploitation of the so called **WallBox,** a double speed system designed for two different environments. The **7kW home charger** allows owners to achieve the 100% charge in just 5.5 hours (70% of reduction from the previous technology). The **22 kW,** especially designed for fleet and business owners, works even better, capable of charging in just 2 hours. So, customers have the possibility to recharge their vehicles at home or at work, in less than 6 hours. In Italy, Nissan has recently started a collaboration with Enel[68], promising to all those customers that will buy the New Nissan Leaf two years of free energy through both the public and private recharging options. Nissan showcased its new home energy storage system, which follows on from the success of xStorage, that gives the possibility to customers to plug their vehicle directly into the wall box to charge. Additionally, it gives the possibility to customers to better manage their energy costs and to produce their own electricity from solar panels. This product sold more than 1.000 units across Europe in just

[67] https://www.nissan-global.com/
[68] http://motori.quotidiano.net/autoecologiche/nuova-nissan-leaf-enel-wall-box.htm

three months, with 5.000 units expected to be sold by the end of March 2018. Forecast are around 100.000 home energy units by the end of 2020.

At the end of December, Nissan also revealed its bold mission to offer customers free power for its EVs. It will happen with **Nissan bi-directional charging**, through which customers can draw energy from the grid to power their car or van and then 'sell' back to the grid for others to use. This means, once the installation of a nominal charge has been paid by the business there are no fuel or energy costs; just free power for Nissan's EVs.

RENAULT

It is a french mulltinational cars' manufacturer founded in 1898 and headquartered in Boulogne-Billancourt, France. The company designs, produces and sells commercial vehicles under five main complementary brands through which it meet customers' needs in different markets: Renault, Dacia, Renault Samsung Motors, Alpine and LADA. It is located in more than 130 countries. Thanks to the Alliance with Nissan and Mitsubishi, it became one of the leading automakers and reached in 2017 the first position as European EV best seller. The strategic actions of Renault can be dividend into two macro-goals: electrification of mobility and global expansion.

The first was pursued through the Alliance 2022 [69]with Nissan and Mitsubishi[70], reaching important result in R&D sector and exploiting global economies of scale (while mantaining financial discipline and cost efficiency). Renault is actually focusing on the "Drive the Future" program. It is a six-year plan with the objective to deliver annual revenues of over 70 billion €, to achieve a group operating margin of over 7% by the end of the plan, with a floor at 5%, and a positive free cash flow every year. It is aligned with the Groupe Renault vision: ***sustainable mobility for all, today and tomorrow***. Renault Chairman and CEO Carlos Ghosn said: *"Drive the Future is about delivering strong, sustainable growth benefiting from investments in key regions and products, leveraging Alliance resources and technologies, and increasing our cost competitiveness. Supported by the men and women of Renault, this new plan will unleash our full potential to innovate and grow in a rapidly-changing industry".*

For the second, the statement that better describe its vision is: "***Everywhere and for everyone***". For Renault, mobility must be accessible to all. Its strenght: its ability to develop reliable and comfortable vehicles with modern features and equipment for different market. In the past years, they drew a Global Access program extended to all countries, even if initially they had focused on Eastern Europe markets and Americas Region.

[69] https://www.alliance-2022.com/blog/drive-future2017-2022-renaults-new-strategic-plan/
[70] already explained in the "Nissan-session"

GAMUT

Renault is one of the strongest automakers, in 2016 it reached 100.000 EVs only in Europe. For Renault I was able to find three main categories:

- **RANGE > 185 km and STARTING-PRICE > 17.000 €**

  ZOE Z.E[71]: it is the eco-friendly model, easy to use, safe and technologically advanced that was introduced on the market since 2012. Initially, it was available in two versions: **Motor R 240** with an autonomy of 240 km and the **Motor Q** with an autonomy of 210 km. In 2016 was introduced also the version with 400-km of range. One of the best characteristics is the **Range Optimizer** that improves the range, making it independent from the external conditions. It is also equipped with a regenerative braking through which it is able to recharge the battery at every deceleration but also during the braking.
  For the standard charge it needs from 6 to 9 hours, connecting the car to a public charging point or to a certified socket Z.E. Ready. The Italian starting price is around 22.750 €.

- **RANGE < 185 km and STARTING-PRICE > 17.000 €**

  KANGAROO Z.E.[72]**:** it was introduced since 2011 and was available in three versions. It is practically a work vehicle. It is the pioneer of electric trucks and has a declared autonomy of 170 km, but in the urban scenario it decreases at 125 km. The starting price is 20.650 €.

- **RANGE < 185 km and STARTING-PRICE < 17.000 €**

  ZWIZY:[73] It is an **innovative response** to the challenge of urban mobility and can be considered as a concept more than a simple car. It is practical and compact, the perfect mix for the city traffic and offers a first-class protection for both driver and passenger. The body does not just protect the passengers (through the deformable structure that is able to protect in case of frontal impact, but also the lateral reinforcement that protects in case of impact from the side), but also makes the vehicle more visible in the traffic and so it constitutes a safe cell. The key words are efficiency, simplicity and speed. In Zwizy also the colors' choice is not by chance: blue and white color scheme creates a soothing atmosphere which isolates the passengers from the stress of urban activity.
  The reachable range is about 100 km and the Italian starting price is 6.900 €.

All the ZE are those launched during the first inauguration of electric gamut in 2013-2014, so everybody is now waiting for new models. The concept Symbioz should be at the basis of the new ZOE 2, while the Master ZE is the recently announced new truck.

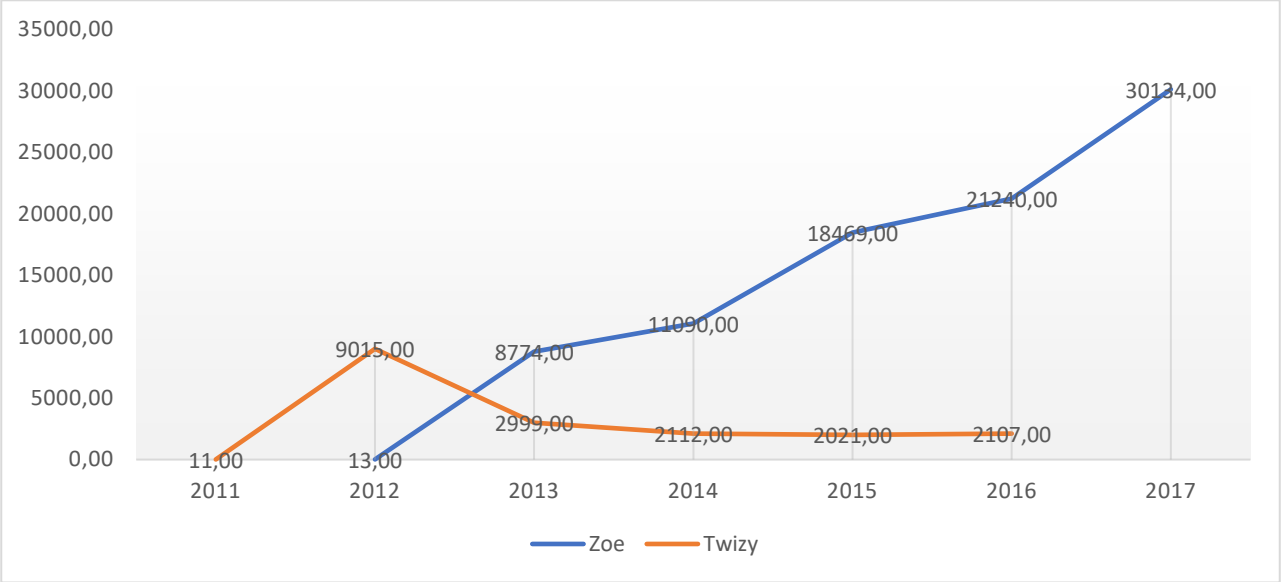
SYMBIOZ: is the concept that links together the autonomous driving, the connectivity and the electric mobility. Probably it will be embodied by the futuristic vehicle that they aim to launch in 2023, Zoe 2. This concept is associated with the idea of being an extension of customers' home.

[71] https://www.tuttogreen.it/auto-elettriche-listino-completo/#Auto_elettriche_lofferta_di_Renault
[72] https://www.tuttogreen.it/auto-elettriche-listino-completo/#Auto_elettriche_lofferta_di_Renault
[73] https://www.tuttogreen.it/auto-elettriche-listino-completo/#Auto_elettriche_lofferta_di_Renault

MASTER ZE: it is the coming new truck with an autonomy of 200 km NEDC that is able to conform itself to different professional needs and environments. It will be available in four versions and will be chargeable in six hours with a Wall-box of 7 kW.

MARKET

As anticipated, Renault was one of the first producer to trust in electric mobility, producing an entire gamut composed of three models. It was not possible to find the annual sales volume of Kangaroo ZE, but this model together with Twizy and Zoe took Renault to sell the 24% of European electric vehicles. The subcompact Zoe is the best-selling electric[74] car in Europe with over 30.000 sales in 2017 and shows a growing trend since the first year of introduction. A completely different trend was followed by Twizy that, after a first important pick in 2014, then decreased and remained stable around 2.000-3.000 units. For this model, we don't have data related to 2017.



***Graph 30** ZOE and TWIZY EUROPEAN SALES by year*

BATTERIES' DEVELOPMENT

Since ever Renault focus on the batteries field following two main paths: the recycling and the continuous quality's improvement.

Considering the recycling, they adopted a circular economy approach [75]empowered by the possibility to make customers rent batteries. In this way, Renault keeps the entire control on the whole batteries' lifecycle, producing an advantage for both customer and planet. The 93% of customers rent batteries, so the company can optimize their usage and the end-of-life phase. This approach is based on three stages:

1. **Optimum battery life in the car:** battery conditions are monitored in real-time and can therefore ensure an optimum battery lifespan on the road. There are

[74] https://www.dmove.it/news/renault-zoe-regina-di-vendite-tra-le-elettriche-europee
[75]https://group.renault.com/en/news/blog-renault/renault-optimizes-the-lifecycle-of-its-electric-vehicle-batteries/

also a lot of repair centres that can repair defective batteries in the majority of situations.

2. **Battery reuse off the road:** once reached the 75% charge capacity a battery can no longer meet the demanding requirements, but it can continue to provide valuable energy storage service in less demanding applications. Renault is an active member of several national and European green energy projects. One of them is the ELSA (Energy Local Storage Advanced System) project in which Renault has been involved since 2015. It is an interdisciplinary consortium of ten partners from five EU countries that aims at the development of low-cost, scalable and transposable energy storage systems, using second-life batteries to power innovative local energy management solutions.
3. **Recycling:** it starts when the cells are removed. The other materials are reused or recycled through conventional processes. Through a hydro-metallurgical process specialist partners of renault recover metals such as copper, cobalt, nickel and lithium. Like electric vehicle itself, the batteries are also recyclable.

Looking at performances, the battery of Renault electric vehicle is for sure one of the pillars of its success [76]and for this reason the company decided to dedicate a Team to the batteries' development. The actual range of Renault ZOE is 400 Km NEDC and it reach it not modifying the battery pack's architecture but improving the software of Battery Management System.

INFRASTRUCTURE's DEVELOPMENT

The Renault' s focus can be divided into two categories:

- **"FAST" EFFORTS**

  Looking at the solutions offered by Renault to its customers:

  a) **Quick charge**: drivers can quick-charge the equivalent of 50 km in less than 10 minutes, or 80% of their total range in 30 minutes. High power quick-charge stations are located in public areas, like service stations. It built them thank to more than 100 agreements with partners in both the private and public sectors: local and national authorities (governments, cities, regions), energy suppliers, infrastructure managers, shopping centers, public parking lot managers, hotels.

  b) **The 3-minute Quick-drop system**: customers can replace a flat battery with a charged battery without even leaving their car.

  Looking at investments and partnerships

  a) At the beginning of 2018, Renault partnered with southern Europe's first High Power charging network, E-VIA FLEX-E., aiming at increasing customers experience and decreasing the charging time. At the end of 2018, there will be an inauguration of 14 High Power charging stations in Italy (8 stations), France (2 stations) and Spain (4 stations). The extra-urban network will comprise High Power Charging (HPC) stations with a capacity of between 150 kW and 350 kW. Together with E-VIA FLEX-E and

[76] https://www.gruppoacquistoauto.it/approfondimenti/batteria-renault-zoe-41kwh/

Renault also ENEL, Nissan, EDF, Enedis, Verbund and IBIL will participate to this project. It represents a portion of the European Commission's Connecting Europe Facility (CEF) for Transport program, aiming at improving the growth and the competitiveness of electric mobility. Total budget: 6.9 million €. The Group Renault has also partnered with the Ultra-E and High-Speed Electric Mobility Across Europe networks in northern Europe, composed of 25 and 158 charging stations respectively.

- **"SLOW" EFFORTS**

  Looking at solutions offered:

  a) **Standard, daily recharge** where customers can recharge their car at home or at a public charging terminal. It is a long-lasting method and takes between 3.5 and 8 hours to fully recharge, depending on the available power and the type of vehicle. At home they can use the Wall-box (that has the characteristic of being easy-to-use, rapid, safe and cost-savings) or a conventional domestic socket using the EVSE cable (Electric Vehicle Supply Equipment) for occasional charging. It is perfect for Twizy.

BMW

It is a Geman company, officially founded in 1917 for producing airplanes' motors and headquartered in Munich. It subsequetly extended its portofolio, becoming one of the most important automakers of today. The first BMW small car was built in 1928 and only fourthyfour years later they started to think to electric motors, as highlighted in the 2014-report. Its "electric path" started in 1972 when BMW developed a 1602 model with an electric motor for the Olympic games of that year. From 2007 it began to focus on sustainable mobility and six years later it launched its first pure electric BMW i3 Megacity Vehicle.

This model was the "son" of a project initiated in 2007, the "project i"[77],with the purpose of developing alternative concepts for individual mobility. Its peculiarity: it didn't focus only on electrically driven cars but also on the entire environmental impact of the value-added chain. As stated in the 2010-report: "*the first publicly visible result of "project i" was the largest electromobility field trial to date: around 600 fully electric MINI cars were handed over to private and business customers in the USA, Great Britain, Germany, France, Japan and China".* The electromobility concept was embodied by the electrically powered Megacity Vehicle (MCV) that was launched in 2013 after a testing phase conducted through the trial versions MINI E and ActiveE, able to provide useful insights for the producer. Its road to e-mobility was defined in three steps:

1. Customers testing the MINI E
2. Customers testing the ActiveE
3. Megacity Vehicle arrived on the market

To completely differentiate this "road" from the traditional, BMW built the sub-brand "BMW i" based on the **LifeDrive concept**, to which all the electric gamut belongs.

[77] BMW official site

The LifeDrive concept comprises two horizontally separated and independent modules: the Drive module that forms the car's stable base and integrates the battery with the drive system; the Life module that comprises a high strength and lightweight passenger compartment made of CFRP (a material that remains unique in the car-making industry and amply demonstrates BMW's technological superiority in the field of lightweight construction).

One of the principal factors of success is its focus on the innovation, as an integral part of its company philosophy. It is through its Strategy NUMBER ONE > NEXT that BMW explained how they are moving towards electric mobility, digitalization and autonomous driving. The key trends of individual mobility are summarized at the BMW Group with the term ACES[78] (Autonomous, Connected, Electrified, Services).

Autonomous: since 2017, it has pooled its development experts in the fields of vehicle connectivity and autonomous driving. More than 600 employees are working in cooperation with other partners at a campus near Munich, thereby developing and expanding the open platform for autonomous driving.

Connected: the second strategic direction is summarized under the term **Connected Drive**. The vehicle can be attuned to the individual needs of each driver, thus making it a smart companion. The future objective is that of transferring certain tasks from the customer to the car when he/she is driving. In this way the driver will reach an increased comfort and safeness.

Electrified: the "BMW i" brand reflects in the most systematic form the term **Efficient Dynamics**. Flexible vehicle architecture, innovative electric and plug-in hybrid drivetrains and the usage of new materials are the results of an integrated approach. It is also reflected in a resource-efficient selection of materials and in the intensive utilization of renewable energy in the production process.

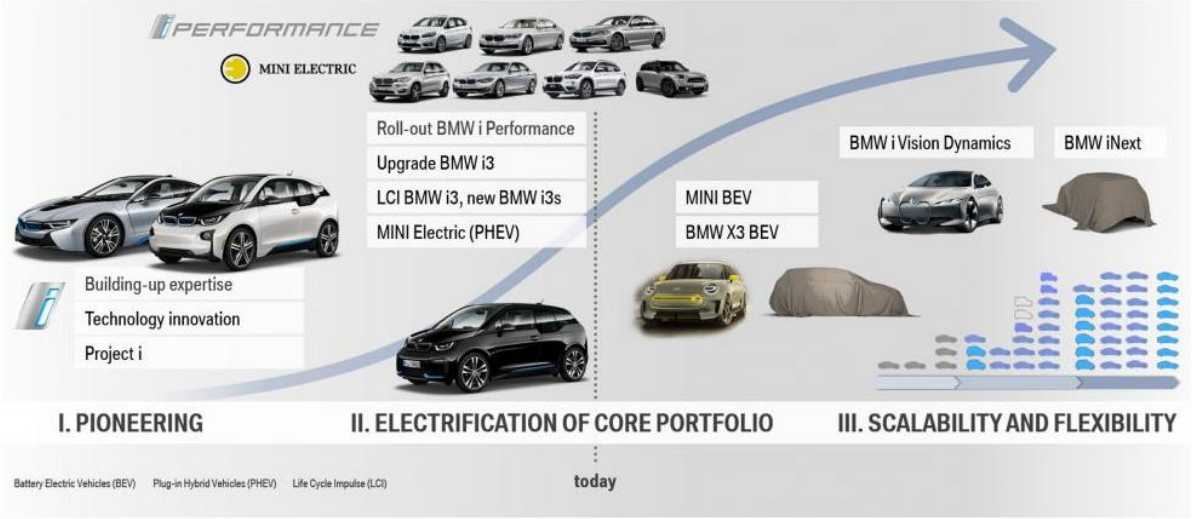
Service: it aims at providing a 360° service. With **360°ELECTRIC**, "BMW i" offers a comprehensive package of services for easy and convenient electromobility. For example, the public **ChargeNow** network is accessible for customers without private parking facilities. This is a network of public charging infrastructure suppliers who provide access to more than 8.000 charging points located throughout Europe. Additionally, there is the **ParkNow LongTerm**, through which the customer can rent a long-term parking space with charging station at a car park cooperating in the scheme.

[78] BMW Official site

GAMUT

For the actual offer the only completely electric car is the BMW i3 that can be grouped in the category of

- **(LAST) RANGE = 220 km and STARTING-PRICE > 35.000 € (average price of the total automakers considered) BMW i3:** it was launched in 2013 and is the first electric car on the market to combine the pleasure of driving, typical for BMW, with an eco-friendly approach. The BMW i3 uniquely combines dynamic driving (from 0 to 100 km / h in 7.2 seconds) with low electricity consumption (12.9 kWh in the EU test cycle). It is powered by a lithium-ion battery specially developed and produced by the BMW Group, which is integrated in the underbody to save space. The energy storage capacity gives the car a range of 130 to 160 km under everyday driving conditions. The last models extended the battery capacity to 220 km and for the owners of oldest models there is the possibility to install the new batteries on the BMW i3 old generation. It is defined by BMW as the "thrilling electric" because of its capability to link sportiness and an "eco-friendly soul" (in fact the car's passenger compartment is made of carbon and is 95% recyclable). Additionally, it comprehends a series of innovative services thank to its solution of "***Connected Drive".*** The Italian starting price is around 37.050 € and can be extended to 43.250 € with the Range extender version.



Graph 31 *PAST, PRESENT and FUTURE electrification pathway of BMW models*

As stated in the 2017 report, they have a clear roadmap to 2025. They forecasted for 2019, a battery-electric MINI; for 2020, the first fully electric model from the core BMW brand, the X3; for 2021 the iNEXT[79], a new technology flagship, that will guide the whole company. This is only a part of the broader objective to entirely electrified its gamut in the future.

ELECTRIC MINI COOPER[80]: its production will begin in 2019 and the assembling and manufacturing phases will be managed between the sited in Bavaria, Dingolfing and

[79] https://www.quattroruote.it/news/industria/2017/05/02/bmw_inext_una_fabbrica_in_germania_.html
[80] https://www.greencarreports.com/news/1110496_new-all-electric-mini-e-to-launch-in-2019-as-halo-for-brand

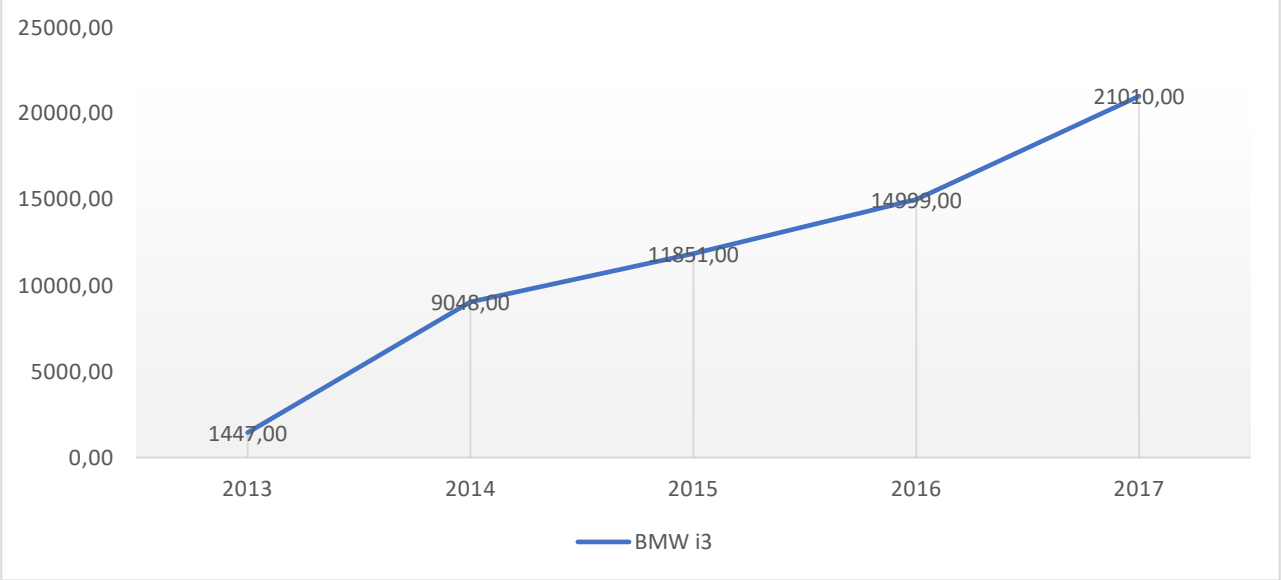
Landshut and that in UK at Oxford. The range on a single charge should be at least 200 miles (around 320 km). Even if it is seen as the first electric MINI ever, it is not entirely true. As I mentioned in the first paragraph some MINIs were distributed in 2008 in small series for conducting a testing process. The Minnie E was the first really fully electric Mini model that was produced.

BMW iX3[81]**:** BMW gave the world a preview of its newest electric vehicle iX3 at the Auto China 2018 show in Beijing. It will be the first long-range battery EV from the German automaker. It will have a 70kWh lithium-ion battery that should provide a range of 250 miles (400km) according to BMW. It presents a design similar to other BMW crossover and it will be built in China. It is considered as a high priority factor having a BEVs for this country. In China it will probably reach leading positions, while in Europe it is expected that plug-in hybrid vehicles will remain the preferred one for some time. "iX3" will go on sale in China in 2020 and will probably be exported to USA and Europe later.

BMW iNEXT: it will be the first model, belonging to the "Strategy Number One – Next". This strategy has been set in order to further advance in electric mobility, autonomous driving and to develop new services able to shape the change. The main theme will be that of autonomous driving, with new models for business and for private customers. It will not only be a model but an entire new brand that will put the technology at the first level.

MARKET

Since its introduction on the market this model were appreciated by customers and pushed a lot of new adopters on BMW direction for the first time. As we can see it presents a growing path each year. I think we can consider its range improvement as a driver that influenced the i3 adoption.



Graph 32 *BMW i3 EUROPEAN SALES by year*

[81] http://www.2019futurecars.com/2017/07/28/2019-electric-mini/ + https://arstechnica.com/cars/2018/04/the-270hp-70kwh-i3x-suv-will-be-bmws-next-electric-vehicle/

BATTERIES' DEVELOPMENT

One of the first partnership they built for developing batteries happens in 2010, when they started working with Tongji University to develop an electric-powered BMW 5 for research purposes. A second important partner was Toyota [82]with which it signed a declaration of intent in 2011 and concretely started to work in 2012. This agreement was signed mainly for developing lithium-ion cells for the batteries used in the electric cars. BMW's Chief Executive commented this event as follows: "*Together we have a great opportunity to continue leading our industry through this transformation. That is why we are pooling our expertise*".

The most recent news about its effort in R&D is that BMW is investing, this year, 200 million € [83]in battery cell development, opening in early 2019 a center in Munich. This interdisciplinary center will be dedicated to the internal improvement of batteries' technology starting from their design and arriving to performances and production processes. The battery cell is the heart of the battery. It determines performance, energy content, charging capabilities and lifespan and so it influences enormously the perceived performances of a vehicle. In this new lab, the current batteries will be analyzed, improved and at the same time will be created new prototypes, with a particular focus on chemical composition, use of different materials, how the cell behaves in critical or extremely cold conditions, and so on. Developing this competence along the entire value chain will mean building a competitive advantage, leveraging on cost benefits and economies of scale. A great advantage will be the possibility to integrate new findings into the latest battery produced.

INFRASTRUCTURE's DEVELOPMENT

- **"FAST" EFFORTS**

  For traditional infrastructure BMW recently decide to partner with Daimler[84], VW, and Ford to set up a standard that will be widely used and will give them the possibility to reduce costs. It is part of the Combined Charging System in Europe with the aim of building 400 high-power charging stations on main roads across 18 European countries by 2020. The actually available chargers are four: the CCS backed by the EU and the European car makers, Tesla's Supercharger system, CHAdeMo by Japanese manufacturers like Nissan and Mitsubishi and GB/T in China.

- **"DIGITAL" EFFORTS**

  The service linked with public charging is the ChargeNow one and is accessible for customers without private parking facilities. This is a network of public charging infrastructure suppliers who provide access at charging points located throughout Europe. It is also integrated with the service ParkNow through which customers can rent a long-term parking space with charging stations. It can be defined as a digital solution and thank to its innovativeness also PSA[85] will cooperate with BMW to provide Peugeot and Citroën

[82] https://www.ft.com/content/1ca4578c-c1de-11e1-8e7c-00144feabdc0
[83] https://www.automotiveworld.com/news-releases/bmw-group-invests-200-million-euros-battery-cell-competence-centre/
[84] https://www.bmwblog.com/2018/01/26/bmw-daimler-vw-join-forces-develop-plug-standard-evs/
[85] https://www.electrive.com/2018/03/06/psa-joins-forces-bmws-digital-charging-solutions/

customers access to 6.360 charging stations throughout France, among them 460 fast-charging terminals. So, BMW will add ChargeMyPeugeot and ChargeMyCitroën services to its app.

The most important and innovative solution announced for 2019 is the WIRELESS CHARGING[86], that will be able to simplify the charging methods at home and is intended to be compatible with all future BMW electric vehicles. Its development is a part of the Strategy Number One > Next and customers will have the possibility to order this option as a leasing-option for a PHEV model. The product offer will start with Germany, followed by the UK, the US, Japan and China.

How does it work? The suppliers transmit the energy without any cables, the car simply need to be positioned over a base pad. This product can be installed in places like garages and the charging process starts when the vehicle is parked in position. There are two main components: the groundPad (that must be installed as an Inductive charging stations on the ground) and the CarPad (that must be fixed in the underside of the vehicle). In an article by Gabriel Bridger, the energy transfer is explained in the following way: "*the contactless transfer of energy between the GroundPad and CarPad is conducted over a distance of around eight centimetres. The GroundPad generates a magnetic field. In the CarPad an electric current is induced, which then charges the high-voltage battery".* The system has a power of 3.2 kW, enabling a fully charge in around three-and-a-half hours.

TESLA

Tesla[87] was founded in 2003 by a group of engineers who wanted to prove that electric car can be better, quicker and more fun to drive than gasoline cars. For Elon Musk, the most famous of the founders, Tesla's mission was "*to accelerate the advent of sustainable transport by bringing compelling mass market electric cars to market as soon as possible*". Headquartered in Palo Alto, California, it operates in North America, Europe, Australia and Asia, China and South Korea. At the beginning Tesla had a unique approach characterized by the focus on the creation of a compelling car, instead of an affordable one. The reason behind this strategy was the following: being a start-up meant there was no possibility to exploit economies of scale and so they could only build an expensive but high-performances vehicle. Once the brand was established, Tesla reinforced its business model[88], stressing on three pillars: *selling, servicing and charging*. *Selling* means that they decided to use only direct sales through a strong network of company-owned showrooms and galleries. In so doing, it reaches an advantage in terms of speed of products' development and better customer experience. *Servicing* means they combined many sales centers with service centers, adding in certain areas also the so called "Tesla-Rangers", mobile technicians who can service vehicles from your house. *Charging* means they created their own network of Supercharger stations, where drivers could fully charge their Tesla vehicles in about 30 minutes for free, a key element to speed up the adoption of electric cars. Recalling Tesla's mission "to accelerate the advent of sustainable transport", they also sell powertrain systems and components to other automakers.

[86] http://www.motoringfile.com/2018/05/30/ahead-2019-electric-mini-bmw-launches-wireless-charging/
[87] https://www.tesla.com/about
[88] https://www.investopedia.com

In addition, it enriched its portfolio of products starting to sell solar panels, full solar roofing, a line of home batteries called Powerwall and financial services.

GAMUT

Analyzing the offer, it was possible to identify two main categories [89]on the basis of *range* and *starting price*[90]:

- **RANGE > 400 km and STARTING-PRICE > 70.000 €**

  MODEL S: this model was announced in 2008 and arrived on the market, with the name of White star, in in the first quarter of 2012. It is one of the most sold electric vehicles in the world and the most sold on the Norwegian market. Tesla offers 7 versions of Model S but in Italy are offered the two standard models with an autonomy of around 400 km and a starting price that goes from 84.000 € to 100.000 €.

  MODEL X: It was presented in 2012 and commercialized b/w the end of 2015 and the beginning of 2016. It is the most powerful car realized by Tesla and it is equipped with two electric motors, an on-board computer and the Autopilot system that guarantees a higher security standard. There are two versions with an average autonomy of 500 km and a starting price of 93.000 €. The standard version goes from 0 to 100 km/h in 5,2 sec, while the premium one does it in 3,1 sec.

- **RANGE < 400 km and STARTING-PRICE < 70.000 €**

  MODEL 3: presented in 2016 and commercialized in 2017, Tesla model 3 is the low-cost electric vehicle designed in order to make “popular” the electric cars category and to target a different segment of customers. It provides to customers an autonomy of around 345 km and has an Italian starting price of 31.100 €. The 2018 objective is to produce more than 500.000 cars.

The offer is going to be enriched thanks to three new models.

TESLA SEMI[91]: The Tesla Semi is an all-electric battery-powered Class 8 semi-trailer truck prototype which was unveiled on November 16, 2017 and planned for production in 2019. The company initially announced two configurations for 483 km and 805 km of range on a full charge and with the possibility to charge the 80% in 30 minutes using a solar-powered "Tesla Megacharger" charging station. It will be equipped with 4 independent electric motors on rear axles that enable an acceleration time, from 0 to 100 km, in 20 seconds. The USA starting price should be around $200.000 that corresponds to 175.000 € and it will be so far from the average price of American trucks.

[89] Tesla.com & Wikipedia.com & tuttogreen.com

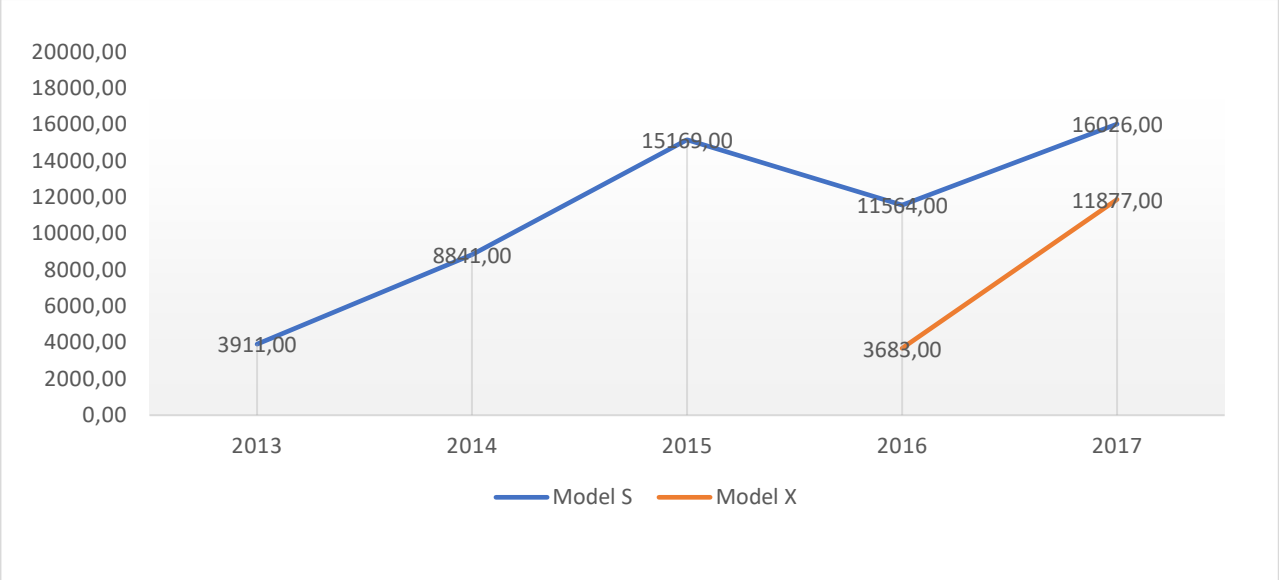
[90] to be considered the fact that for the majority of models there are different variants

[91] [https://en.wikipedia.org/wiki/Tesla_Semi] + [https://electrek.co/2017/11/17/tesla-semi-electric-truck-specs-cost/] + [http://punto-informatico.it/4414429/PI/News/tesla-semi-un-truck-elettrico-800-km-autonomia.aspx]

TESLA ROADSTER 2020[92]: Tesla Roadster was the first sport car launched by Tesla in 2008, with a range that was almost double than any other commercially released electric vehicle. It remained on the market until 2012. The Tesla Roadster 2020 is the evolution of the first model launched by Tesla in 2008. The car will be characterized by its sleek new design and incredible specs with a claimed acceleration time of 1,9 seconds, from 0 to 100 km, which would make it the fastest accelerating produced car ever. It will have an autonomy of 1.000 km and a maximum speediness of more than 400 km/h. The only defect will be that it will come on the market in 2020 with an estimated American price of $200.000 (around 175.00 €).

MODEL Y: [93]the forecasted production of model Y, not yet the official name, is for Nov-2019. It will be a crossover SUV of compact size, enriching the so called "S-E-X-Y" format (model S, X, 3=E). It will probably inherit the style and technological staff of model 3, with a similar range (around 340 km) and a price that will be in the middle between model 3 and model X.

MARKET[94]



Graph 33 *MODEL S and MODEL X EUROPEAN SALES by year*

The graph shows the European sales volume of Tesla model X and S. It was not possible to find data about the model 3, as it started to be commercialized in 2017 and only few models are actually crossing the European boundaries, with an announced delay for the Italian one, in which the model 3 will be available until the end of 2018. The Model S started its sales in the same year in which Tesla opened a factory in Netherlands for assembling this model for the European market. Before that moment, Tesla had appeared on the European scenario with the Roadster,

[92] [electrek] + http://www.motorbox.com/auto/magazine/auto-novita/nuova-tesla-roadster-2020-prezzo-prestazioni-scheda-tecnica
[93] [http://www.ilsole24ore.com/art/notizie/2018-04-12/tesla-model-y-produzione-partira-novembre-mercedes-prepara-l-ammiraglia-elettrica-132312.shtml?uuid=AETKpFXE] + [https://www.money.it/Tesla-Model-Y-prezzo-caratteristiche]
[94] http://carsalesbase.com/european-car-sales-data/tesla/

reaching low volumes. This model sold over 16.000 cars in Europe in 2017, becoming the third best-selling EV in the continent, behind the cheaper Renault Zoe and Nissan Leaf. The highest European market share of this model was reached in 2016 and was around 0,10%. The success of Model S, which competes in the same class as the BMW 5-series, Mercedes-Benz E-Class and Audi A6, is still dependent on government incentives on EV's and for this reason Tesla was one of the best sellers in Northway and Netherland. The Model X started European sales in the second half of 2016 and has shortly reached good results, with nearly 12.000 sales in its first full year.

BATTERIES' DEVELOPMENT

As one of the most important factors for electric vehicle, is important to speak about how Tesla managed and is managing the "batteries-topic". In 2009, Panasonic[95] and Tesla Motors entered a supply agreement for the automotive-grade lithium-ion battery cells. During the following years they finalized the agreement through which Tesla aimed at being able to meet its costs and margin target for Model S. They worked together in the development of a next-generation automotive-grade battery cells and in the acceleration of the market expansion of electric vehicles. They continued their partnership over time, with a culmination in 2017 when Panasonic started the production of batteries at the Gigafactory[96], a lithium-ion batteries factory on which Tesla is concentrating a lot of efforts and investments for reaching the batteries' production needed for equipping 1,5 million of electric vehicles per year. Together they will develop new batteries, slightly larger in size than the ones it is using, in order to sell the car at a relatively lower cost (in comparison to the other Tesla's models). The new, bigger batteries hold more raw materials than the former ones and thus stores more energy and produces more power. Tesla can get the same (or more) range for its cars and potentially use fewer battery cells. With these batteries, Tesla will be able to reach a batteries' cost reduction of 30%. At the end of the day, the news is also an important validation for what Tesla and Panasonic are trying to do in Nevada. They said they planned to make these batteries by the end of 2016 and now they are. This is the proof of how uncertain this market is.

INFRASTRUCTURE's DEVELOPMENT

Tesla charging infrastructure is based on the concept of ***CHARGING EVRYWHERE*** thanks to three different charging programs developed by the company.

- **"FAST" EFFORTS**

  SUPERGARCHER NETWORK – *ON THE ROAD:* The **Tesla Supercharger network** [97]is a system of 480-volt DC (direct current) fast-charging stations built to allow longer journeys for their all-electric manufactured vehicles (Model S, 3 and X). Tesla began building the network in 2012. At December 2017, there were 1.045 stations globally, with 7.496 chargers. A software installed in 2015 in all the Tesla, uses demand information from each Supercharger station to plan the fastest route, if charging will be necessary to reach the destination. As of April 2017, Tesla plans to expand from approximately 9.000 destination

[95] https://www.greentechmedia.com/articles/read/tesla-and-panasonic-kick-off-battery-production-at-the-gigafactory#gs.cB5eD88
[96] https://www.vaielettrico.it/tesla-punta-tutto-sul-fattore-gigafactory/
[97] https://cleantechnica.com/2018/01/13/tesla-supercharger-network-2018-plans-call-rapid-expansion-throughout-north-america-asia-europe-oceania/

charging stations to 15.000. It was the consequence of the Model 3 rollout that was expected to create a growing demand for the availability of these facilities.

- **"SLOW" EFFORTS**

  DESTINATION NETWORK – *INCOMING:* this kind of infrastructure give to Tesla's customers the possibility to charge their vehicles for free (the cost of electricity will be covered by these structures), for few hours or for the entire night, at hotels, restaurants or chipping centers slathered along the territory. This kind of structures will increase the number of customers attracted by their buildings (that will be "equipped" with the needed tackle and a personalized assistance service for the installation, together with the advantage of appearing on the web-site and on the navigator, as one of the recharging station).

  URBAN SUPERCHARGER – *WHEN YOU PARK:* through this network customers will be able to charge their vehicle at home or at car parks.

  Additionally, Tesla is adding a new program, similar to the "Destination network": **WORKPLACE CHARGING.**[98] The program aims at providing the same Tesla Wall Connectors for free, but it focuses on parking at workplaces. Tesla realized an agreement with properties' owners, for the "Destination charging" and the "Workplace charging", in which it seems to be more generous since it even covers the installation of charging stations for other EVs.

VOLKSWAGEN

It is a German company, founded in 1937 under the german dictatoship and is actually headquartered in Wolfsburg. Its name leterally means "demos's car" and it remainds the reason why Adolf Hitler opened this company: for providing to the lower-class population a mean through which it can move around urban areas. In 2015 it decresed its brand image cheating its emissions test and so the following year the company decided to launch a concrete electrification strategy in order to win back its customers trust. Their strategy is called the *"Think New"* [99]and is based on the four following areas of innovation:

1. **Smart Sustainability** - Volkswagen is advancing along e-mobility road.
2. **Automated Driving** - Volkswagen automated driving aims at improving the comfort of drivers.
3. **Intuitive Usability** - Volkswagen concentrated on the easy-to-use concept, trying to make its vehicles as much intuitve as possible.
4. **Connected Community** – it will create an ID for each customers and will interconnect them through a community, increasing the level of commitment of drivers.

This strategy is conceptualized by the I.D concept[100], that currently represent only a concept but will be concretized in the next years, as the car that will merge together the present and the future. It summarizes all the features of a futuristic vehicle but its strongest starting point is the MED platform, where MED stands for Modular Electric Drive. It is considered as a milestone for

[98] https://electrek.co/2018/02/22/tesla-workplace-charging-program/
[99] VW official website
[100] http://www.thisismoney.co.uk/money/cars/article-3813746/VW-reveals-pure-electric-D-concept-rival-future-Golfs.html

future VW electric models because it will provide the basis for different elements as the design, the powertrains, the components. The passphrases: ***comfort, optimum use of space, maximum safety and ground-breaking sustainability.*** Coerehntly with digitalization trends, it will integrate a self-driving system as well as the possibility to wirelessly charge the vehicle.

VW consideres this concept as much revlutionary as beetle was seven decades ago and the mean through which this brand will take customers to perceive electric cars as an "*everyday choice",* with an impressive range and an attractive price.

Its revolutionarity is also mirrored into the idea of connecting each customers with an ID. It will virtually link him with his individual profile, his air conditioning settings, his favourite radio stations and songs, hif favourite ambient lighting as well as his contacts details, friends and business's associates. The driver's smartphone will be its "digital key" to access to his profile.

It will be like having home on move. For example, the driver will have the possibility to interconnect his home and to check whether everything is OK at home, from the car.

GAMUT

The current gamut of VW can be divided into two clusters containing a model each one.

- **RANGE < 230 Km and STARTING-PRICE < 33.000 €**
  E-UP: the electric version of VW UP started to be produced in 2013. It is the comfortable city car, with a modern design that guarantees an acceleration from 0 to 100 km/h in 12,4 sec and an autonomy of 160 km. It is also equipped with an application for smartphone the "*Car Net"* that permits to drivers to remotely control numerous functions of the vehicle. The starting price is 27.850 €.
- **RANGE > 230 Km and STARTING-PRICE > 33.000 €**
  E-GOLF: unveiled in 2013 it was not subjected to design-modifications in comparison to the traditional model. It has a battery of 35,8 kW through which it is able to reach an autonomy of 300 km. The quick charge happens in around 45 minutes and the domestic one goes from 5 to 13 hours depending on the kind of socket. The Italian starting price corresponds to 39.000 €.

Following I will describe the coming models.

E-CRAFTER: this model is launched by the VW's MAN[101] and is categorized under the group of electric vans. It has an autonomy of 160 km, not so attractive but fitting with the urban deliveries' needs. Drivers can recharge it for the 80% of its capacity in 45 minutes (Dc CCs Combo) or in 5,5 h AC. Its price is around 69.500 €.

Finally, it is not possible to categorize the ID car expected for 2020 as we know the range but not the price.

[101] One of the sub-brand of the company

ID car: [102]what I previously described as a concept is going to become a car in few years. This car will be able to accelerate from 0 to 100 km/h in 8 seconds and will present a variable range (from 400 to 600 km). Thanks to the rapid charging system the battery is already 80% charged after just 30 minutes. I already described the other less technical features.

MARKET

It was not possible to find annual data about **E-golf and E-Up European sales.** So, I tried to collect some information related to the market trend of these models. For what concerns the E-Golf[103], it was the fifth pure electric vehicle sold in Europe in 2017 and more recent data, taken from an article of cleantechnica.com, show the E-golf as the first 2018 European best seller in Jan-2018 with 1.985 vehicles sold. While speaking about E-up there are no information available online about sales volume or annual registrations. Moreover, it was not mentioned in the list of best EV-seller models.

BATTERIES' DEVELOPMENT

In 2015 batteries' capacity could be considered one of the weaknesses of VW and for this reason they relied on suppliers like Sanyo (owned by Panasonic) and Samsung, but they also put internal effort in the development of different technologies. VW's strategy can be defined as "*parallel",* because they focused also on slid-state batteries starting from 2012 together with lithium-ion batteries. Its "Center of Excellence"[104] focused during these last years on two macro-areas: batteries' technologies and processes, with the objective to gain competitive advantages not only through the kind of technology but also through the way in which they produce it.

VW can be considered one of the most interested automakers in the field of solid-state batteries. They started to speak about them in 2012 and they recently announced little progresses along that field. Solid-state batteries present different advantages in which VW really trust and so it has the intention to strengthen its position also through some partnerships. They recently announced the partnership with California-based QuantumScape, [105]becoming majority shareholders in the start-up. It will also create a new joint-venture, a strategic action that was commented as follows by the company:

"By increasing our stake in QuantumScape and forming the joint venture we strengthen and deepen our strategic cooperation with an innovative partner and secure access to the promising QuantumScape battery technology for Volkswagen."

The strategy[106] that VW is adopting about the utilization of its batteries is particular. I can define the in-use batteries as a compromise between BEV and PHEV. In fact, the company installs the same kind of cells on BEVs and PHEVs facing some pros and cons.

[102] http://www.thisismoney.co.uk/money/cars/article-3813746/VW-reveals-pure-electric-D-concept-rival-future-Golfs.html
[103] https://cleantechnica.com/2018/03/03/europe-electric-car-sales-january-vw-e-golf-starts-lead/
[104] https://www.autovistagroup.com/news-and-insights/vw-advances-battery-development-plans-loses-company-car-share
[105] https://insideevs.com/volkswagen-testing-developing-3-4-times-higher-energy-dense-batteries/
[106] https://pushevs.com/2016/09/13/volkswagens-strategy-for-batteries/

Using the same cells means that they have to meet a point of balance between the energy and the power density and this represents a disadvantage, as usually cells with higher energy density are used for BEVs and those with higher power density are used for PHEVs.

At the same time, it produces advantages in terms of:

- Costs: VW can negotiate lower prices with cell makers and the cells' makers will sustain lower production costs
- Quality: the cell maker can focus on a unique kind of batteries and so can optimize the R&D efforts and results
- Substitutability: the act of replacing cell makers or replacing the cells using those with more energy is simplified.

Together with VW also Tesla adopts the same tiny cells for all its vehicle, but Tesla is a pure EV producer, so this decision presents only positive aspects from Tesla's perspective

INFRASTRUCTURE's DEVELOPMENT

VW as all the other automakers is providing to its customers different charging solutions, that are similar to those previously described. One element on which I would focus my attention is the recent investment VW announced in 2016 and launched in 2017 in collaboration with other producers.

- **"FAST" EFFORTS**

  BMW Group, Daimler AG, Ford and the Volkswagen Group with Audi and Porsche have joined together, as IONITY[107], with the objective to increase the number of fast charging stations around Europe and to implement a High-Power Charging (HPC) network for electric vehicles across Europe. The objective is to build 400 charging sites by 2020 that will be based on the CCS standard and will be compatible with the majority of car models (Tesla makes an exception and so Tesla's customers will need an adaptor to access to these points). The peculiarity of this network will be linked to the high charging level provided (350 kW) and so the deriving charging time. It will be able to charge the 80% of battery in 10-15 minutes, closed to the time taken by traditional vehicles. As a consequence, the interest, the diffusion and current customers' experience are expected to growth, because one of the higher limits to EVs adoption seems to have been almost overcome.

- **"DIGITAL" EFFORTS**

  Another proof of VW effort in charging infrastructure field is the fact that it lunched in Dec-2016 the MOIA[108] company with the purpose of redefining the mobility of urban drivers. Its focus is on the in-house development of IT-based on-demand offerings, such as ride-hailing and ride-pooling services. For this MOIA is also specifically investing in digital startups and collaborating with cities and established transport providers. Through MOIA,[109] VW took shares in Hubject, the leading e-Roaming car charging platform in Europe and its objective

[107] https://www.cnet.com/roadshow/news/bmw-ford-vw-invest-in-european-ev-fast-charging-corridors/
[108] https://www.volkswagenag.com/
[109] https://www.autoexpress.co.uk/volkswagen/98048/volkswagen-invests-in-europe-wide-electric-car-charging-platform

is that of connecting charging stations across the continent. Hubject's pursues to create a fully standardized network, with an international method of payment, reducing or at least removing the confusion that actually persists in the EV market and related fields, caused by the existence of different providers. If gained, this result will surely guarantee a higher diffusion of electrified vehicles.

HYUNDAI MOTOR GROUP

This group was founded in 1998 when Hyundai Motor Group purchased Kia, and is headquartered in Seoul, South Korea, embodying the mix of two different cultures. Hyundai initially was "*electric vehicle shy"*, but after being pressured by investors it announced a change in its direction at the Los Angeles [110]auto Show in 2016. Starting from 2005 [111]this company have built an eco-car powertrain division, that was able to start working only after two years because of the lack of available Korean engineers (they spent two years for assembling a relevant team). So, its strategic change can be considered more as an evolution and expansion of the company's green-car plans than as a shift.

One of the problems that this company is meeting is that it dominates its home market, but it is not large enough to permit the exploitation of economies of scale in developing new components. For this reason, Kia and Hyundai must leverage on common components between them. One of the consequences of this consciousness is the fact that they are developing a dedicated platform[112], inspired at that of Tesla (with batteries in the floor that enable a higher battery's capacity and a cabin space) that will provide them the possibility to exploit economies of scale and lower costs, offering higher ranges. This is part of the long-term program that they internally dubbed as the *"Project Ioniq"*, [113]taking the name from the Hyundai electric model. The plan aims at launching 26 hybrids, plug-ins and electric vehicles by 2020.

GAMUT

The group currently has on the market two models, one under the Hyundai brand and the other under the Kia brand. The design is different and also some features, but the range and the price are really similar.

- **RANGE = 250 km and STARTING PRICE > 35.000 €**
  HYUNDAI IONIQ ELECTRIC[114]: it has the peculiarity to be the only model on the market available in the hybrid, plug-in hybrid and full electric versions. It was introduced in Europe in 2016, as the electric version of the already existing hybrid one and in 2017 it was rated best in fuel economy by the EPA, achieving an EPA rating of 136 MPGe.[115] It is perceived as

[110] https://wattev2buy.com/electric-vehicles/hyundai/
[111] http://www.autonews.com/article/20160404/OEM05/304049949/hyundai-kias-grand-electrification-plan .
[112]https://www.reuters.com/article/us-space-paulallen/paul-allens-space-firm-details-plans-for-rockets-cargo-vehicle-idUSKCN1L52AY
[113] http://www.autonews.com/article/20160404/OEM05/304049949/hyundai-kias-grand-electrification-plan
[114] https://www.fleetcarma.com/ev-review-2017-hyundai-ioniq-electric/
[115] Miles per gallon gasoline equivalent is a measure of the average distance traveled per unit of energy consumed. MPGe is used by the United States Environmental Protection Agency to compare energy consumption of alternative fuel vehicles, plug-in electric vehicles and other advanced technology vehicles with the energy consumption of conventional internal combustion vehicles rated in miles per US gallon.

an attractive car, is comfortable and easy to drive. It has a declared autonomy of 250 km that makes it a little bit less attractive. The Chevrolet Bolt, its direct competitor, has a higher range. A positive aspect is the regenerative braking.
It obtains the 80% of charge in around 24 minutes with a fast charger and has a maximum speed of 165 km/h. The Italian starting price is 37.000 €.
KIA SOUL EV: it is a small and agile cross-over, ideal to be used in the urban areas. The battery can be charged in less than a hour with a 50kW charger and has a guarantee of seven years. It can accelerate from 0 to 100 km/h in 11,2 seconds and can reach a maximum speed of 145 km/h. The autonomy is similar to that of HYUNDAI ICONIC ELECTRIC and the starting price is around 36.000 €.

Let's analyze the future developments of the Group' offer.

KONA: [116] Hyundai will offer this Kona Electrical in 2 variations, that can be differentiated on the bases of battery pack capability and electric motor productivity. It will not only have a higher range (around 480 km) but also will be more rapid and efficient. It was not possible to find information about the expected price.

NEW ELECTRIC SEDAN (under Genesis brand): this kind of model will be launched until three years, but Hyundai still does not present its name. The only available information is that they are working for improving the range to 500 km.

MARKET

The same difficulties met for VW were met for Hyundai.

For Ioniq, since its introduction on the European market it passes from around 4.000 units to more than 20.000. In 2017 list of best sellers it gained 6.117 unit sold, while in the list of Jan-2018 Ev best seller it already reached the 1.017 units, demonstrating how strong is the interest in this model from customers' perspective. The Hyundai Ioniq Electric still holds the crown of 'most efficient passenger car. But Hyundai in 2018 started limiting supply and cancelling orders[117], replacing them with 2019 model or suggesting to adopt the PHEV and HEV models (with high level of inventory). Officially it is due to "global battery shortage". Even if it is true that this market is facing a global battery shortage, from their report results that Hyundai ordered 6.000 to 7.000 EV battery packs from LG Chem before starting production and that they were planning for only 1.200 vehicles per month. For this reason, some experts thought it was a strategic initiative more than a necessity.

For Kia Soul EV, I can provide only few information. Looking at 2017 European annual sales it was in the last positions gaining a total of 5.551 units sold. While in Italy it was not mentioned in the 2017 best sellers. For 2018[118], in the Jan-classification published by cleantechnica.com related it was the sixth best seller and the tenth (considering both BEV and PHEV)

[116] https://www.2019hyundai.com/2019-hyundai-kona-electric/
[117] https://electrek.co/2018/05/08/hyundai-ioniq-electric-battery-shortage-limiting-production/
[118] https://cleantechnica.com/2018/03/03/europe-electric-car-sales-january-vw-e-golf-starts-lead/

BATTERIES' DEVELOPMENT

Hyundai as well as Volkswagen is conducting a parallel strategy in the development of batteries. Demand for minerals used in electric car batteries will increase in next years as the demand of EV is generally increasing. It is due not only to customers that are appreciating this new trend but also to most of governments that see e-mobility as a mean to decrease the level of pollution and increase the society's health. Hyundai is focusing of this field, especially putting a strong effort along the solid-state batteries' path. On one hand, it is reducing its dependence [119]from established batteries' producers as LG Chem and SK Innovation and it is planning to set up its first production lines thank to the hiring of new researchers, for battery development and manufacturing. It happens in its Namyang R&D Center for batteries development. On the other hand, it is establishing partnerships and is investing in start-ups like Ionic Materials. [120]Ionic Materials is particularly focused on the development of solid-state batteries and is working on the solid polymer that would replace the liquid electrolytes of lithium-ion batteries. This kind of technology can bring a lot of advantages to both producers and customers, but at the same time it is difficult to find someone able to produce them in large scale[121]. There are some companies that are investing in order to introduce them in the market but from the commercial point of view these are currently uncompetitive in comparison with lithium-ion ones.

Which is the Hyundai objective[122]? To realize vehicles powered by solid-state batteries by 2020, but it actually seems to be an almost utopian aim.

INFRASTRUCTURE' s DEVELOPMENT

In 2016 Hyundai partners with EnBW[123], a company with a long-standing experience with charging stations in e-mobility that already supplied more than 700 public charging points and 68 quick charging points stations at the 34 Tank&Rast motorway service stations, for equipping dealership and service points of Hyundai Motor Deutschland GmbH with 560 points for the launch of Ioniq Elektro. An evolution of the service provided will be the utilization of home-charging facilities, the acquisition of cards for the public stations operated by EnBW and the possibility to exploit an all-inclusive package for the e-mobility. Each charging station will present a capacity of two vehicles per time.

- **"DIGITAL" EFFORTS**

  Another field along which Hyundai and Kia are working, as latest researchers, is the wireless charging. [124]They conducted a three-years project, seeing a collaboration between Hyundai-Kia America Technical Center, wireless charging company Mojo Mobility and the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE), that culminated with five vehicles equipped with this system and tested in the real environment. This system is similar to those previously developed, but it has a positive

[119] https://www.electrive.com/2018/05/30/hyundai-to-produce-its-own-electric-car-batteries/
[120] https://www.autoblog.com/2018/07/10/hyundai-solid-state-battery-ionic-materials/?guccounter=1
[121] https://electrek.co/2017/04/06/hyundai-solid-state-batteries-electric-vehicles/
[122]https://www.reuters.com/article/us-huawei-tech-solar-electronics/u-s-tariffs-cast-a-cloud-over-huaweis-solar-electronics-launch-idUSKCN1L609Y
[123]https://www.pveurope.eu/News/E-Mobility/E-mobility-EnBW-and-Hyundai-cooperate-charging-infrastructure-and-green-power
[124] https://www.autoblog.com/2018/04/10/kia-soul-ev-wireless-charging/

feature: even if the driver conducts an imperfect parking it is capable to recharge the vehicle. For this reason, the system is considered to be really efficient. Wireless charging could fit with other technology for Kia. For example, if installed on autonomous cars it means that a Kia could not only drive and park itself, but also take care of its own charging duties.

DAIMLER

It is a German automaker, specialized in the offer of mobility services and headquartered in Stuttgart. It represents the parent company of different brands like Mercedes, Smart, Fuso and some of them can be considered as complementary to its sector like Car2Go, MyTaxi, Mercedes Benz Financial Services. Generally speaking, its strategy [125]can be divided into five main pillars, through which it can maintain its orientation to the future:

1. ***CORE:*** *Strengthening its global core business* → it aims at continuing its core business expansion, through its strong network remaining flexible to market conditions' changes and effective in the generation of value for both the company and customers.
2. ***CASE:*** *leading in new future fields* → CASE represents the acronym for Connected, Autonomous, Shared & Services and Electric. So, their objective is that of being in line with transformation.
3. ***CULTURE:*** *adapting its corporate culture* → they redesign their leadership culture through the Leadership 2020 program, based on dismantling bureaucracy and reinforcing entrepreneurial spirit and creativeness (they are actually developing additional business ideas through innovation platforms like **Startup Autobahn** and **Lab1886**)
4. ***COMPANY:*** *strengthening its divisional structure* → in order to meet environment's changes and the consequences of its dynamism they are restructuring the organization in order to become faster and agiler in the operations
5. ***CUSTOMERS:*** *putting all its efforts in favor of customers*

Focusing more on the alternative mobility strategy[126], Daimler was always a strong well-wisher of e-mobility and it was demonstrated when it was listed in the group of investors of Tesla[127], where it invested $50 million, saving Tesla from 2009- bankruptcy. In 2016 Daimler started its acceleration path along the alternative mobility, seen as a big opportunity that they decided to boost through the listed key areas:

1. **EQ BOOST:** it is linked to an efficient high-tech combustion engine that will permit to achieve savings not imaginable previously. It will be firstly introduced in every Mercedes-Benz model series.
2. **Plug-in hybrid drive:** they will enrich the group of plug-in hybrid vehicles that they consider as key technology for leading to emission-free driving.

[125] Daimler.com
[126] Daimler.com
[127] https://wattev2buy.com/daimler-ev-strategy-trumps-bmw/

3. **EQ:** it is the name under which they will register all the pure electric vehicle of their gamut. Follow their description about the planned investments for this sector: "*approximately €10 billion between now and 2022 to expand our range of EQ models alone. In addition, we will spend about €1 billion to expand our global battery production network. About €500 million of that amount will be spent just on the construction of a second production plant for batteries at our Accumotive subsidiary in Kamenz.*
In parallel, behind our plant gates we will be preparing for the production of our future EQ models. In the future they will roll off the assembly lines of six production plants on three continents — the same assembly lines as our traditional combustion-engine vehicles. We estimate that in the year 2025 up to one quarter of all the automobiles we sell at Mercedes-Benz Cars will be electric vehicles".

GAMUT

Smart and Mercedes represent the main brands linked to the electric offer of Daimler.

- **RANGE < 170 km and STARTTING-PRICE < 33.000 €**
  SMART FORTWO ELECTRIC DRIVE: it is the city-car ideal for the urban traffic. Easy to drive, agile and safe, it does not abandon the performances, being able to reach a maximum speed of 125 km/h. It offers an autonomy of 145 km and the battery can be charged in less than 8 hours at a domestic socket. During the breaking the motor works as a generator, converting the kinetic energy into electric one. The Italian starting price can vary from 24.978 € to 28.150 € for the coupé version.
- **RANGE > 170 km and STARTTING-PRICE > 33.000 €**
  CLASS B ELECTRIC DRIVE: it is a vehicle with good performances, reaching an acceleration from 0 to 100 km/h in 7,9 seconds and a maximum speed of 160 km/h. The minimum slow recharging time is about 3 hours (at a public charging stations) and the maximum 11 hours (with a domestic charge). It has a declared autonomy of 200 km and the possibility to be driven under three modalities: E+, that guarantees lower consumption of electricity; E, that maximizes comfort; Sport, for driving in a sportive way. The starting price is around 41.600 €.

In 2016 they announced their intention to enrich their gamut, through the introduction of their EQ concept.

EQ CONCEPT[128]: this concept can provide a lot of information about which will be the key features of the next Daimler's model, under the Mercedes-Benz model. This vehicle will present the appearance of a sporty SUV coupé, will be connected, safe and comfortable and able to meet every contemporary necessity. It will be based on an architecture specifically developed by Daimler for all its electric models, to optimize the production and so the customers' satisfaction. The architecture is based on an intelligent multi-material mix of steel, aluminum and carbon fiber. This ensures that the requirements in terms of

[128] Daimler.com

lightweight design, strength and cost efficiency are ideally met. Additionally, the vehicle will be ready for both charging at home and for fast charging.

MARKET

It was not possible to find year by year sales' information.

For Smart Fortwo ED, it gained 5.119 units in 2017 and in the first month of 2018 it already reached the 1.143 units, positioning itself in the fourth position as pure EV and in the fifth in the total classification, comprehending BEV and PHEV. So, the expected trend is really positive, considering the fact that in just one month it reached the 1/5 of 2017-sales.

For the class B, I didn't find any data. For sure it wasn't and isn't one of the preferred models of European customers. It was not mentioned in both the 2017 list and Jan-2018 list.

BATTERIES' DEVELOPMENT

One of the symbols of Daimler's efforts in the battery field is the Deutsche Accumotive [129]GmbH & Co. KG, founded in 2009. It is actually a wholly-owned subsidiary of Daimler AG. Accumotive develops and produces highly complex drive batteries for hybrid and electric vehicles based on lithium-ion technology for passenger cars of the brands Mercedes-Benz and Smart. It recently opened a new factory in Kamenz, spending around 500 million euros. This factory represents an important point from two perspectives: it is the synonymous of innovation and jobs. On one hand it will be the first factory to develop premium e-battery and on the other hand it will provide jobs to people living around this city.

The construction of this plant is only a part of the strategy followed by Daimler, that has been defined as "competitive multiple supply strategy[130]". In fact, in 2015 Daimler declared to have the best cells available but at the same time it was conscious about the fact that customers were not able to feel the difference and so it considered a waste developing cells internally. On the contrary, what they could do better was the pack around cells and so they started to concentrate their R&D efforts on that field, increasing the competition at cell-supplier level.

The **analyst expects that most automakers will focus on making the packs and developing** the associated control technology in-house, partly to offset the potential loss of thousands of powertrain assembly jobs, but also to better differentiate vehicles from those of rivals. The biggest cell suppliers are actually:

- LG Chem that is building a plant in Wroclaw, Poland, with a capacity of more than 100.000 batteries and a delivery range of up to 320 km.
- Samsung SDI, that has an annual capacity of 50.000 batteries.

Additionally, the company is working with different start-ups and other companies for developing development new technologies to be used for electric vehicles.

[129] Daimler.com

[130] http://europe.autonews.com/article/20170102/ANE/161219895/automakers-hunt-for-battery-cell-capacity-to-deliver-on-bullish-ev

Speaking about lithium-ion partnerships: StoreDot[131] is a start-up "coming from" Tel Aviv that developed a nanotechnology material able to permit a complete charge of the vehicle from flat in around five minutes.

Speaking about solid-state batteries: it partners with Solid Power[132], a Colorado-based start-up that is looking to develop and scale solid state battery tech.

But it is also working with major corporations like Volkswagen and China's BAIC.

INFRASTRUCTURE's DEVELOPMENT

Because they believe EQ family will represent 15 to 25 percent of their sales in 2025, they are investing a lot, especially in Europe, for the development of a diffused charging infrastructure.

- **"FAST" EFFORTS**

  In 2017, it announced an investment of $82 million in Chargepoint[133], the world's largest EV charging network that was aiming at expanding itself in the European territory. Through this action it attracted potential buyers and began a sort of fight with Tesla. In fact, the American automaker was dominating the US charging infrastructure and the aim of Daimler was that of protect its home territory from Tesla's domination.

  In the same year, together with BMW, Ford and VW it participated to the construction of 400 high-power points through the project Ionity[134], described above.

- **"DIGITAL" EFFORTS**

  In 2018 the focus has been more digital. Being a shareholder of Hubject[135] since 2012, Daimler decided during last years to develop with it a digital solution for simplifying and increasing the convenience of the access' process to public charging. The solution implemented has been dubbed Plug&Charge, certified by the international standard ISO 15118. Actually, the needed operations are complex and so they thought to reduce the complexity by introducing the following methodology, based on encryption and digital signature mechanisms.

  1. Establishment of the connection between the vehicle and the station
  2. The authorization data from driver are transmitted and the authenticity verified through the encrypted form
  3. If the check is validated the charging process starts automatically and the same for the payment.

  This process is also available off-line.

[131] http://lithium-news.com/2018/01/18/mercedes-developing-solid-state-batteries-applying-mild-hybrid-tech-across-range/
[132] http://lithium-news.com/2018/01/18/mercedes-developing-solid-state-batteries-applying-mild-hybrid-tech-across-range/
[133] http://www.newmobility.global/e-mobility/daimler-invests-infrastructure-takes-fight-tesla/
[134] https://www.theverge.com/2017/11/3/16603616/bmw-daimler-ford-vw-electric-charging-europe
[135] http://www.newmobility.global/smart-infrastructure/hubject-daimler-pilot-solution-plugcharge/

THE CONSEQUENCES

In this session I will compile the summary of what emerged from the analysis on each automaker.

I will divide the summary into three main part:

1. Analysis of the offer and how it is distributed in comparison to the AVERGAE PRICE AND RANGE calculated.
2. Analysis of the battery development, how automakers are facing this issue, and which will be the expected results.
3. Analysis of the charging infrastructure and solutions on which automakers are focusing, trying to derive possible consequences on EV adoption.

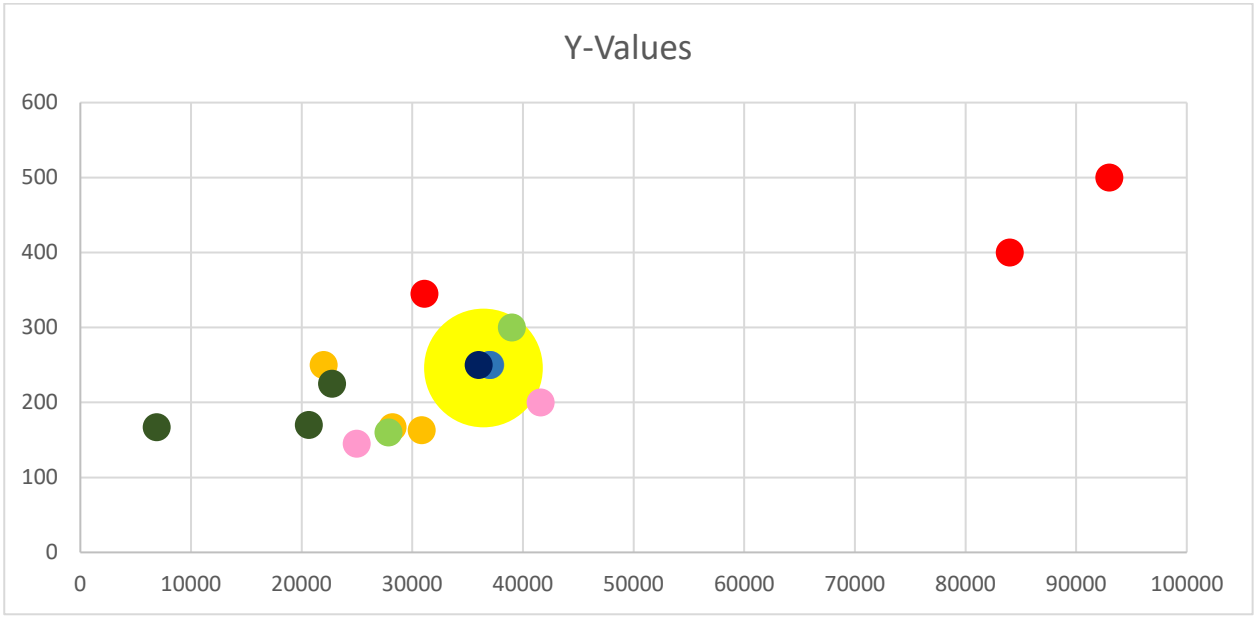
OFFER's ANALYSIS

In this paragraph I reported a table that sums up prices and ranges of each existing model analyzed together with average prices and ranges used for deriving the different clusters of each automaker and the total average price and range. Starting from this table I will build a X-Y table, considering the total average price and the total average range as central, with the objective to individuate different clusters and to understand strategies adopted by automakers.

AUTOMAKER	MODEL	LOWER ST. PRICE	AV PRICE (per automaker)	DECLARED RANGE	AV RANGE (per automaker)
NISSAN	Nissan Leaf	21990		250	
	e-NV 200 EVALIA	28218		167	
	e-NV 200	30850		163	
			27019,33		193,3333
RENAULT	ZOE Z.E.	22750		225	
	KANGAROO Z.E	20650		170	
	TWIZY	6900		167	
			16766,67		187,3333
BMW	i3	37050		250	
TESLA	MODEL S	84000		400	
	MODEL X	93000		500	
	MODEL 3	31100		345	
			69366,67		415
VOLKSWAGEN	E-UP	27850		160	
	E-GOLF	39000		300	
			33425		230
HYUNDAI	IONIQ ELECTRIC	37000		250	
	KIA SOULL EV	36000		250	
			36500		250
DAIMLER	SMART FORTWO ELECTRIC DRIVE	24978		145	
	CLASS B ELECTRIC DRIVE	41600		200	

			33289		172,5
TOTAL AVERAGE		36433,5		246,375	

Table 13 *CALCULATIONS' TABLES*



Nissan	
Renault	
BMW	
Tesla	
Volkswagen	
Hyundai	
Daimler	
Average point	

Looking at the table we can individuate three macro-clusters: the one represented by the Renault's Zwizy that is far from the average price; the one that is between 20.000 to 40.000 €, that represented the most selected price from both customers and automakers; the one that represents the luxury models and is embodied only by Tesla.

Looking at automakers strategy that emerged from this table I can conclude that:

- Tesla is the only leveraging on the luxury segment, offering cars that have a starting price of around 60.000 € more than the average, but it is also producing a single model that fits with the "average point" in terms of price and overcomes the average range.
- Hyundai is producing two models that completely stands on the average point and so is not differentiating its offer, as done by the majority of others.
- Looking at other producers, the range of price into which they provide different models varies from 20.000 € to 40.000 € and often they differentiate also the range.

For the new coming models, it was not possible to define a similar graph, as for most of announced model the launching price in unknown. What is sure is that, on average, they are focusing on ranges' improvement

BATTERIES' DEVELOPMENT ANALYSIS

Here I will primary focus on chemical evolution of batteries over time and then I will have a look on the directions that the automakers are following.

The chemical composition evolved over time, adopting three main technologies:[136] NiMH (nickel-Metal-Hydride battery), PbGel/Silicon, Li (lithium). Different advantages, disadvantages and performances are linked with them.

- **NiMH[137]:** these were the first batteries used on hybrid vehicles and are actually going to be substituted by Lithium batteries. There are some advantages and disadvantages, especially in comparison with Lithium batteries that I will list below.

ADVANTAGES	DISADVANTAGES
Wide operating temperature range – recently extension of operating temperature (to over 100 °C (-30 °C to + 75 °C)) that exceeds the range achievable by lithium batteries	*Battery deteriorates during long time storage* - this problem can be solved by charging and discharging the battery several times before reuse. This reconditioning also serves to overcome the problems of the "memory" effect
Safer than Lithium based cells - due to the use of more benign active chemicals	*Suffers from memory effect* - the situation in which batteries gradually lose their maximum energy capacity if they are repeatedly recharged after being only partially discharged → **High self-discharge rate**
Robust - NiMH batteries also tolerate over charge and over discharge conditions and this simplifies the battery management requirements	*Only 1.2 Volts cell voltage* - many cells are required to make up high voltage batteries. The competing Lithium cells typically have 3 times the cell voltage (3.2 Volts to 3.7 Volts) and a much higher energy density
Possible reconditioning	Scarce autonomy provided when only electric traction is used
Environmentally friendly (No Cadmium, Mercury or Lead)	
Half of Lithium batteries cost	

- **PbGel/Silicon:** these are also going to be replaced by lithium ones, that are lighter. The PbGel is the oldest technology but not the most obsolete because recently it has been innovated and its performances have been improved. These are considered safe and reliable but the oldest need a continuous maintenance and have a low autonomy. The PbGel/Silicon are a little bit better.
- **Lithium:** [138]these are actually the most used and exist in different variants. But it is possible to describe advantages and disadvantages that are common to all the variants.

ADVANTAGES	DISADVANTAGES
High energy density - the much greater	*Protection required* - lithium ion cells

[136] https://www.ideegreen.it/batterie-auto-elettriche-37724.html
[137] https://www.mpoweruk.com/nimh.htm
[138] https://www.mpoweruk.com/lithiumP.htm

energy density is one of the chief advantages of a lithium ion battery or cell (it means smaller dimensions). With electronic equipment needing to operate longer between charges while still consuming more power, there is always a need to batteries with a much higher energy density	and batteries are not as robust as some other rechargeable technologies. They require protection from being over charged and discharged too far. They also need to have the current maintained within safe limits.
Self-discharge - one advantage of lithium ion cells is that their rate of self-discharge is much lower than that of other rechargeable cells such as NiMH forms	*Ageing* - not only is this time or calendar dependent, but it is also dependent upon the number of charge discharge cycles that the battery has undergone.
Low maintenance - they do not require any maintenance to ensure their performance. Ni-Cad cells required a periodic discharge to ensure that they did not exhibit the memory effect. This process or other similar maintenance procedures are not required	*Transportation* - there can be certain restrictions placed on their transportation, especially by air
Variety of types available – this can mean that the right technology can be used for the particular application needed. Some forms provide a high current density, others are able to provide much higher current levels and are ideal for power tools and electric vehicles	*Immature technology* - it is a developing area. This can be a disadvantage in terms of the fact that the technology does not remain constant. However as new lithium ion technologies are being developed all the time, it can also be an advantage as better solutions are coming available.
	Cost - typically they are around 40% more costly to manufacture than Nickel cadmium cells.

Actually, there are two main field on which automakers are concentrating their efforts: lithium-ion batteries and solid-state ones. For the first, all the automakers are developing this kind of technology using different strategies, from the outsource to the internal development to the construction of partnerships or to the contemporary adoption of different of them. There are still important improvements that can be reached through this technology in order to increase the range capacity, but it is important to focus also on new ones. Solid-state batteries can be considered as the "shaker "new technology in this field. This kind of batteries concretely substitutes the liquid lithium electrolyte, the element that permits the transportation of power between the two electrodes, its solid form. The result [139]is a safer battery holding more power, needing lower charging and costing less. Being at the solid state means that the density is higher and so with the same dimensions you can provide a higher capacity. The Alliance as well as the majority of analyzed automakers are developing this kind of batteries, adopting different strategies. Nissan and Renault are planning to put them on the market by 2030. While Tesla seems to be less focused on this technology, the reason[140] behind this is that after being in contact with different research centers they still don't see anything that can change their strategy.

AUTOMAKER	LITHIUM-ION	SOLID-STATE
NISSAN	X	X
RENAULT	X	X
BMW	X	
TESLA	X	
VOLKSWAGEN	X	X
HYUNDAI	X	X
DAIMLER	X	X

To be mentioned also the recent effort putted by incumbents and new comers in the research about the exploitation of graphene [141] in lithium batteries. This element should be able to increase the range autonomy to 800 km, weighting 100 kg and being rechargeable in five minutes. Companies like Samsung are investing in this field, but actually its application is rare.

The prior objective of the researches is the improvement of range, so what is expected is that in few years they will be able to concretely increase the range capacity. The impact on demand will be extremely positive, considering that now consumers are still looking at range as one of the major limits.

In this image we can see the chemical composition evolution. By 2020, the expected range that will be possible to reach is around 600 Km through the traditional Li-ion technology and it will improved over time. As highlighted, a lot of uncertainty actually persists looking at new batteries' technologies.

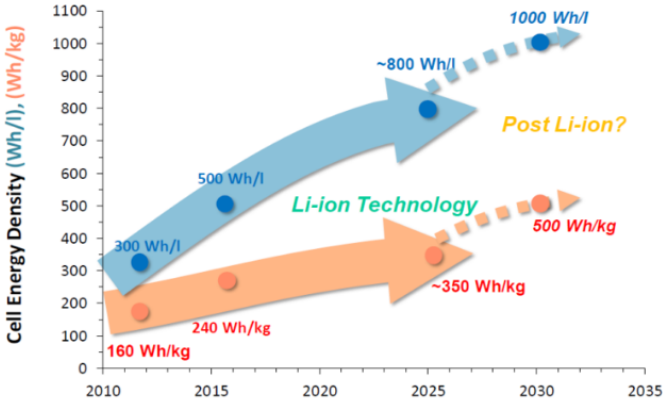


Figure 6 THE EVOLUTION OF BATTERIES' CHEMICAL COMPOSITION

[139] http://www.ilsole24ore.com/art/motori/2017-12-13/batterie-stato-solido-cosa-sono-e-perche-sono-futuro-auto-elettriche-120746.shtml

[140] http://www.ilsole24ore.com/art/motori/2017-12-13/batterie-stato-solido-cosa-sono-e-perche-sono-futuro-auto-elettriche-120746.shtml

[141] http://www.hdmotori.it/2018/06/19/batterie-grafene-earthdas-5-minuti-ricarica/ +http://www.greenstart.it/graphenano-batteria-auto-elettrica-autonomia-disponibilita-9750

INFRASTRUCTURE's DEVELOPMENT ANALYSIS

AUTOMAKER	FAST	SLOW	DIGITAL
NISSAN	X	X	
RENAULT	X	X	
BMW	X		X
TESLA	X	X	X
VOLKSWAGEN	X		X
HYUNDAI	X	X	X
DAIMLER	X		X

For what concerns the infrastructure's development automakers are mainly focusing on two fields: the development of digital solutions (coherently with the actual trend) and the fast charging ones. Considering the first, they are searching for solutions able to reduce customers' efforts and increase their satisfaction as well as the service level. Considering the latter, all the automakers are focusing on this field. It is not surprising as the charging time is perceived as a limit of electric vehicles and so increasing the availability of fast charging methods means decreasing the charging time and reducing the gap with traditional vehicles.

Recalling the chapter about the "Demand and its driver – consumers' side", is clear that cars' producers are acting on those elements that I listed as demand's influencers. By doing this, they are decreasing the majority of existing gaps with traditional transportation means. In fact, the price is expected to decrease, thank to improvement in batteries' development (that influences also the range capacity increase) and the same is expected for the charging time.

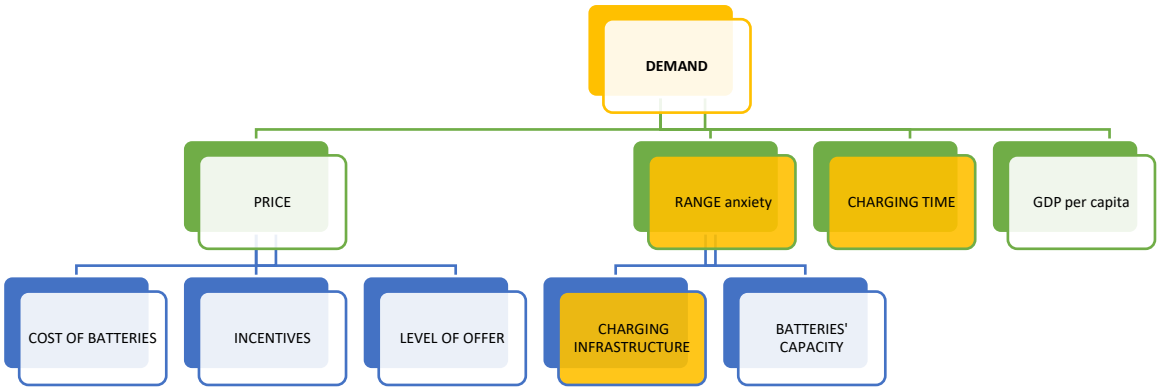
These combined actions are the proof of how much these actors trust in EV revolution.

It is seen not only as a business opportunity but also as a relevant element for the society and the health of the planet.

5 FINAL CONCLUSIONS: possible future scenarios

After this multi-perspective analysis, it was possible to delineate future scenarios for our country.
I found out three possible future scenarios. Looking at the six points that Studio Ambrosetti defined as key pillars for the development of the market, I will identify the possible effects of combined actions along those ways.
Each scenario is different and implies different outcomes.
The first and second scenarios are more realistic and look at gradual interventions on Italian environment that, depending on the kind of action, can be compared with different European countries.
For example, for the first I supposed that through PNIRE Italy will reach the current German situation, in terms of public charging infrastructure, and so I used Germany as reference country. While, for the second I supposed that through a combined action of both Government and PNIRE's mandants Italy will reach the actual Dutch situation, in terms of incentives provided and so I used Netherlands as reference country.
Finally, the third was the most optimistic and hypothesized that Italy will cover its current gap with the average European countries and that contemporary the market will follow its natural growth. For this reason, the differences between the third and the other scenarios are substantial in terms of IT expected sales.

AS IS or PNIRE DOMINATED



In this scenario, the State will only concentrate its effort on the development and accomplishment of the PNIRE plan. The development of 2.000 ÷ 4.500 high power points and 4.500 ÷ 13.000 slow/accelerated ones will take Italy to improve enormously its public charging network. In case they will be able to build the maximum number of slow accelerated and the maximum number of high power charging points, they will reach a ratio between the *TOTAL LAND AREA* and the number of *PUBLIC CHARGING POINTS* similar to the current German one.
So, to quantify this scenario, I will take German data as starting point.

In 2017, Germany had a BEV market share of ***0,7%*** (on the German total cars sales) and sold 25.070 BEV. To evaluate the number of electric vehicles that will be sold in 2025, I started from **the total Italian sales (2011-2017),** deriving the average annual growth rate as follows.

2011	2012	2013	2014	2015	2016	2017	GR 12-11	GR 13-12	GR 14-13	GR 15-14	GR 16-15	GR 17-16	AVG GR
1.942.949	1.545.764	1.420.814	1.493.008	1.726.079	2.050.292	2.190.403	-0,204424	-0,080834	0,050812	0,156108	0,187832	0,068337	0,029639

Then I took ***the total sales[17]*** and I calculated ***the total sales[25]***, supposing the growth rate as stable and equal to ***2,9%,*** year by year.

	2017	2018	2019	2020	2021	2022	2023	2024	2025
Expected total sales	2.190.403	2.255.323	2.322.168	2.390.994	2.461.860	2.534.826	2.609.954	2.687.310	2.766.958

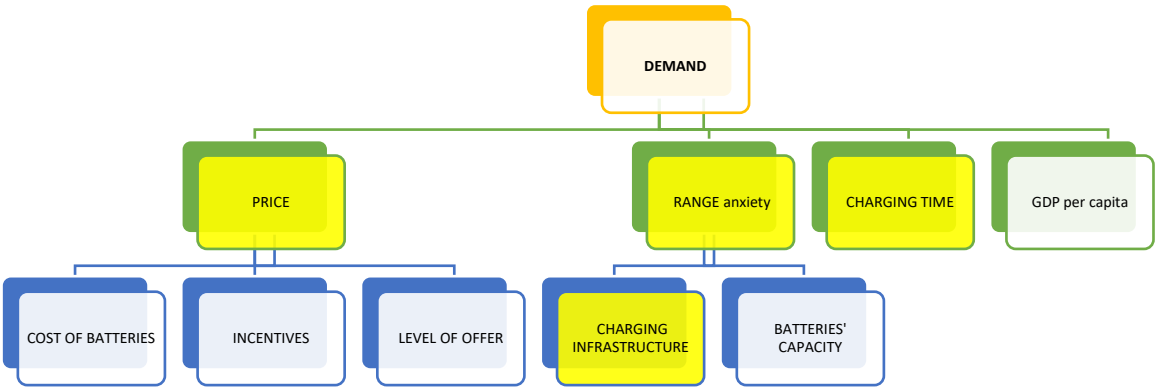
Coming back to Germany and to its current EV market share (=***0,7%***), I supposed that thank to PNIRE Italy will reach the German EV market share[17] in 2025 and so I calculated the expected Italian EV sales as follows.

$$IT\ Expected\ BEV\ sales = 0{,}7\% * Italian\ expected\ total\ sales^{25}$$

The final result was that, through the maximization of PNIRE performances and the application of the described hypothesis, **Italy will sell around 19.370 BEV in 2025**.

From the qualitative point of view, acting on charging infrastructure will have an impact on the reduction of range anxiety and on charging time (as a part of PNIRE project is dedicated to the construction of High-Power points).

TOP-DOWN



In this scenario, I supposed that Italy will develop a strong national strategy for increasing the EV market penetration. Starting from what was stated by Vittorio Chiesa *("without a real purchase incentive nobody buys"*) I defined a situation in which sales are mainly influenced by ***purchase-incentives.*** I took Netherlands as reference, because its incentives' economic equivalent is in the middle between the maximum and the minimum amounts provided by the analyzed European countries.

HPs:

1. Until 2025, Italy will provide purchase incentives for the same amount of Netherlands.
2. Until 2025, Italy will finalize the PNIRE program

Again, I considered the ***IT average growth rate*** (previously introduced and equal to ***2,9%***) and the **IT expected total sales**[25](previously calculated).

I came back to Netherlands and to its ***EV market share***[17]***= 2,1%*** (on the Dutch total cars' sales). So, I supposed that Italy will be able to reach the same EV market share in 2025, through the new incentives 'policy and the finalization of PNIRE.

Then, I considered the impact of the variation in public charging infrastructure. Actually, Netherlands has 35.875 public positions and Italy 3.124. If Italy will be able to complete the PNIRE until 2025, finally it will count for 20.624 public positions, that is the ***57,48%*** of the current Dutch infrastructure.

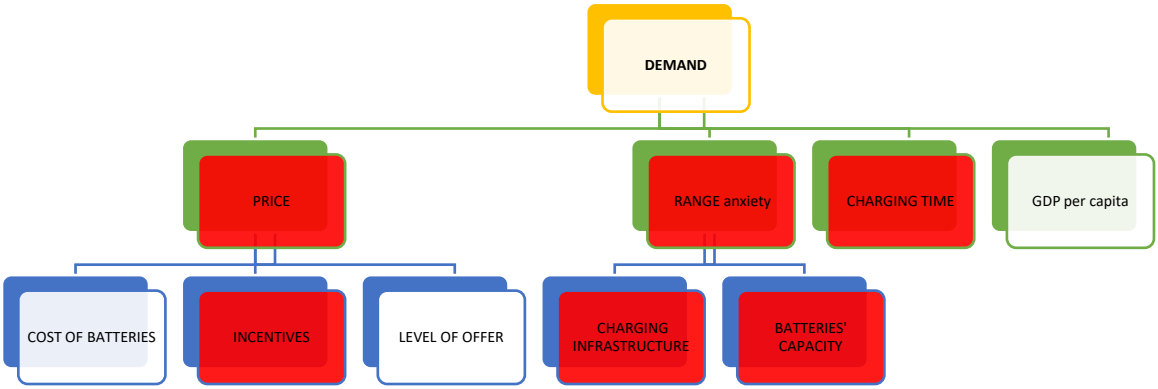
I calculated the expected Italian sales as follows.

$$IT\ Expected\ BEV\ sales = 2{,}1\% * Italian\ expected\ total\ sales^{25} * 57{,}48\%$$

The final expected result was that **Italy will sell around 33.399 € cars.**

This will signify an economic effort of **350.693.660 €** from Italian Government side.

OPTIMISTIC



Finally, I defined the optimistic scenario. It needs different hypothesis to be applied and is based on the assumption that until 2025 Italy, speaking about e-mobility diffusion, will be able to reach the actual average European market share (=8,3%). [1] The output can be seen as the answer to the ***Vision-ire*** scenario, in parallel with a natural development of technology.

HPs:

1- This scenario comprehends only the analyzed automakers and, for some of them, there were no available data about sales volume→ **UNDERSTIMATION.**
2- The impact of new models that will be introduced until 2025 is not taken into consideration→ **UNDERSTIMATION.**
3- Coherently with the estimations described in the previous chapters, the prices of cars are still considered higher than the traditional until 2025.
4- The impact of existing models that will be eliminated from the market until 2025 wasn't considered.
5- Thanks to the PNIRE (that will improve the charging infrastructure situation) and to the introduction of a strategic vision Italy will improve its current condition (related to e-mobility) and will reach the market share of an average European country.[142]

*I started from the analyzed automakers and I tried to calculate their **future European sales**[25] as follows:*

1. I calculated the total European sales[17] of electric models of the best-selling brands that are currently on the market;
2. I evaluated the average annual growth rate for each model and for each brand;
3. Finally, I calculated the total average growth rate;

calculated the expected sales as follows:

[142] https://www.tomshw.it/italia-2025-boom-dell-auto-elettrica-anche-italia-89449

		2013	2014	2015	2016	2017	GR 14-13	GR 15-14	GR 16-15	GR 17-16	AVG per model	AVG per brand
NISSAN	*e-NV 200*	11097	15158	15303	18210	16832	0,365955	0,009566	0,189963	-0,0756727	0,122452678	0,122452678
RENAULT	*ZOE*	2999	2112	2021	2107		-0,29577	-0,04309	0,042553	-1	-0,098766395	0,13788047
	ZWIZY	8774	11090	18469	21240	30134	0,263962	0,665374	0,150035	0,41873823	0,374527335	
BMW	*BMW i3*	1447	9048	11851	14999	21010	5,252937	0,309792	0,265632	0,40076005	0,531125053	0,531125053
TESLA	*MODEL s*	3911	8841	15169	11564	16026	1,260547	0,715756	-0,23766	0,38585265	0,531125053	1,376562526
	MOD x				3683	11877				2,22481673	2,222	
HYNDAI	*Ioniq*					6117						
	Kia Soul EV					5551						
DAIMLER	*Smart*					5119						
TOTAL						112666						0,542005182

I increased the total sales[17], considering the fact that for some models I didn't find data about their sales volume and so the final starting number for my calculation was **130.000 units**. Using the evaluated growth rate as the average annual growth rate from 2017 to 2025, I came out with the following table.

2017	2018	2019	2020	2021	2022	2023	2024	2025
130.000	200.461	309.111	476.651	734.999	1.133.372	1.747.666	2.694.909	4.155.564

Coming back to the fifth hypothesis and assigning the **8,3%** to the Italian market share, compared to the European one, this was the final equation I used:

$$IT\ Expected\ BEV\ sales = Italian\ expected\ total\ sales^{25} * 8{,}3\%$$

The final result was that **Italy will sell 344.912 units of electric cars.**
It could be the output of a combined action on different fronts and so it will influence the majority of demands' drivers individuated. For this reason, the final result is so different in comparison to the previous scenarios.

6 LIST OF SYMBOLS, ABBREVIATIONS and ACRONYMS

% Percent

€ Euro

AEEGSI Autorità Energia Elettrica Gas e Sistema Idrico

BEV Battery electric vehicle

CO2 Carbon dioxide

CNG Compressed natural gas

EV Electric vehicle

FCV Fuel cell vehicle

GHG Green House Gases

h hour

PHEV Plug-in Hybrid electric vehicle

ICEV Internal combustion engine vehicle

Kg kilogram

Km Kilometre

Kwh Kilowatt hour

REEV Extended range electric vehicle

R&D Research and development

TCO Total Cost of Ownership

ZTL Limited traffic zone

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All the links in the end notes

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