POLITECNICO DI TORINO

Master of Science in Management Engineering

Master's Degree Thesis

The charging infrastructures for electric vehicles and their installation process

The Turin project with Enel X Way

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"In the middle of difficulty lies opportunity"

Albert Einstein

ABSTRACT

This study aims to make an overall analysis of public charging infrastructure for electric vehicles, with a particular focus on the installation process. The research is based on the practical case of the installation of two charging infrastructures in the Municipality of Turin, thanks to the collaboration with Enel X Way company which made participation in its project possible. The ambitious European targets have set 2035 as the deadline for the transition to completely green mobility. In light of this, the thesis aims to understand how the charging infrastructure network is developing and whether it is currently adequate for the development of electric vehicles and for the achievement of European targets. Similarly, the critical analysis of the installation process of an electrical infrastructure is carried on, to highlight any limitations and to propose solutions that make the process as smooth, rapid and adequate as possible. The study adopts a technical-economic perspective in order to provide specific notions of charging methods, processes and technical procedures required by the regulations, without however neglecting business opportunities, market analyzes, at national and European level, and the decision-making process that underlies the choice of locations and the type of infrastructure to install. Finally, it will end with the application to a practical case in the city of Turin which will give the opportunity to implement the methods and concepts analyzed, also through the use of photographic material developed during inspections at specific sites.

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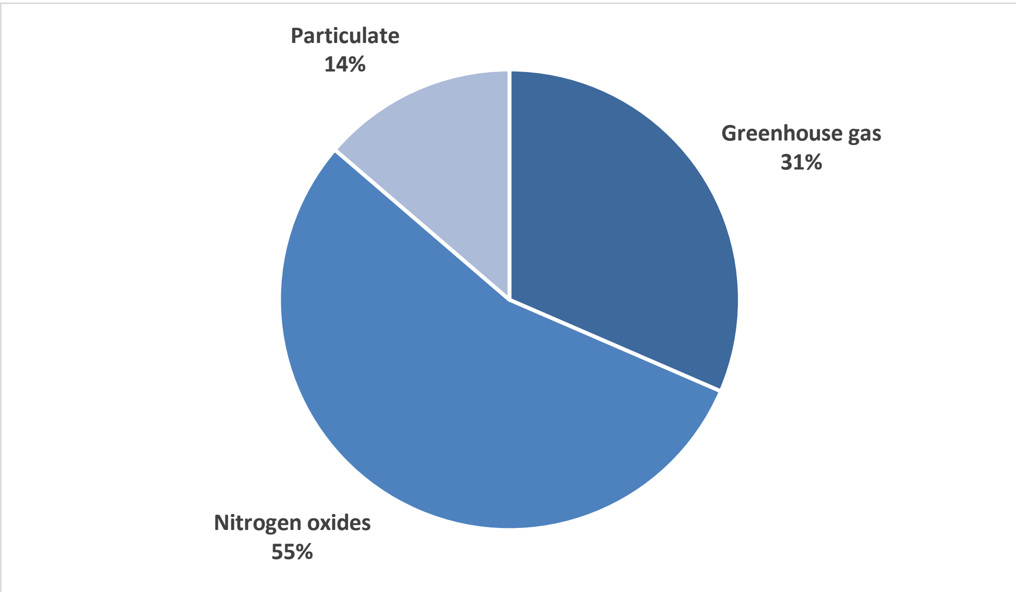
Chapter 1

INTRODUCTION

To date, one of the most debated issues on which local, national and global environmental policies are increasingly focusing is sustainable mobility. This concept expresses a transport system aimed at reducing the environmental, social and economic impact of the sector, making travel faster and more effective at the same time. When a nation sets itself the goal of developing sustainable mobility projects, it focuses on the environment and the quality of life of people by encouraging alternative mobility to the use of private vehicles powered by fossil fuels, such as: public transport, mobility pedestrian and cycle paths, electric vehicles and shared mobility.

Based on recent data reported on the Enel X website (1), road transport contributes to emissions as it has been summarized in the following pie chart:

Graph 1: Road transport emissions



Sustainable mobility therefore becomes essential for the protection of health, society and the planet and is now central to many projects at European level.

Not surprisingly, in the second half of 2021, the European Union proposed Regulation 2021/0197 (COD) on CO2 emissions standards (part of greenhouse gas), according to which new vehicles sold in 2030 will have to foresee average emissions of CO2 55% lower than the 2021 levels and, from 2035, they will have to be zero. To meet the new standards, it is necessary to increase the production and sale of zero-emission vehicles, first electric.

Electric mobility, in fact, represents a zero-impact solution both at an environmental and acoustic level. Not only full electric cars, but also hybrid ones prove to be valid solutions for the fight against air pollution, emitting about 40% less CO2 than a fuel-powered car. However, the electric car is confirmed to be more environmentally friendly than a hybrid, being without a heat engine and minimizing harmful CO2 emissions.

As emerges from the Motus-e study, the adoption of electric cars depends mainly on three factors: (2)

1. The development of technologies
2. The introduction of new European and national legislation
3. Changes in consumer purchasing behavior

Regarding the first point, the development of technologies is fundamental not only in the context of the conception and construction of the electric car itself, but also in that of the electric car complementors, first of all the charging infrastructures.
A fundamental prerequisite for the push for the adoption of an electric vehicle is precisely the presence of a widespread network of charging infrastructures that can support the spread and adoption by users of electric cars in the city, as on extra-urban roads.

This thesis focuses attention on charging infrastructures, with the aim of making an in-depth analysis and verifying whether the state of development and diffusion of the public charging infrastructure network present today on the Italian territory is adequate for development of electric vehicles. The main purpose is to make a current overview and explain the installation process of an electric charging infrastructure for electric vehicles. In this way it will be possible to identify the critical points of the process, if any, and then propose solutions to make the transition to electricity and the fulfillment of ambitious European objectives easier and faster.

Preceded by a first theoretical part, in which the fundamental issues regarding recharging infrastructures are presented, the study then continues with a second practical part, which sees the application of the topics covered to a case study carried out in Turin together with Enel X Way. Furthermore, the study, consisting of four more chapters, is approached with a dual vision that adopts a technical key and an economic key.

More specifically, in the second chapter an analysis was conducted on the charging of electric vehicles, with a first part dedicated to the technical explanation of the charging process which highlights the technologies currently in use and the widespread standards. In the second part, on the other hand, market analyses on the charging infrastructures, on electric vehicles, on their distribution in the territory and on their development over time are carried out. The goal is to highlight the development of the charging infrastructure network in recent years, in the national context, but also at the European level. This section also examines the situation relating to Italian motorways, which are a case in themselves. Finally, the infrastructure plan of Enel X Way will be presented in relation to the analyzes previously illustrated and future objectives.

The third chapter outlines the complete process of installing an infrastructure, starting from the agreements with the Municipality, the choice of sites, the authorization process and, finally, the physical installation and commissioning. Also in this case, the process will be dealt with in a critical way to identify any critical issues.

The fourth chapter provides an in-depth study of the various actors taking part in the process and their ways of interacting. According to the respective roles, the various business opportunities that can be established and the respective applications are then identified.

The fifth chapter is dedicated to the description of the project that is the basis of this thesis, that is the analysis of a practical case. The technical and theoretical description, referred to in the previous chapters, will in fact be applied concretely by accurately describing the entire installation phase of two Enel X Way charging infrastructures in the Municipality of Turin.

It should be noted that the study focused on public charging infrastructures, highlighting the characteristic features of these compared to private ones.

Finally, it is important to emphasize that the laws and regulations, which strongly affect the installation of charging infrastructures, are subject to continuous changes, additions and simplifications. The study reported the regulations in force at the time of drafting with the awareness that, given the strong topicality of the topic, they will be subject to inevitable future changes, which could partially modify what is reported in the study.

Chapter 2

RECHARGING INFRASTRUCTURE: TECHNICAL AND MARKET ANALYSIS

The first step for a comprehensive analysis of charging infrastructures is to understand the underlying technology. In particular, in this chapter it will be analyzed how charging takes place from a technical point of view: the charging technologies, the different charging modes and the plant architecture. Afterwards, the focus will shift to the development of the market for electric infrastructures: a European comparison and estimates on future development will be made. Finally, an analysis of Enel X Way's market position and the deduction of its infrastructure plan will be carried out based on the data found.

It should be emphasized that this study focuses only on charging infrastructures for public use and does not take into account those for private use. In particular, infrastructure for public use refers to both those on public land and on private land for public use (such as shopping centers). The difference between these two types of public infrastructure is mainly related to the authorization process and will therefore be outlined in the reference chapter.

2.1 TECHNOLOGY

Charging modes and charging technologies are defined by various regulations and standards at European level which aim to achieve interoperability of charging systems across the whole territory and, thus, define requirements with general validity.

The most important regulatory references for the installation of charging points, which will be referred to throughout the study, are three:

- Directive 2014/94/EU of the European Parliament and of the Council of 22 October 2014 on the establishment of an alternative fuels infrastructure (DAFI: Directive alternative fuel initiative). The Directive was transposed in Italy by the relevant Legislative Decree No. 257 of 16 December 2016, with an effective date of 14 January 2017. Then, the European Commission published on 14 July 2021 the AFIR (alternative fuels infrastructure regulation), the draft proposal for an update that would replace the DAFI. If approved, this would entail a change in the framework. However, as this has not happened yet, reference in this study will be made to the current directive only.
- Law No. 134 of 7 August 2012, Art. 17, paragraph 1, better known as PNIRE, National Infrastructure Plan for the recharging of electrically powered vehicles.
- The Simplifications Decree-Law, 77/2021 - PNRR Governance and Simplifications.

The first regulation contains all the requirements that must be met for the development of infrastructure for alternative fuels, including electricity. The PNIRE, on the other hand, is a set of guidelines promoted by the Ministry of Infrastructure and Transport, aimed at guiding the development of electric mobility in Italy. Finally, the Simplification Decree-Law defines implications on authorization issues for the installation of public access recharging infrastructures and has the task of simplifying the procedures for entrusting works, services and supplies. (3)

2.1.1 DEFINITIONS

Decree Law No. 257 of 2016 provides the definitions of an electric vehicle and charging point.

The electric vehicle is defined as a motor vehicle equipped with a powertrain, containing at least one non-peripheral electric machine as an energy converter, with a rechargeable energy storage system, which can be recharged externally; the charging point, on the other hand, is: an interface capable of charging one electric vehicle at a time or replacing the battery of one electric vehicle at a time.[1] In addition, the decree distinguishes charging points by power:

- Standard power: these are the recharging points that allow the transfer of power of 22 kW or less and more than 3.7 kW. Recharging points with powers below 3.7 kW are mainly used in private homes and are not accessible to the public.
  The standard power charging point is detailed in the following types:
    1. slow = equal to or less than 7.4 kW;
    2. quick = greater than 7.4 kW and equal to or less than 22 kW;

- High power: these are charging points that allow the transfer of power in excess of 22 kW. The high power charging point is detailed in the following types:
    1. fast or fast = greater than 22 kW and equal to or less than 50 kW;
    2. ultrafast or ultra-fast = above 50 kW;

Before analyzing the different recharging modes, it is necessary to delve into the technical aspects of electricity transmission and the implications for electric vehicle recharging.

[1] Translation of the definitions given by the Decree Law No. 257 of 2016 of an electric vehicle "un veicolo a motore dotato di un gruppo propulsore, contenente almeno una macchina elettrica non periferica come convertitore di energia, con sistema di accumulo di energia ricaricabile, che può essere ricaricato esternamente" and of a charging point "un'interfaccia in grado di caricare un veicolo elettrico alla volta o sostituire la batteria di un veicolo elettrico alla volta". (56)

2.1.2 ALTERNATING CURRENT AND DIRECT CURRENT

The transmission of electrical energy in an electrical system can take place in the form of direct current or alternating current.
There are many differences between the two types of energy: firstly, direct current uses a constant flow of electric charges that always circulate in the same direction through a conductor; alternating current, on the other hand, has a sinusoidal pattern and the intensity varies over time in an oscillating pattern.
In devices, the abbreviation for direct current is DC (Direct Current), otherwise indicated by the symbol of a continuous line (-) with three shorter lines (---) underneath; for alternating current, the abbreviation AC (Alternating Current) or the symbol (~) is used instead.

Furthermore, in terms of application, direct current is mainly used in electronics, especially in battery-powered equipment, which can only generate direct current. In contrast, alternating current is applied in the production and transport of electricity.
In general, the latter is more widely used because the machines to generate such energy are cheaper and easier to produce. Finally, alternating current, unlike direct current, allows the use of transformers, high-efficiency machines that allow varying the voltage of the current itself and are essential for transporting energy. (4)

It can be concluded that:

- The power grid supplies electricity in alternating current (AC);
- The battery only accepts direct current (DC);
- The motor is predominantly supplied with alternating current (AC), single-phase or three- phase.

This means that the electrical energy must be transformed up to two times before it can be used to drive the electric vehicle: from AC to DC, for the battery, and from DC to AC, for the motor.
Energy conversion takes place with converters located in the stationary charger and/or converters and inverters in the vehicle. Stationary chargers are therefore classified as AC, if they do not incorporate a converter, and DC if they do.

All vehicles, both two-wheelers and four-wheelers, can be powered by AC chargers, while only a few car models, a few motorbikes and no mopeds accept DC charging. (4), (5)

2.1.3 CHARGING TIMES AND POWERS

AC recharging can take place at different powers: from 3 kW in normal households to 22-43 kW in public areas. In contrast, DC charging takes place at higher powers, as the limits of the in-vehicle AC/DC converter are exceeded. The most common are 50 kW, but thanks to the latest technological developments, recharging can take place with powers even higher than 150 kW (HPC, high power chargers).
Power and charging time are two inversely proportional factors: as the former increases, the latter decreases. To calculate the charging time, the battery capacity (in kWh) is considered and divided by the charging power in kW. Batteries with a higher capacity take longer to charge. Considering a vehicle with medium-capacity batteries (between 30 and 40 kWh), the charging times to reach 80 per cent of the battery's potential capacity are approximately 8 to 10 hours, with normal domestic charging at 3 kW, and approximately 2 hours, at 22 to 43 kW.
Below a summary table of the charging powers is shown (6):

Table 1: Charging powers

CURRENT TYPE	NAME	POWER
AC	Slow	≤ 3.7 kW
	Quick	$7<P\leq 22$ kW
	Fast	$22<P\leq 43$ kW
DC	Fast	$43<P\leq 50$ KW
	Ultra Fast	$50<P\leq 150$ kW
	High Power Chargers	$P>150$ kW

Charging times therefore depend on charging power and battery capacity. However, other determining factors are related to vehicle characteristics. Indeed, cars have an internal system that regulates energy absorption to prevent overheating and excessive battery wear. In particular, one factor to be taken into account is the maximum power accepted by the integrated charger. For example, some vehicles cannot be recharged by HPCs, which is why it is essential to diversify the supply of charging infrastructure in locations. (7)
Then, another influencing characteristic is the battery temperature at the time of charging. The charging time will be longer for a vehicle that was previously stationary and, therefore, with a lower battery temperature, than for one that was already in motion and with a higher battery temperature. The reason is to avoid a thermal shock that would wear out the battery. Another factor to be taken into account is that charging is not linear: charging depends on the battery capacity reached; after 80% of the battery's potential capacity is reached, the time to reach 100% recharging becomes longer.
As power increases, so do the risks of overheating and accidents, so it is necessary to equip systems with safety systems for connectors and sockets. Standards and regulations define the necessary safety systems.

2.1.4 CHARGING INFRASTRUCTURE STANDARDS AND TECHNOLOGIES: connection types, charging modes, sockets, plugs and connectors

After an international debate in which each nation tried to impose its own standards on the market, nowadays, 3 connection types and 4 charging modes, as well as different types of connectors, plugs and sockets, have been established.
The charging mode choice depends on the characteristics of the vehicle and its batteries, as well as the characteristics of the charging infrastructure and the location of the charging facility (5).

2.1.4.1 Connection Types

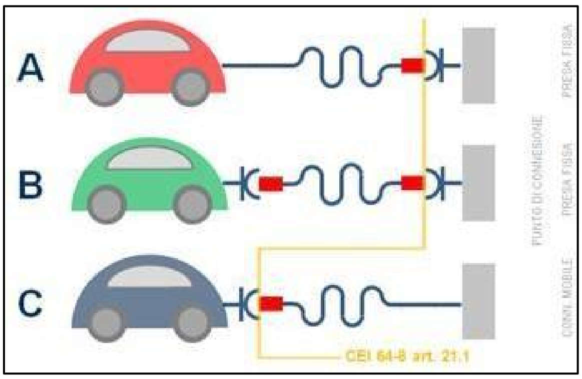
Currently, the three most popular connection types are distinguished according to the side, or sides, that are provided with the connection and are defined by the IEC (International Electrotechnical Commission) standard 61851-1. (8), (9), (10)

In this regard, it is emphasized that the term socket/plug refers to the connection on the side of the charging infrastructure, while the term connector, to the connection on the side of the vehicle. The electric vehicle can be connected to the charging point using:

1. A power cable and plug, permanently attached to the vehicle (type A in Graph 2);
2. A removable power cable with a movable connector and plug for connection to the AC power socket (type B in Graph 2);
3. A power cable and a movable connector permanently attached to the power supply equipment (type C in Graph 2).

It should be noted that the absence of the on-board power cable is an advantage in terms of space and weight. The three connection types are shown in the following graph (9), where the yellow line indicates the different boundary of responsibility for each type:

Graph 2: Connection Types



2.1.4.2 Charging modes

The IEC (International Electrotechnical Commission) standard 61851-1 defines four different standards for charging technologies, depending on the following characteristics: (8), (5)

1. The regime: alternating current, direct current;
2. Maximum current;
3. Connector type;
4. Socket/plug;
5. Possible communication/control between the vehicle and the electrical station.

The four charging modes, the advantages and disadvantages of each, and the areas of application are explained below.

- "Mode 1" - *slow charging from a household-type socket-outlet.*

  In this mode, charging takes place in alternating current. As explained in the PNIRE, there are some limitations:

  - The first limitation is the available power, which must be controlled to avoid the risk of overheating the socket and cables due to intensive use over several hours;
  - The second limitation is related to the energy management of the system. The charging of the vehicle is in fact shared with other sockets (there is no dedicated circuit), if the sum of consumption exceeds the protection limit (in general in a domestic environment 16A, i.e. 3kW), the switch will trip, interrupting the charging[2].

  For these reasons, charging takes place via standardized sockets and plugs up to 16A, i.e. ordinary industrial CEE or Shoku sockets, connected to the vehicle with the supplied charging cable. In addition, there is a Mode 1 power limit of 3kW, to ensure safety and quality of service.
  Mode 1 is the simplest and most straightforward solution to implement and the one with the lowest investment cost. However, this charging mode is only allowed in private areas, not open to third parties, and it is used for electric bikes, light vehicles and scooters. A graph together with a summary table follow below: (5)

[2] Translation of the limitations exposed in the PNIRE "la prima limitazione è data dalla potenza disponibile che deve essere controllata, per evitare rischi di surriscaldamento della presa e dei cavi dovuti all'uso intensivo per diverse ore; la seconda limitazione è legata alla gestione energetica dell'impianto, la ricarica del veicolo infatti è condivisa con altre prese (non esiste un circuito dedicato), se la somma dei consumi supera il limite di protezione (in generale in ambito domestico 16°, ovvero 3kW), l'interruttore scatterà, interrompendo la carica" (10)

Graph 3: Charging Mode 1

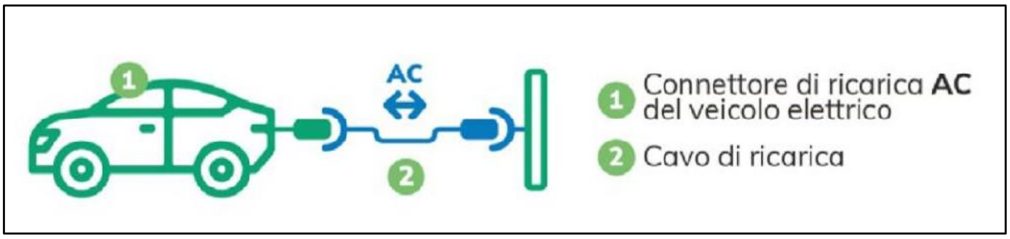


Table 2: Summary Charging Mode 1

Recharge	Slow (6-8 hours)
Environment	Domestic and empty spaces
Plug	Industrial CEE or Shoku
Power	3 kW
Type of connection	From the vehicle to a socket with up to 16A AC and without control box
Suitable to	Light vehicles and motorbikes due to the absence of a control box

- "Mode 2" - *slow charging from a household-type socket-outlet with an in-cable protection device.*

  In mode 2, charging always takes place in alternating current and with industrial CEE or Schuko sockets and plugs, but with a nominal current of up to 32 A. In addition, compared to mode 1, a control box, containing a 30 mA differential, is placed on the cable between the vehicle and the charging station, which has a control and protection function.
  For this reason, Mode 2 is considered to be safer than Mode 1 and allows not only light vehicles, but also cars with a power output of more than 3 kW to be recharged at home or in private spaces.
  However, this mode has the disadvantage of having a control device placed on the cable and only protecting the downstream cable and the vehicle, but not the plug, which is the component most subjected to wear and tear. A graph and summary table follow below: (5)

Graph 4: Charging Mode 2

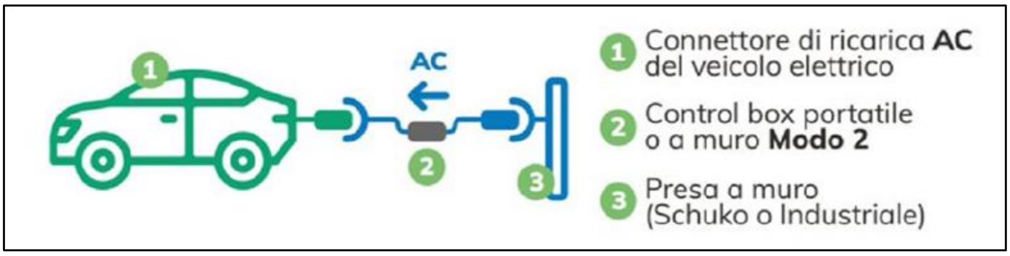


Table 3: Summary Charging Mode 2

Recharge	Slow (6-8 hours)
Environment	Domestic and Private spaces
Plug	Industrial CEE or Shoku
Power	3-7 kW
Type of connection	Between a vehicle power cable and a power socket via an ac control box

- "Mode 3" - *slow or fast charging using a specific EV and PHEV socket-outlet with control and protection function installed.*

  Mode 3 is the only AC charging mode allowed for public use and that fulfils the safety level set by European standards. Unlike mode 2, public facilities must be equipped with a control box permanently integrated into the infrastructure. The vehicle is connected directly to the electricity grid via a specific plug and a dedicated circuit. A Mode 3 charging cable, which is supplied with the vehicle, is required to connect the electric vehicle to the charging station.
  The sockets are Type 2 or Type 3A (for scooters and light mobility) and have pilot contacts that communicate with the vehicle. A graph and summary table follow below: (5)

Graph 5: Charging Mode 3

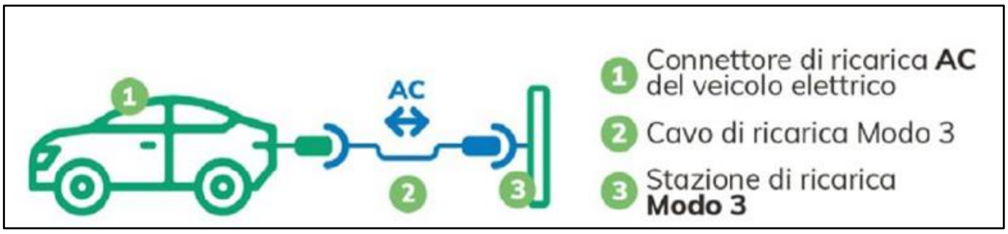


Table 4: Summary charging mode 3

Recharge	Slow (6-8 hours) or relatively fast (30 minutes-1 hour)
Environment	Domestic and private spaces, mandatory in public spaces
Plug	Type 2 and type 3A
Power	7-43 kW
Type of connection	Via the vehicle power cable and the charging infrastructure with control box

- "Mode 4" - *fast charging using an external charger.*

  In mode 4, charging takes place in direct current: the AC/DC converter is integrated in the infrastructure and thus the vehicle will be lighter and easier to connect. The control, protection functions and charging cable of the vehicle are permanently integrated into the charging infrastructure.
  This recharging mode is only allowed in public places and overcomes the constraints imposed by the internal AC charger, making high-power (i.e. ultra-fast) recharging possible at powers of 50 kW or more. Again, the sockets are specific and vary according to the standards adopted by the vehicles (CHadeMo for Asian cars and CCS or Combo for European ones). A graph and summary table follow below: (5)

Graph 6: Charging Mode 4

Table 5: Summary Charging mode 4

Recharge	Fast (5-10 minutes)
Environment	Public spaces
Plug	CSS or COMBO2 (Europe) and CHAdeMO (Japan)
Power	50 kW and over
Type of connection	The AC/DC converter is internal to the infrastructure, enabling high-power DC charging

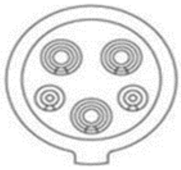
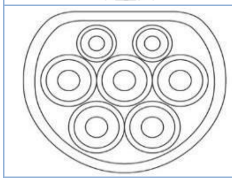
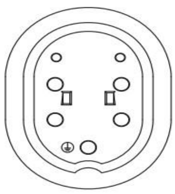
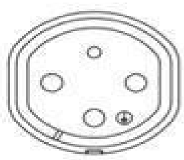
Finally, public charging stations are equipped with systems for measuring the energy delivered for the purpose of subsequent payment of the charging service and are often interoperable, i.e. usable by customers registered on the platforms of different operators. This topic will be dealt with in more detail later on.

2.1.4.3 Sockets, plugs and connectors

The International Electrotechnical Commission (IEC), in the 62196-2 standard, has defined 3 specific types of sockets, plugs and connectors for AC charging, depending on the current, nominal voltage, number of phases and number of pilot contacts. (11)

Information on sockets are summarized in the following table:

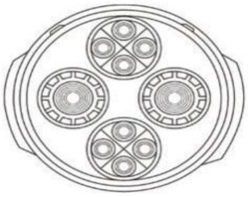
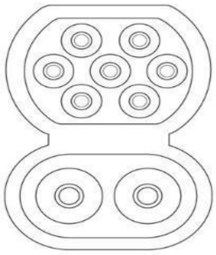
Table 6: Alternating current sockets

Sockets	Type	Nominal voltage	Nominal current	Number of phases	Pilot Contacts	Side	Use
	1	230 V	32 A	1	2	Vehicle side	Japanese and American standards
	2/2s (Mennekes)	230 V single-phase, 400 V three- phase	70A single-phase, 63A three-phase	1 o 3	2	Vehicle side and column side	European standard (except in France)
	3c (EV-Plug Alliance)						In disuse
	3A	230 V	16 A	1	1	Column side	Light vehicles

As already mentioned, the 2 Mennekes socket and 3A are used in the European context, while 3C is in disuse and socket type 1 is the Japanese and American standard.

DC sockets, on the other hand, are defined by IEC 62196-3. (12)
Two standards are common for DC charging, depending on location, as summarized in the following table: (13)

Table 7: Direct current sockets

Sockets	Type	Use
	CHAdeMO	Japanese Standard
	CCS (combined charging system) or Combo2	Integrates AC charging (consisting of Socket 2) and DC charging (two contacts at the bottom) in one device. European and American standards.

In Europe, the socket used for DC charging is the CCS or also known as Combo 2. This integrates the possibility of alternating current charging, consisting of Socket 2, which is at the top of the socket, and DC charging, consisting of the top of the socket plus two contacts which are placed at the bottom. As an example, two photos of the CSS socket taken during an inspection of the Turin Case Study:

Figure 1: CSS for AC charging

Figure 2: CSS for DC charging

2.1.4.4 Standards in the Market

As already reported, nations have strong interests in imposing their own standards on the market, both from an economic point of view and in terms of national pride.
In the past, for example, the German 'Mennekes' Type 2 plug competed with the French 'EV Plug Alliance', i.e. the 3C, then the former became the standard and the latter fell into disuse. (14)

Even in DC, as described in the table, there are two standards with different geographical applications.
In 2010, the Japanese, who were then the undisputed leaders in electric cars, founded the CHAdeMO Association, an organization whose aim was to promote the use of the CHAdeMO standard. In Europe, although columns with this standard had already been installed, another standard was preferred: CSS. To date, although CHAdeMO is the world's most widely used DC fast-charging standard, CSS is gradually becoming more widespread on new electric vehicles. This is because vehicles equipped with CHAdeMO require another connector for AC charging (normally Type 1), whereas CSS allows both AC and DC charging.
Today, it is possible to distinguish between car manufacturers that adopt one standard rather than another. The car manufacturers that rely on CHAdeMO are: BMW (i3 only and only for the Japanese market), Citroën C-Zero (based on Mitsubishi i-Miev), Honda, Hyundai, Kia, Mitsubishi, Nissan, Peugeot iOn (based on Mitsubishi i-Miev), Toyota. Those that have chosen CSS instead are: Audi, BMW, Jaguar, Mercedes, Porsche, Renault, Volkswagen and Volvo. (15)
Finally, other vehicles, such as Smart, Renault Zoe and Tesla Model S, do not provide direct charging, but rely on FAST AC Mode 3 for fast charging. (16)

A special mention must be made of the Tesla case, which was able to develop its own standard independently. The American company has developed an exclusive charging system for its cars, called the Supercharger. The reason behind Tesla's choice is certainly strategic and competitive: the Supercharger, in fact, guarantees charging power of up to 250 kW, basically allowing a range of 250 kilometers in just 15 minutes. With more than 30 000 Superchargers located globally, Tesla owns and operates the largest global charging network in the world.
The Supercharger network was introduced on 24 September 2012, with six Supercharger stations. As of 18 February 2021, there are 2564 stations located worldwide: 1101 stations in North America, 592 in Europe and 498 in Asia. Initially, Tesla Model S was the first car to be able to use the network, followed by Tesla Model 3 and Tesla Model Y. The company managed to make the Supercharger a standard thanks to strong financial incentives in the initial period of its development. In particular, when Tesla Model S was launched, Tesla guaranteed free Supercharging for life. This incentive was later removed in 2017, as sales of the car began to increase and charging stations to become more congested. However, the incentive remained valid for those who had bought the car between 2012 and 2016. This

shows how the company realized early on the importance of the close relationship between electric vehicle use and the charging infrastructure network. Furthermore, Tesla vehicles are also compatible with the CSS and CHAdeMO standards through dedicated adapters, giving users a wide choice. (17)

2.1.4.5 Charging modes in the Italian context

In the Italian context, the technical specifications for charging points for public use and the intended areas of application have already been summarized above in the tables 2,3,4 and 5. From a legislative point of view, it is possible to find references in Annex 1, paragraph 1, of the Legislative Decree 2016 which sets out that:

- For alternating current (AC) charging: charging stations must comply with Mode 3 of IEC 61851 and be equipped with a Type 2 charging socket according to EN 62196;

- For direct current (DC) recharging: the station must at least be equipped with Standard CCS Combo2.[3]

In conclusion, the two modes allowed in the public sector are Mode 3 (AC) and Mode 4 (DC); whereas, in the domestic sector, charging is typically done in alternating current (AC) Mode 2. For AC charging (Mode 2 and Mode 3), the main type of connector is Type 2 (Mennekes) and the charging cable is an accessory of the electric vehicle; whereas, for Mode 4 (DC) charging, the connector provided is CCS and the cable is directly connected to the charging infrastructure.

The PNIRE, however, specifies that "the development and deployment of infrastructures in the public sector must still take into account the presence of vehicles equipped with other DC charging devices (such as CHAdeMO - 'Mode 4') and Fast AC Mode 3, socket 'Type 2', adopted by many car manufacturers".
For this reason, the use of multi-standard charging stations (thus integrating the three standards on the market for fast charging of electric vehicles) is always strongly recommended when installing DC charging systems (DC - Mode 4). (18)

[3] Translation of the Annex 1, paragraph 1 of the Legislative Decree 2016 "Per le ricariche in corrente alternata (AC): le stazioni di ricarica devono essere conformi al Modo 3 della IEC 61851 e devono essere dotate di Presa di ricarica Tipo 2 secondo EN 62196. Per le ricariche in corrente continua (DC): la stazione devono essere almeno dotata di Standard CCS Combo2." (56)

2.1.5 ENEL X WAY CHARGING INFRASTRUCTURE (19)

In general, to date, Enel X Way installs three types of charging infrastructure, depending on scope and use.

In the public sector, Juice Pole and Juice Pump are installed. The first type has less power and therefore requires longer charging times. It is also more compact and has less visual impact. The Juice Pump, on the other hand, allows much shorter refilling times and is bulkier. For these reasons, the Juice Pole finds applications in contexts where vehicles are parked for longer periods, while the Pump in contexts where vehicles are parked for shorter periods. In the domestic sphere, then, where charging times are longer, Juice Boxes are preferred.

The technical characteristics of these three types of columns, in their variants, are summarized below.

2.1.5.1 Juice Pole (19)

Figure 3: Juice Pole

The Juice Pole has two poles from which it can charge two vehicles at the same time in alternating current and corresponds to the Mode 3 IEC61851-1 standard.

There are two variants of Juice Pole, the technical characteristics of which are summarized in the table, where a 'V' corresponds to a socket on the electric infrastructure:

Table 8: Juice Pole Variants

Name	Description	Type 3A (3kW)	Type 2 (22kW)
Juice Pole 03+22	Type 3A 3kW + Type 2 22kW (25kW 32A @400V)	V	V
Juice Pole 22+22	Type 2 22kW + Type 2 22kW (44kW 64A @400V)		VV

Its use is suitable in both public and private spheres, where private is understood to mean a specific group of people and not in the domestic sphere.

2.1.5.2 Juice Pump (19)

Figure 4: Juice Pump

The Juice Pump has the characteristic of recharging with direct current and therefore reflects Mode 4.
In general, three versions were developed depending on the maximum DC power output: up to 50 kW, 75 kW and 150 kW.
In addition, depending on requirements, there is the possibility of AC recharging via a Type 2 connector, in the version with the cable integrated in the column.

The Juice Pump has been designed in several variants, as summarized in the table, where a 'V' corresponds to a column socket:

Table 9: Juice Pump variants

Name	DC				AC	
	CHAdeMO	CCS2			Type 2	Type 2
	50 kW	50 kW	75 kW	150 kW	43 kW	22 kW
JuicePump 50 Trio 43	V	V			V	
JuicePump 50 Trio S22	V	V				V
JuicePump 50 Duo	V	V				
JuicePump 50 Duo CHAdeMO + 43	V				V	
JuicePump 50 Duo CHAdeMO + S22	V					V
JuicePump 50 DUO CCS2 + 43		V			V	
JuicePump 50 Duo CCs2 + 43		V				V
JuicePump 75			V			V
JuicePump 75 Trio	V		V			V
JuicePump Flexi 150 1				V		
JuicePump Flexi 150 2				VV		
JuicePump Flexi 150 3	V			VV		
JuicePump Flexi 150 Trio 1				VV		V
JuicePumpFlexi 150 Trio 2	V			V		V

2.1.5.3 JuiceBoxPro and JuiceBox Pro Cellular (19)

Figure 5: JuiceBoxPro and JuiceBox Pro Cellular

The JuiceBox is available in two versions: single-phase and three-phase. In single-phase, there are two versions: at 3.7 kW and up to 7.4 kW. In three-phase, on the other hand, there is one version: up to 22 kW. The charging standard is mode 3 and the sockets are Type 2 or Type 3A.

2.1.6 PLANT ARCHITECTURE

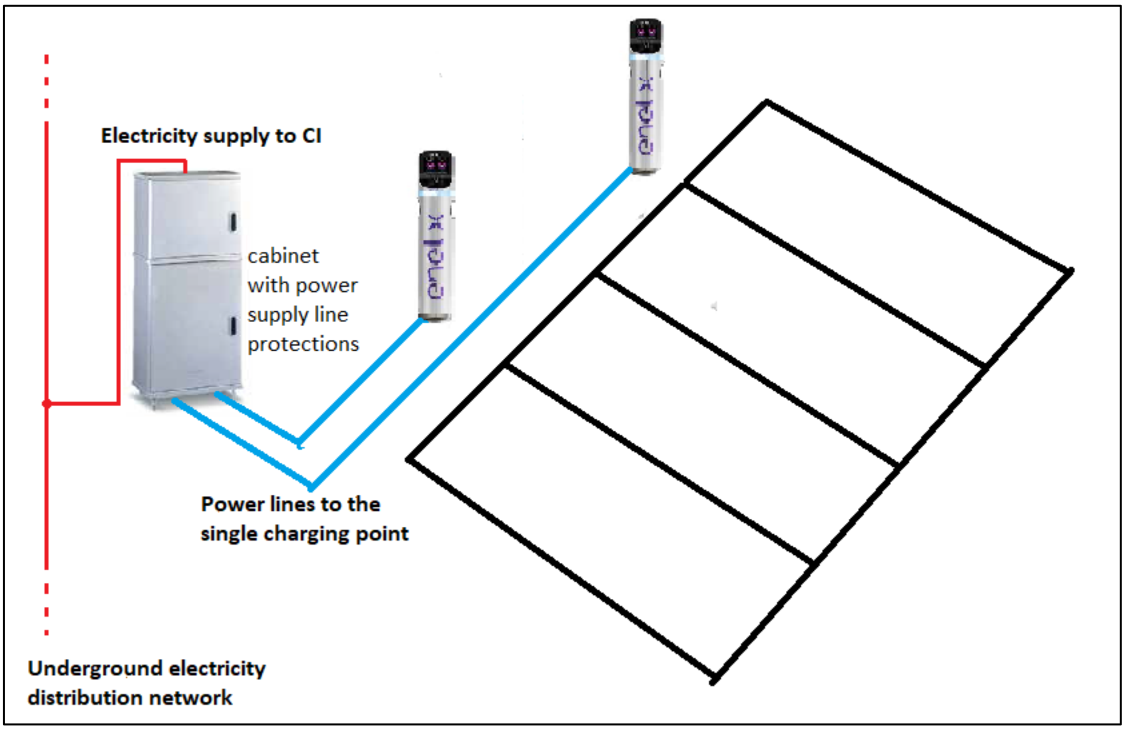
We conclude our analysis of charging infrastructure technology by focusing on the plant architecture. The plant architecture of the charging infrastructure has undergone a change since the introduction of the DAFI directive. Therefore, two architectures will be analyzed:

1. The Service Provider Model;
2. The DSO model.

The current model, introduced after the DAFI directive, is called the "*service provider model*", or "*DAFI model*", or "*post-contractor model*". In the following section, reference will be made to the actors in the value chain, such as: DSO, distributor system operator, and CPO, charging point operator. The two roles will be discussed in more detail in the dedicated chapter, but it should be emphasized that the first one is the electricity distributor, while the second one is the charging infrastructure operator.

An explanatory diagram of the architecture follows below, considering two poles with two parking spaces each:

Graph 7: Service Provider Model plant architecture



In this model the system typically consists of:

1. A container with a supply measuring unit inside;
2. An enclosure containing one or more protective devices;
3. A supply line (shunt);
4. An earth plant;
5. One or more charging infrastructures;

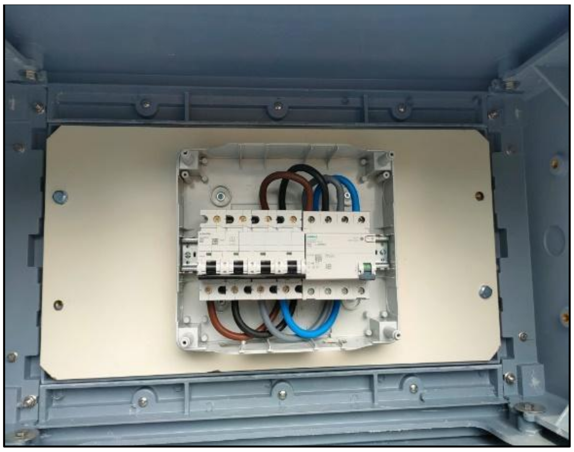
The red line, shown in the graph, is the power distribution network that runs the DSO.
The distributor identifies the exact point where to branch off to get the line to the charging plant (Electricity Supply to the charging infrastructure).

The distributor line arrives in a cabinet that is made of fiberglass and contains two compartments: the first compartment is dedicated to the switchboard, the second, to the meter.
The switchboard contains all circuit breakers and protection devices, while the meter is the measuring unit of the supply and is the property of the distributor.

As an example, the photos taken in the Turin Case Study in Via Carema are shown:

Figure 6: Fire glass cabinet before electrical work

Figure 7: Fire glass cabinet after the electrical work and meter installation



Everything downstream of the meter belongs to the owner of the electrical infrastructure, while everything upstream is the responsibility of the distributor.

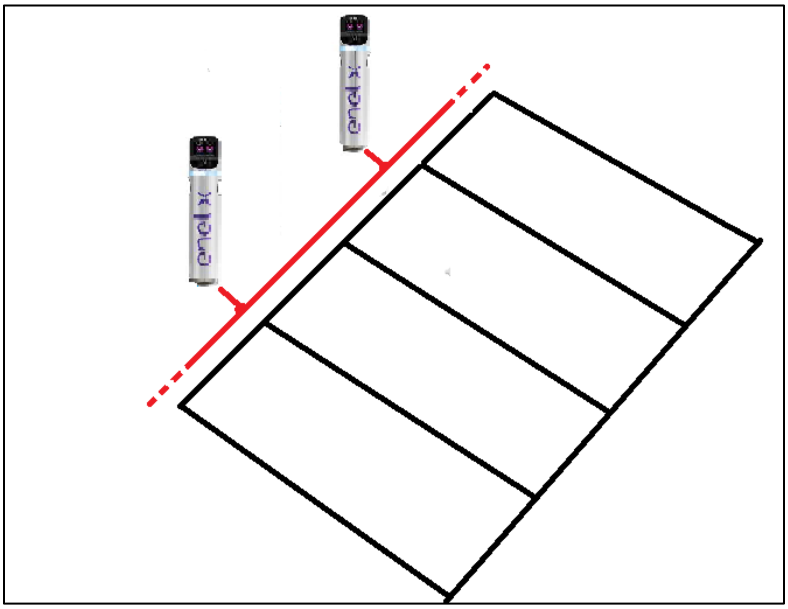
Therefore, from the point of delivery of the electric supply, it is the customer of the DSO that must carry out all the necessary works for the supply of the individual charging infrastructure.

In particular, the works to be borne by the customer are: the fiberglass cabinet, the overcurrent protection equipment (the switchboard), of the magneto-thermal and differential type, the connection from the distributor line to the CIs (one line for each CI), the earthing system and the horizontal and vertical signs plus the bollards to protect the CIs.

These works must comply with the specifications provided by the local distributor.

The architecture that was released before the DAFI regulations, called "*DSO model*", was different, as shown in the following diagram, considering two poles with two parking stands each:

Graph 8: DSO Model plant architecture



In this model, the CI was connected directly to the distributor's network and there were no fiberglass cabinets. The CIs themselves were different, as they had the metering units inside. There was one meter per outlet, which had the dual function of metering to bill both to: the DSO's customer, depending on the energy withdrawn from its network; and the CPO's customers, who used the CI on the individual outlet to charge their vehicles.

In the Service Provider model, on the other hand, there is a single meter upstream of the entire system (in the fiberglass cabinet) and meters on the individual outlets. The meters on the individual outlets are used by the CPO to bill the customer for consumption, while the upstream meter is used by the DSO to account for the energy the CPO takes from its network.

2.2 THE MARKET

Having concluded the examination of the charging infrastructure from a technical point of view, the thesis proceeds with the analysis of the market.

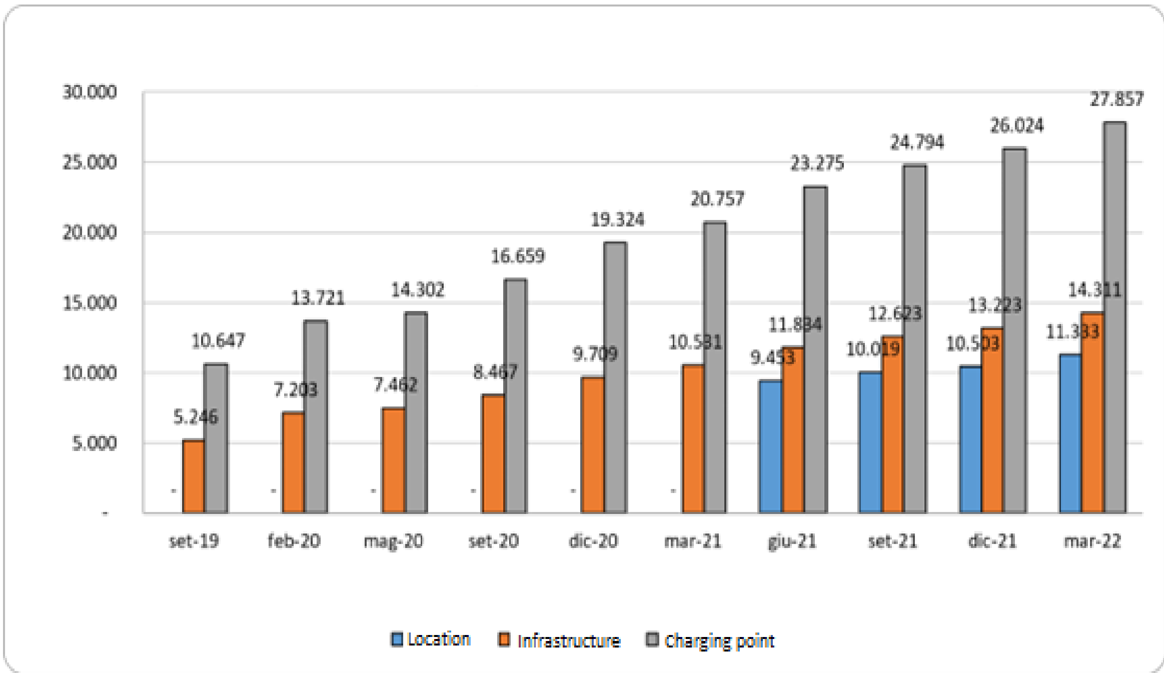
The electric infrastructure sector has been growing for several years now, thanks to its central role in the transition to electric mobility and the spread of electric vehicles. The topic has also gained a central role due to new European targets and regulations: from 2035, the European Union has banned the sale of fossil-fueled vehicles. As a consequence, all car manufacturers have chosen 2035 as the target date for the total switch to electric. In view of this, actions must be taken to create a widespread recharging network that can support the transition to electric.
Please note that the data collected in the following study refer to public charging infrastructures and do not take private ones into account.

2.2.1 A GROWING SECTOR

Through data analysis, it is possible to gain an insight into the development of the charging infrastructure market. For this purpose, the data made available by Motus-e concerning charging points, charging infrastructure and locations were considered.
Charging infrastructures may include one or more charging points and locations are geographical points where there may be one or more charging infrastructures. As of March 2022, there were 27,857 charging points in 14,311 charging infrastructures and 11,333 publicly accessible locations. Of these, 77.3 percent are locations on public land, while the remaining 22.7 per cent are private land for public use.
It is important to emphasize that public-use infrastructures on private land have advantages over public-use infrastructures on public land for two reasons: they allow for the deployment of a charging network even in places where public areas have limitations for the installation of electric infrastructures; and they allow for the reduction of administrative time and minimization of fixed costs by using the power already used by private establishments.

To understand the market trend, the graph below shows the trend of the last 30 months of locations, infrastructures and charging points: (20)

Graph 9: Evolution of the infrastructures and charging points in Italy



The graph shows a positive trend of charging points, infrastructures and locations over the underlying period.
Focusing on recharging points, it is possible to calculate the growth percentage, both from a quarterly and an annual point of view (considering March 2021 to March 2022), as it is shown in the following table:

Table 10: Percentage growth of charging points

Historical	Sept-20	Dec-20	Mar-21	Jun-21	Sept-21	Dec-21	Mar-22
Charging points	16.659	19.324	20.757	23.275	24.794	26.024	27.857
Quarterly difference		2.664	1.433	2.518	1.519	1.230	1.833
% Quarterly difference		16%	7%	12%	7%	5%	7%
Annual difference							7.100
% Annual growth							34,2%

The calculations confirm the strong growth of the charging infrastructure sector. In particular, the quarterly growth rate peaks at 16% in the quarter from September 2020 to December 2020 and it is never lower than 7%. On a yearly level, then, a significant percentage growth of 34.2% can be observed.

Unfortunately, about 12% of the installed infrastructure is not available for end use, mainly for two reasons: inability of the energy distributor to connect it to the grid and/or lack of all necessary authorizations. This percentage has decreased since March 2021, when it was 22%, indicating an effort to improve authorization processes by local distributors and administrations. However, measures and simplifications are still needed to avoid having idle infrastructure. In the following, the authorization processes and procedures for connecting with DSOs will be analyzed.

2.2.2 THE EUROPEAN COMPARISON

At the European level, Italy ranks fifth in terms of number of charging points as of December 2021. In particular, in first place is Netherlands, with about 93,000 points, followed by Germany, with about 60,000 charging points, then France and the United Kingdom, with about 51,000 and 48,000 points respectively, and finally Italy, with about 26,000 charging points.

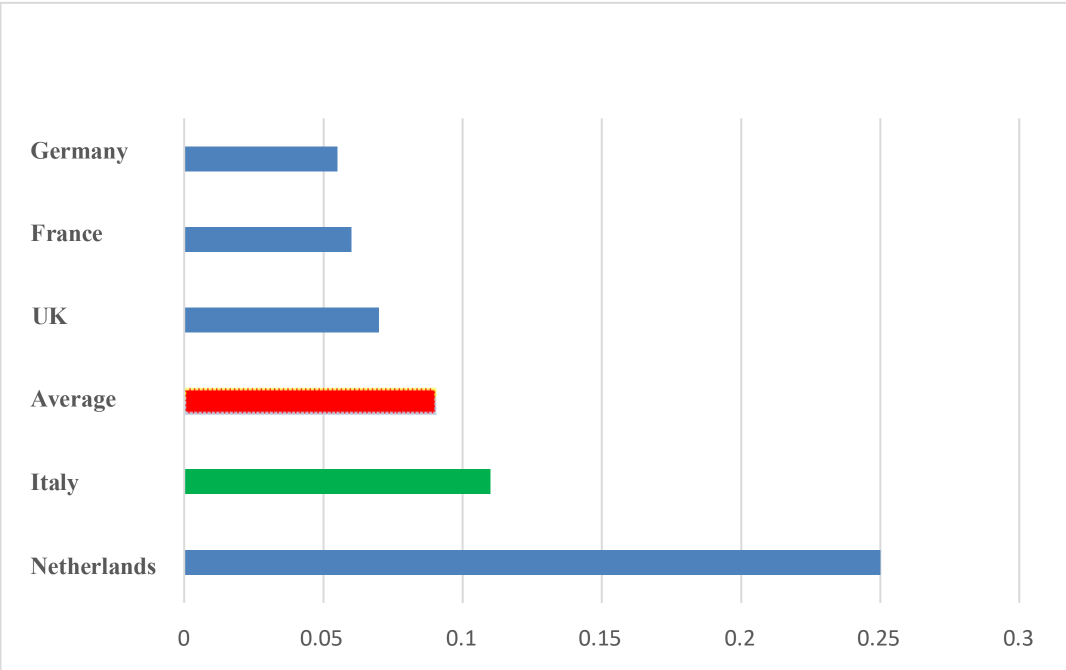
It is also interesting to continue with a joint analysis of the electric infrastructure and electric vehicles on the road.
In order to make the comparison with electric infrastructures, it was deemed preferable to consider the number of registered electric vehicles rather than sales data, since the latter may not correspond to the actual use of the vehicle and thus to the use of the charging points. When analyzing the ratio between the number of recharging points and the number of PEVs, the sum of BEVs (battery electric vehicles) and PHEVs (Plug-in Hybrid Electric Vehicles),

Italy was second in Europe in March 2022, preceded only by the Netherlands, as the following table and graph show: (20)

Table 11: European comparison on charging points

	Netherlands	Italy	UK	France	Germany	Average
PEV registrations (BEV+PHEV)	372.440	256.721	694.229	854.050	1.103.600	3.281.040
Public charging points	93.110	26.024	48.596	51.243	60.698	279.671
Public charging points per PEV	**0,25**	**0,11**	**0,07**	**0,06**	**0,055**	**0,09**

Graph 10: Public charging points per PEV in Europe



The graph above shows that the ratio of public recharging points to electric vehicles in Italy is adequate and above the average of the other countries considered, demonstrating that the development of a capillary network of recharging points is continuing.
The biggest limitation compared to other European countries is not the spread of charging points, but of electric vehicles. In fact, the relatively low number of electric vehicles on the road limits the return on investment in public charging points and does not allow a growth rate like in other European countries. For this reason, the impetus for an acceleration must first come from the use of electric vehicles and thus from government incentives.

2.2.3 INSTALLED POWER AND GEOGRAPHICAL DISTRIBUTION

In this section, it is emphasized the importance of developing a charging network that differs in the power delivered, depending on the need of the user and the vehicle, as seen earlier in the technical section of the chapter.

Motus-e also provides data by type of electric infrastructure, as shown in the following table: (20)

Table 12: Charging points by type of power output

Type	Powers	Points	% (excluding N/A)
Slow	≤ 3.7 (AC)	4.080	14,9%
	$3.7 < P \leq 7$ (AC)	213	0,8%
Quick	$7 < P \leq 22$ (AC)	20.499	74,8%
Fast	$22 < P \leq 43$ (AC)	767	2,8%
	$43 < P \leq 50$ (DC)	936	3,4%
Ultra-Fast and High-Power Chargers	$50 < P \leq 150$ (DC)	568	2,1%
	$P > 150$ (DC)	344	1,3%
N/A		450	
	TOTAL	**27.857**	

The sum of AC charging points is 93%, compared to 7% of DC charging points. In particular, the most common charging points are AC accelerated (74.8%), followed by AC Slow (14.9%) and DC Fast (3.4%). However, we are witnessing installations at increasingly higher power levels, as shown in the table below, which describes the evolution of the power delivered by the charging points:

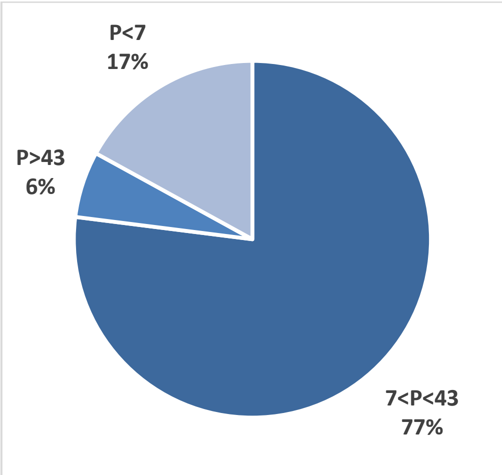
Table 13: Evolution of charging points by power output

Charging points by power output	Sept-19	Feb-20	May-20	Sept-20	Dec-20	Mar-21	Jun-21	Sept-21	Dec-21	Mar-22
$P \leq 7$ (AC)	28%	25%	24%	23%	19%	18%	19%	19%	17%	15%
$7 < P \leq 43$ (AC)	69%	71%	73%	74%	77%	78%	77%	76%	77%	78%
$P > 43$ (DC)	3%	3%	3%	3%	4%	5%	5%	5%	6%	7%

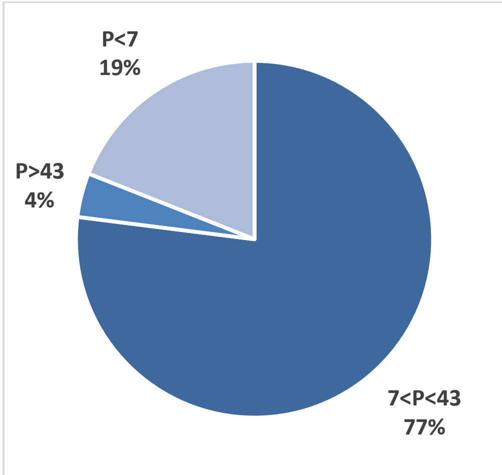
The trend over the last 30 months reports: a decrease of 13 percentage points for P<7; a growth of 9 percentage points for powers greater than 7 and less than 43; and, finally, a crescent of 4 percentage points for powers >43.

Restricting the comparison to one year, from December 2020 to December 2021, the percentage of charging infrastructures with power above 43kW rose from 4% to 6%, at the expense of those with power below 7kW, which rose from 19% to 17%, as shown in the following pie charts:

Graph 11: Infrastructures in December 2020



Graph 12: Infrastructures in December 2021



In particular, installing charging points with higher power and direct current allows for faster vehicle charging. As seen above, in fact, direct current implies that the converter is on the infrastructure, and not on the car, with the consequence of being more powerful.

2.2.4 GEOGRAPHICAL DISTRIBUTION

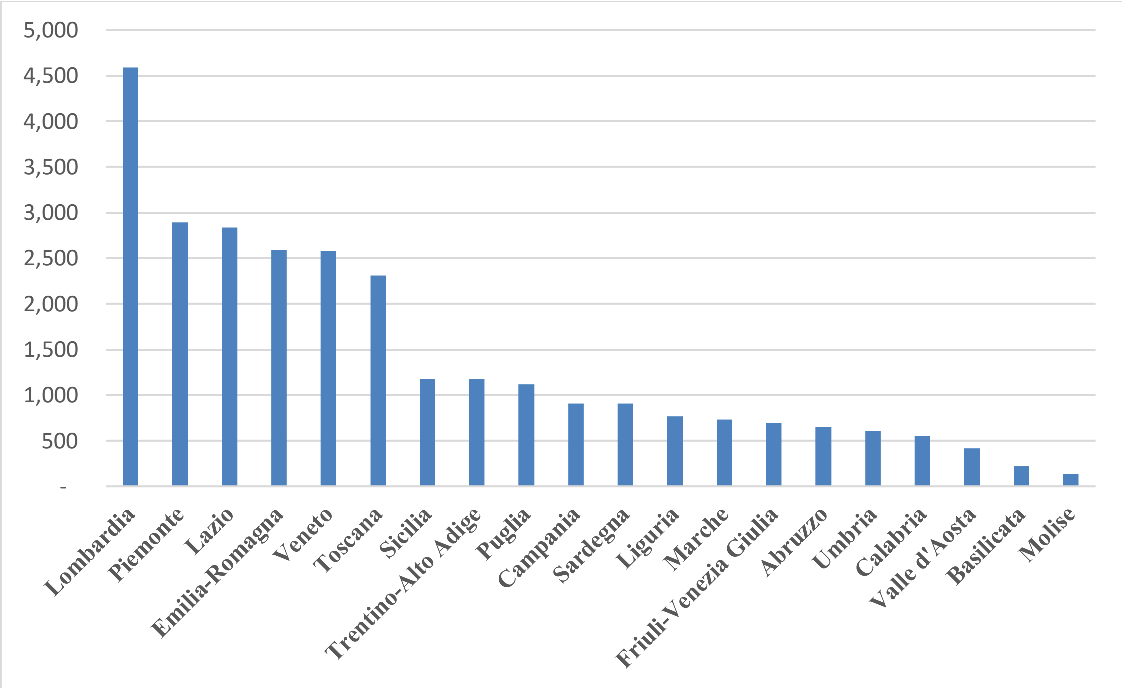
Recharge infrastructures are most present in central and northern Italy and in metropolitan cities. The table shows the data per region provided by Motus-e as of March 2022 in descending order of the number of infrastructures present:

Table 14: Geographical distribution of charging points in Italy

Region	Charging points	Region	Charging points
Lombardia	4.592	**Sardegna**	904
Piemonte	2.894	**Liguria**	765
Lazio	2.834	**Marche**	732
Emilia-Romagna	2.591	**Friuli-Venezia Giulia**	698
Veneto	2.579	**Abruzzo**	648
Toscana	2.313	**Umbria**	605
Sicilia	1.176	**Calabria**	553
Trentino-Alto Adige	1.174	**Valle d'Aosta**	419
Puglia	1.115	**Basilicata**	223
Campania	904	**Molise**	138

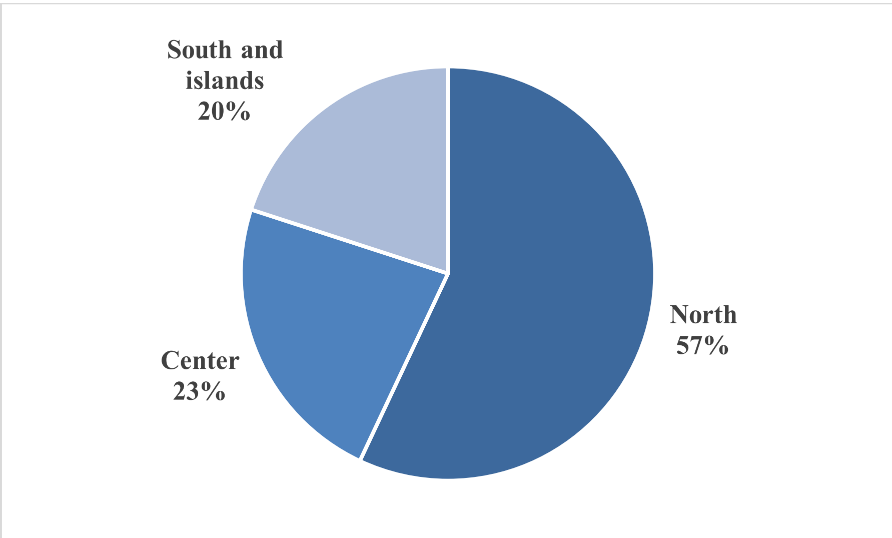
The following graph visually summarizes the data shown in the table concerning the distribution at national level.

Graph 13: Distribution of charging points by region



Finally, the following pie chart shows the distribution of charging points by area:

Graph 14: Distribution of charging points by geographical area

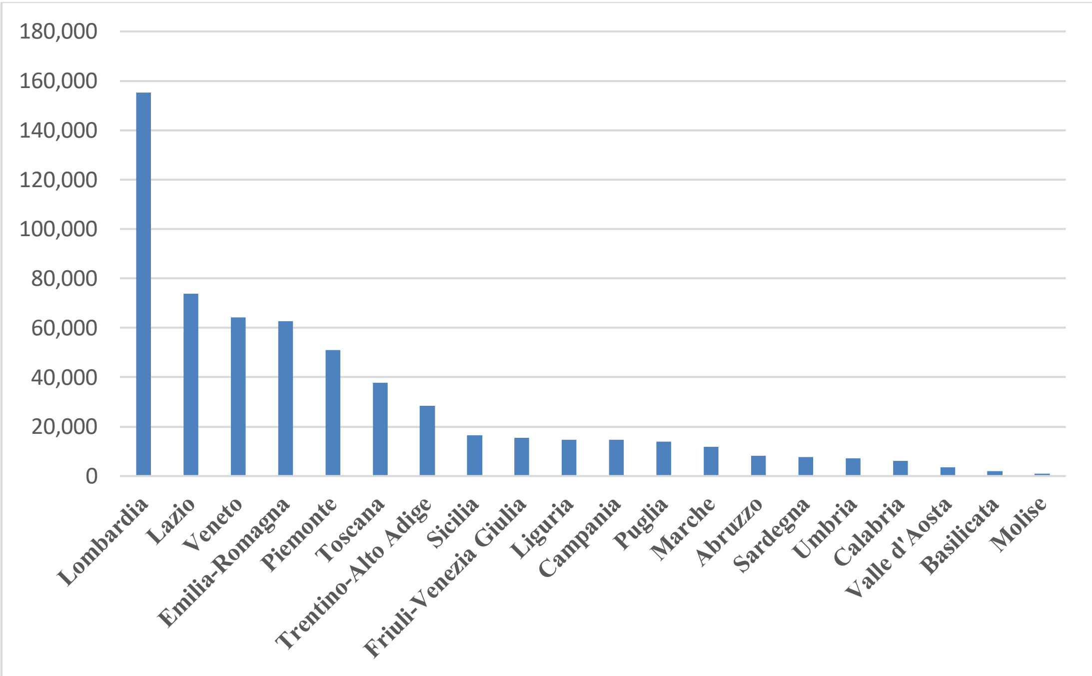


As can be seen from the graphs, the highest concentration of recharging points is in the North (57%), with Lombardia holding the record with 4,592 (16% of the total), followed by Piemonte and Lazio, with 10% of the total, respectively.

In terms of absolute growth, the regions with the highest growth in the last quarter are: Piemonte, Emilia Romagna and Lazio, while the regions that grew the most in terms of relative growth are Basilicata, Campania and Puglia. Although there is still a great disparity in numbers in absolute terms, the data on relative growth are positive for a rebalancing of the concentration of infrastructure.
The results of the charging infrastructure are consistent with the sales of PEVs (both BEVs, fully electric, and PHEVs, plug-in hybrids) in the different areas of Italy.

Considering the data published by la Repubblica about vehicles on the road at the beginning of 2021, it is possible to analyze the vehicle fleet by region, as shown in the following graph[4]: (21)

Graph 15: Electric vehicle fleet by region



As can be seen from the graph, the largest number of electric vehicles is concentrated in the North and Center, especially in the region of Lazio. In March 2022, sales of PEVs in the North-East was 36%, in the North-West 31%; followed by the center with 25% and the South and Islands with 5% and 3% respectively (20). Therefore, if the ratio of recharging points to registered vehicles is again considered, it can be concluded that the Italian recharging network is spreading extensively and that, the greatest limitation, stems from insufficient penetration of electric vehicles in some regions, as analyzed above in the European context. The following table and graph show the analysis that has been carried out:

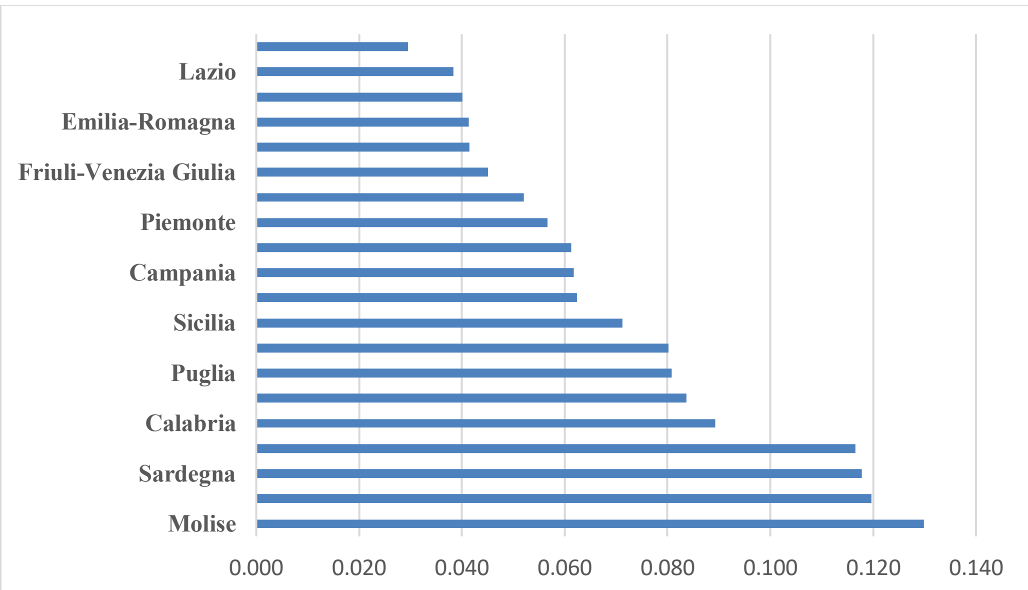
[4] Although the data date from early 2021, the analysis is for comparative purposes and therefore assumes that current fleet figures are higher in all regions. For this reason, even though the data is not up-to-date, it is not influential for regional comparisons.

Table 15: Italian comparison on public charging points

Regions	Molise	Valle d'Aosta	Sardegna	Basilicata	Calabria	Umbria	Puglia	Abruzzo	Sicilia	Marche
PEV fleet (21)	1.063	3.502	7.675	1.914	6.190	7.228	13.804	8.085	16.518	11.727
Public charging points (20)	138	419	904	223	553	605	1.115	648	1176	732
Public charging points per PEV	**0,130**	**0,120**	**0,118**	**0,117**	**0,089**	**0,084**	**0,081**	**0,080**	**0,071**	**0,062**

Regions	Campania	Toscana	Piemonte	Liguria	Friuli	Trentino	Emilia Romagna	Veneto	Lazio	Lombardia
PEV fleet (21)	14.649	37.745	51.039	14.713	15.499	28.345	62.611	64.264	73.847	155.299
Public charging points (20)	904	2.313	2.894	765	698	1.174	2.591	2.579	2834	4.592
Public charging points per PEV	**0,062**	**0,061**	**0,057**	**0,052**	**0,045**	**0,041**	**0,041**	**0,040**	**0,038**	**0,030**

Graph 16: Public charging points per PEV (Italy)



As can be seen from the graph, the regions with the highest public charging points to circulating electric vehicles ratio are also those with the lowest number of charging points. The analysis again confirms the importance of the development of an adequate circulating electric fleet to sustain the electric infrastructure.

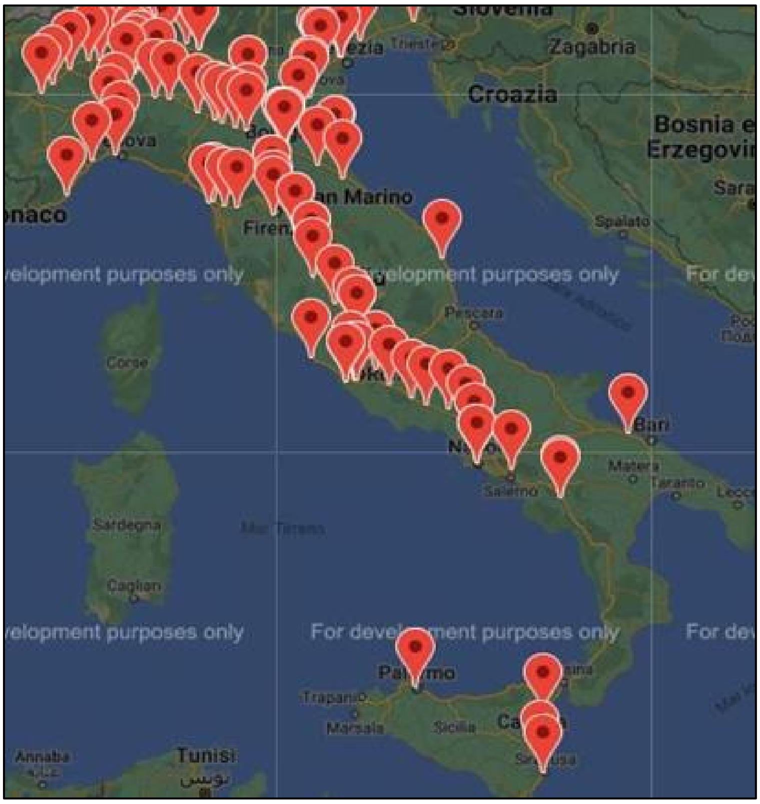
In the following, we will proceed with a description of the elements that must be taken into account in order to make a correct choice on which type of power to install and where to install the electric charging infrastructure, which also takes into account the different cases, as well as the modes of use.

2.2.5 THE MOTORWAYS

According to data from Motus-E, as of December 2021, there were 118 public charging points on motorways, of which 78% are DC and recharge at power ratings above 43 kW, while the remaining 22% are AC and below 43 kW. Even though about half of the charging points (48%) have a power of 150 kW or more, their number on motorways is so small that they do not facilitate travel and commuting on extra-urban stretches. (22), (3)
At the moment, this is a major limitation and one of the reasons why consumers still prefer combustion cars over electric cars. In fact, considering that the total Italian motorway network is about 7,318 km and that there are about 90 fast charging points, it follows that by December 2021 there will be 1.2 fast or ultra-fast charging points per 100 km of motorway network. Compared to the rest of Europe, Italy lags far behind in this respect.

However, it should be mentioned that several recharging points have been installed at motorway toll stations, which, although not part of motorways in the strict sense of the word, add to the supply of recharging infrastructure for the motorway network. In particular, Enel X Way took part in the EVA+ project, a European project aimed at building a network of fast electric recharging infrastructures on motorways in Italy and Austria. In particular, Enel X Way has installed recharging stations on the A1 Rome Milan every 60 km near motorway toll booths, but also on other motorways. Below is a photo of the map of charging points at motorway toll stations, installed by Enel X Way with the EVA+ project: (23)

Figure 8: Charging points EVA+project



In Legislative Decree No. 257 of 2016, the installation of electric charging stations on motorways was made mandatory.

However, given the low number of installed charging points in the following years, in December 2020, with the "*Budget Law 2021*", further measures were introduced that set timeframes and countermeasures in case of non-compliance. According to the law, motorway concessionaires must install charging infrastructures with a power output of more than 22 kW, i.e. at least Fast, along the sections under their jurisdiction, at least every 50 kilometers. In particular, the concessionaires must publish the minimum technical requirements of the columns they intend to install within 60 days of the approval of the Budget Law.

After that, if they have not done so within 180 days, motorway concessionaires are forced to choose an operator to install the infrastructure. In this regard, the concessionaire will have to publish an expression of interest within 30 days to select the operator on the basis of identified technical and commercial characteristics.

The following is a summary of the deadlines in the Budget Law 2021:

- 1 March '21: publication of minimum technical requirements for charging infrastructure on motorway corridors by concessionaires;
- 1 July '21: start of charging infrastructure installations on motorway network;
- Within 30 days from 1 July: publication of expressions of interest for operators interested in installing and operating a motorway charging network

However, none of these deadlines were met.

Moreover, to date, no call for tenders has been published by motorway concessionaires for the construction and operation of a charging network for electric vehicles.
Hoping to kick-start the opening of invitations to tender, in December 2021 the Transport Regulatory Authority (ART) published a document entitled "*Measures for the definition of invitations to tender by motorway concessionaires"*. The document highlights the constraints related to tenders.

The main topics are summarized below: (24)

- Participation requirements: which must meet the general principles of relevance and proportionality to the subject matter of the tender and non-discrimination, ensuring equal treatment where there are equal substantive conditions, in order to protect all potential participants in the tender;
- Bid evaluation criteria: the choice of the sub-concession must be based on the economically most advantageous bid. In addition, the concessionaire is obliged to publish in the tender documents the award criteria and the manner in which the bids are evaluated in a transparent manner;
- The determination of the royalties to be paid by the service operators to the motorway concessionaire: the document defines first that the royalty is the fee for access to and occupation of the public territory, which in turn the motorway concessionaire manages under concession from the State, for the purpose of its exploitation for commercial reasons.

Then the document provides that the fee is related to:

1. the cost of operating the portion of motorway infrastructure pertaining to the individual concession and not directly assigned to the service provider;
2. the specific benefit obtained by the service provider for the exploitation, for commercial purposes, of access to the motorway infrastructure and the allocated public domain, also based on the rental value of comparable private properties.

As can be seen from the above, the focus of the document is clear: concessions for motorway charging services must be transparent and take place in a competitive procedure, ensuring a high level of competition between services.

In this regard, the Antitrust Authority, i.e. Agcm, the competition and market watchdog, commented on the publication of the ART.
Agcm is in favor of a requirement for at least two charging point operators (CPOs) per Ads (service areas), so that consumers can better compare the various offers and competition between CPOs is guaranteed. The Antitrust Authority then argues that charging points must have a minimum power of 100 kW to allow charging times comparable to those of refueling.

Finally, as far as the concession period is concerned, the minimum sub-concession period is set at five years and can be increased depending on the 'infrastructure needs of the area'. However, operators' return on investment times range between 8 and 10 years. (25)

The new European proposal for a regulation (AFIR: Alternative Fuel Infrastructure Regulation) also emphasizes the importance of competitive procedures and obliges each state to meet infrastructure targets along the motorway network.
In Italy, the obligation for the concessionaire to select the operator for the motorway recharging service 'through competitive, transparent and non-discriminatory procedures' is contained in the DDL "*Annual Law for the Market and Competition 2021*".

To date, there has not yet been a standardized competitive process for electric charging infrastructure in a motorway context, and we must wait to see what happens in the future. However, given the complexity with which motorway charging points are being developed, it would be desirable for the following principles and criteria to be taken into consideration:

- Procedure through non-discriminatory competitive tendering;
- Installation of high-power recharging infrastructures: both HPC (power above 150 kW) and power between 50 and 100 kW. This is to ensure: on the one hand, the possibility of recharging vehicles that do not accept higher powers; on the other hand, time flexibility for users with vehicles that, while accepting ultra-fast recharging, want to stay for longer periods of time without the pressure of penalty time (additional cost in the case of remaining in the stall once the vehicle has been recharged);
- Minimum distance between one service area with infrastructure and another.

Finally, while there is the importance with which concessions are entrusted, there is also the need to at least triple the number of points on motorways within the next four years in order to meet the AFIR targets. The goal just described is also mentioned in the report published in October 2021 by Motus-e "*PNRR and Charging Infrastructure for Electric Mobility in Italy @2030: opportunities and strategic directions*", in which the need to install about 2,000 charging points on motorways (with fast and ultra-fast charging) by 2030 is forecasted. (26)

The chapter concludes with an analysis of Enel X Way's position in relation to the market, according to the data just collected, and then deduces Enel X Way's infrastructure plan, otherwise known as Piano Italia.

2.2.6 INFRASTRUCTURE PLAN

In the following analysis, Enel X Way's infrastructure plan for recharging electric vehicles has been drawn up, considering the future estimate of the infrastructure for recharging electric vehicles in Italy and Enel X Way's current market share, with the assumption that it will remain constant over time.
Future infrastructure estimates were based on the data contained in the national incentive plan: the PNRR. The national recovery and resilience plan, in fact, allocated 750 million euros to install 21,400 additional publicly accessible Fast and Super-Fast charging points by 2026. However, Motus- e's study 'PNRR and Charging Infrastructure for Electric Mobility in Italy @2030: Opportunities and Strategic Directions', published in October 2021, shows that of this 750 million, only 500 million are needed to reach the plan's targets by 2026.
Therefore, the remaining 250 million could be invested in "more high-power or low-power charging points in areas of weak demand (5,000 municipalities)" and to increase motorway infrastructure. Analyses by Motus-e show that by 2030 it will be possible to reach 108,000 public charging points, of which 51% will be slower AC and 49% faster DC. (26), (27)

The number of recharging points that Enel X Way interconnects and makes available to its customers through interoperability agreements are, as of April 2022, approximately 15,000 in Italy and 320,000 across Europe, as stated by Elisabetta Ripa, CEO of Enel X Way on the occasion of the Rome Formula E E-Prix in April 2022. (28)
As of today, therefore, it can be inferred that Enel X Way's electric infrastructure market share in Italy is about 54%, considering the current number of 27,857 recharging points illustrated above. Assuming that Enel X Way manages to maintain this fixed market share and considering the target of 108,000 recharging points by 2030, it is possible to estimate that Enel X Way's infrastructure plan by 2030 is to reach a capillarity of about 58,000 recharging points. Therefore, it is concluded that in order to maintain its market share at 54%, Enel X Way would have to install an additional 43,000 charging points by 2030. (29)

In addition, it is possible to investigate not only the number of charging points in general, but also the division by type of power and, considering the targets estimated by Motus-e to 2030, to trace the infrastructure plan of Enel X Way specifically by power output. In order to simplify data collection, the analysis was conducted on the mere distinction between AC and DC charging points, i.e. respectively between lower and higher power charging points.

The following table summarizes the charging points in these two modes currently present in Italy (data: March 2022), previously displayed in table 12 "Charging points by type of power output", and those estimated by Enel X Way. Enel X Way data were estimated through the map of charging points where Enel X Way is a charging point operator, considering that the total must correspond to the 15,000 charging points declared by Enel X Way.

In this way, it was possible to deduce the market share of Enel X Way by type of charging point, as shown in the following table:

Table 16: Enel X Way Charging points

	Sum of AC	Sum of DC	Total
Enel X Way[5]	13.800	1200	15000
Grand total (20)	26.009	1.848	27857
% of total	**53%**	**65%**	**54%**

It should be noted that the undeclared charging points (N/A) in the table 12 "charging points by type of power output" were considered as AC charging points and therefore added in the column "Sum of AC".
From these results, Enel X Way's market share is 53% in AC and 65% in DC, compared to the total number of charging points.

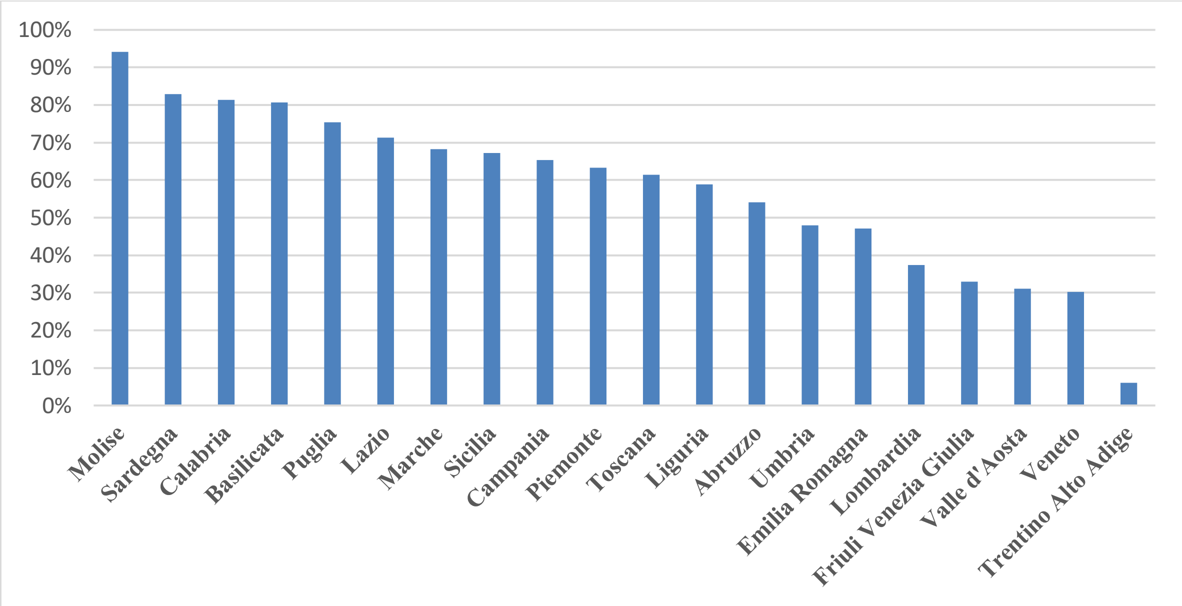
According to the Motus-e study, 51% of the charging points in 2030 will be AC and 49% DC and, thus, of the total 108,000 charging points, 55,080 will be AC and 52,920 DC. Furthermore, knowing that currently the sum of the AC charging points is 26,009 and the DC ones 1,848, it means that the effort will have to focus mainly on the infrastructure of DC charging points and 29,071 AC and 51,072 DC points will still have to be installed nationwide. Considering Enel X Way's infrastructure plan deduced above (58,000 charging points by 2030) and considering that 92% of its charging points are AC and 8% DC, Enel X Way, like the rest of the market, will have to shift its efforts to higher power DC charging points.

Finally, it is also possible to cross-reference the national data provided by Motus-e with those of Enel X from a geographic location perspective. Considering the total number of charging points per region provided by Motus-e and the number of Enel X charging points per region, it is possible to estimate the market share of Enel X Way per region. These values were taken from the count on the map of charging points where Enel X Way is a charging point operator, available on the Enel X Way website (30). The numbers obtained were then corrected by a percentage of +12%, to consider the charging points that were installed, but not actually active, as previously noted.

[5] Data taken from the Enel X CPO map (30)

The results are shown in the following bar chart:

Graph 17: Enel X Way market share by region



From the following analysis, it is possible to trace the regions where Enel X Way's presence as CPO is higher than average, which are in order: Molise, Sardinia, Calabria, Basilicata, Apulia, Lazio, Marche, Sicily, Campania, Piedmont, Tuscany, Liguria and Abruzzo.

From the joint analysis of the graph of Enel X Way's market share by region and fleet by region, evaluated above, the market share of Enel X Way is inversely proportional to the maturity of the market. Enel was a forerunner as a CPO: it was the first to install charging infrastructure on public land in Italy. Its mission until 2020 was precisely to install electric infrastructure on all Italian soil, regardless of the return on investment, to facilitate electric mobility.

Today, the market is in a more evolved phase, and its mission is different: to install charging points where they are needed. However, from an initial analysis, Enel X Way has retained the role of forerunner among CPOs in regions where the electric fleet is still in the development phase; whereas, in those where it is more developed, such as Lombardy, Veneto and Emilia Romagna, the market share is lower.

The reason for this lies in the fact that Enel X Way's high market share is not due to a current phenomenon, but rather to the past. In fact, although its market share on the installed base is not high, its total market share is still higher than average, due to what was installed in the early stages of the development of electric charging infrastructures and its pioneering role as CPO.

From the market analysis, currently the two main issues in the development of an extensive network of electric vehicle charging infrastructure are: the percentage of installed

infrastructure that is inactive and the distribution of infrastructure across the territory.
For this reason, the next chapter will analyze the process of installing a charging infrastructure: from administrative procedures to site selection criteria and the authorization process. It will then proceed with the identification of the value chain and business models, as well as the identification of the different actors involved. Finally, the last chapter will deal with the Turin case study: the procedures and criteria analyzed will be applied to the city of Turin, thanks to the projects followed on the installation of a Juice Pole and a Juice Pump by Enel X Way in the city's municipality.

Chapter 3

THE INSTALLATION PROCESS: ADMINISTRATIVE PROCEDURES, SITE IDENTIFICATION, AUTHORISATION PROCESS AND INSTALLATION OF THE CHARGING UNIT

After analyzing how charging takes place from a technical and market perspective, the study focuses on the process of installing an electric infrastructure for electric vehicles charging. The process involves several steps and the involvement of different actors and entities. It is not trivial to identify a standard process applicable to every circumstance, since there are several variables to take into account that influence the process. For example, a process might vary depending on the rules of the municipality, or the local distributor, or the physical characteristics of the site where it is to be installed.

Although the process of installing electric vehicle charging infrastructure is case-specific, the general steps involved can be summarized as follows:

1. Administrative procedures: agreement between municipality and charging company

2. Sites choice:
   a. Identification of sites
   b. Technical feasibility

3. Authorization process

4. Installation of the charging unit by a contracted company, connection to the electricity grid by the distributor, testing and commissioning

The process starts with an administrative procedure, through which the municipality and a charging service provider enter into an agreement for the infrastructure of a certain number of columns. Once the agreement is signed, the private operator proceeds with the identification of the site where the infrastructure is to be installed. The decision involves the operator, the municipality and the energy distributor.
In particular, the identification of the site consists of two phases: a first phase in which, depending on market parameters, the most convenient sites where to locate the infrastructure are identified; a second phase in which the technical feasibility of the possibility of connecting that site to the electricity grid is studied.
After analyzing the results of the technical feasibility study, the operator decides whether to continue with that site or choose an alternative one. Finally, the final word goes to the municipality, which must approve the installation at that site.

Once the site identification is completed, the agreement between the municipality and the operator is finalized and the authorization process begins. During the process, the private operator obtains all the necessary documents for the infrastructure. Once the permits have been obtained, the infrastructure is installed through the execution of construction and electrical works by the appointed company. This is followed by connection to the distributor's electricity grid, testing and commissioning of the infrastructure.
A detailed analysis of all the stages follows.

3.1 ADMINISTRATIVE PROCEDURES

When a municipality decides to equip itself with an electricity infrastructure network, the first step is to activate an administrative procedure through which it can reach an agreement with one or more charging service providers. In particular, there are three administrative procedures that a municipality may decide to adopt: (5)

1) Joint Memorandum of Understanding Municipality - Private Operator
2) Expression of interest / competitive procedure
3) Predefined regulation

3.1.1 JOINT MEMORANDUM OF UNDERSTANDING MUNICIPALITY - PRIVATE OPERATOR

The memorandum of understanding[6] is signed between the municipality and a private operator wishing to install a charging infrastructure in the municipal territory. The memorandum of understanding in question sets out the rights and duties of the parties regarding the installation and management of the charging infrastructure.

The duties of the municipality include:

- Grant the use of the installation area to the private operator for a period of time sufficient to amortize the investment;
- Allow free parking in the charging bays;
- Check that the parking spaces are only used by electric vehicles that are charging. The Highway Code, in fact, prohibits the parking of a vehicle in the spaces reserved for stopping and parking charging electric vehicles.

On the other hand, the operator who signs the memorandum of understanding is responsible for

- Carry out installation work;
- Manage the infrastructure;
- Ensure an adequate level of service during the concession period.

[6] A memorandum of understanding is defined as a legal document describing a bilateral or plurilateral agreement between two or more parties. It expresses a convergence of interests between the parties, rather than a contractual bond. (57)

This procedure is simple and fast from an administrative point of view. It is therefore suitable for small and medium-sized municipalities that have received installation proposals from private operators. This is the case, for example, with the Municipality of Bologna, which, after receiving solicitations from operators, was able to respond quickly by signing a memorandum of understanding. However, the input could also come from the municipality itself, as in the case of Pesaro which, through the publication of a public notice, solicited operators to put forward their proposals.

3.1.2 EXPRESSION OF INTEREST / COMPETITIVE PROCEDURE

Whereas in the first procedure it is generally the operators who submit their proposals and, following this, collaboration is initiated, in the second procedure it is the municipality that launches a public expression of interest[7]. In this way, the municipality invites operators to express interest in a concession and can then carry out market surveys to select the operators. The successful bidders will be able to install the infrastructure and operate it for a period commensurate with the return on investment.

The selection process and the selection by the municipality can take place through:

1. A single, objective criterion;
2. A ranking drawn up by a technical committee on the basis of objective criteria defined in the call for expressions of interest

In the first case, the municipality chooses the single criterion on which to base the choice of contractor.

The two most common criteria are:

1. The number of charging infrastructures offered by the operator;
2. The ratio between quick (up to 22 kW) and fast (above 50 kW) type infrastructures. Then, in the event of a tie, a further criterion is defined on which to base the choice.

The successful bidder is the operator who excels in the criterion selected by the municipality. However, it is also possible for the municipality to select more than one contractor.

In the second case, the technical committee compares the proposals received based on objective criteria and possibly assigns a score to each of them in order to determine a ranking. Usually in this case the criteria, with or without a score, are:

[7] An expression of interest is defined as an information tool that is generally linked to a negotiated procedure for the award of a contract, i.e. the competitive procedure (58)

1. The number and type of charging infrastructures;
2. The contribution the operator is willing to make towards the realization of the investment;
3. Compliance with the requirements of the PNIRE (especially with regard to interoperability);
4. The planned date of installation;
5. The experience of operators;
6. How to promote the service.

Again, the municipality, depending on the number of charging infrastructure it wants to install, may select more than one operator. Based on the ranking list drawn up, the operators with the highest score will have priority on where to install their sites according to the lots pre-defined by the municipality. It is also emphasized that the municipality may assign additional charging infrastructure at a later stage with the same procedure.

The expression of interest is a procedure suitable for larger municipalities than those in the MoU, or even for smaller municipalities that have not received any proposals. In conclusion, this administrative procedure is a competitive comparison that allows municipalities to make a market analysis of operators, establishing minimum installation criteria and maximizing service quality.

One of the municipalities that has adopted this procedure is, for example, Treviso. This municipality presented operators with a precise plan: the number of installations (44), the mix of charging types, the map of sites and the interoperability requirement, which will be analyzed in the next chapter. Regarding the selection process just described, the municipality opted for the first case: a single objective criterion and, in the case of a tie, a second additional criterion. The criterion chosen was the number of infrastructures, i.e. the operator proposing the most installations was preferred, up to the maximum indicated by the municipality (44). In the case of a tie, the second criterion chosen was the precedence criterion: whoever submits the bid first is selected.
In contrast, the Unione Montana Comuni Olimpici Via Lattea opted for the second selection process,
i.e. for a technical commission to evaluate the proposals received. The six municipalities of the Union - Cesana, Claviere, Pragelato, Sauze di Cesana, Sauxe d'Oulx and Sestriere - entrusted the choice to a pre-established technical commission: they left the operators free to submit their proposals, not specifying the award criteria, except for the constraint of a number of installations which was between 10 and 20. This choice is in line with the characteristics of the area, which, by including six different municipalities, is certainly larger and more dispersed.

3.1.3 PREDEFINED REGULATION

The latter procedure requires the municipality to define a very detailed regulation, leaving it open to all operators to install and operate the electrical infrastructure without making a choice.
Operators must submit installation proposals, which must contain executive projects in specific locations and in compliance with minimum elements and any limits defined by the regulation.

In particular, the executive design for each installation must respect parameters such as:

1. Minimum output power of charging infrastructure;
2. Maximum size of charging infrastructure;
3. Minimum distance from existing infrastructure;
4. Distribution criteria to ensure capillarity throughout the territory;
5. Sufficient presence of services (not related to recharging) for the end user.

The predefined regulation is suitable for large municipalities, as the underlying administrative process is very complex and articulated. This procedure, in fact, is the one that most deeply defines the criteria and minimum service standards, which are necessary to outline a standard application procedure aimed at the generality of operators.
Having a standard procedure is essential for more populous areas, where a high number of infrastructures need to be installed and capillary deployment guaranteed. Theoretically, even smaller municipalities could adopt a standardized regulation, possibly simplifying certain aspects.

Only the municipalities of Rome, Milan and Turin have opted for this administrative procedure. For example, the regulation of the Municipality of Rome provides that operators can bid for lots of up to 40 plants, distributed among the 200 areas into which the territory has been divided, for a maximum of 6 plants per area. There is no distance limit between installations, but there must be one fast installation for every four standard installations. The concession has a duration of 6 years, renewable for another 6 years at the operator's discretion. In addition, executive plans must already be attached when the offer is submitted.
As far as the City of Turin is concerned, however, the regulation is simpler. Each operator must submit a site map and may install up to 200 infrastructures, with a constraint of at least 250 meters distance from the nearest facility. The concession is for 10 years renewable.
The Rules of the City of Turin will be described in more detail in the last chapter, which is devoted to an in-depth study of the City's Case Study.

A table summarizing the administrative procedures with which the process of installing the charging infrastructure begins follows below:

Table 17: Administrative procedures

Types of procedures	What they provide	Administrative procedure	Suitable for Municipalities
Joint Memorandum of Understanding	Municipality and operator discuss an agreement	Easy	Small
Expression of Interest	Competitive procedure	Average	Average
Predefined regulation	Operators submit an offer compatible with a detailed regulation	Complicated	Great

Once the administrative procedures have been completed, the municipality issues the applicant or successful bidder with the concession to use public land for the installation of the charging infrastructure.
The finalization of the agreement with the municipality takes place at a later stage, i.e. after the winning operators have identified the sites, made a technical feasibility study and the municipality has approved these sites.

Therefore, we proceed with the analysis of site selection and location.

3.2 SITES CHOICE

3.2.1 IDENTIFICATION OF SITES

As mentioned in the previous chapter, Enel's mission has changed over the years. Until 2020, the goal was to equip the country with recharging infrastructures; later, as the market grew, the development plan was adapted to the new needs of users: in particular, the choice of recharging sites began to be based on strategic criteria related to users' needs to recharge their cars in each location.
In the following, we proceed first with an analysis of the criteria for choosing charging sites and then with that of the criteria for choosing the infrastructure to be installed, and thus the power to be installed: slow, quick or fast.

3.2.1.1 Choice of locations

It is possible to distinguish the criteria into two types:

A. Statistical factors: relating to objective data and estimates
B. Dynamic factors: related to vehicle movement

A. <u>*Statistical factors:*</u>

- *Level of infrastructure*
  The first factor to consider is the number of infrastructures in the area.

- *Fleet distribution*
  It is important to consider the distribution of the car fleet as a figure and not the distribution of registrations, which would be misleading. To demonstrate this, it is possible to analyze Motus-e's data as of March 2022: considering the market channels for electric cars, the predominant channel is rental (41.6% of total registrations), followed by the private channel (30.4%), self-registrations (19.2%) and company fleets (8.8%) (20). Therefore, most registrations are made by rental companies, which register their vehicles in provinces where IPT is less onerous. IPT is the Imposta Provinciale di Trascrizione, a tax to be paid to the province where the vehicle is registered at the time of purchase. To the basic amount, a provincial majority is added, which may be applied up to 30% of the total amount (31). The provinces that do not apply any majority are those of Aosta, Bolzano and Trento (32). Therefore, there are many registrations in these provinces, which, however, are not matched by a high utilization of electric cars and, therefore, a high utilization of charging infrastructure. The above is confirmed by the March 2022 registration data, where it appears that Trentino-Alto Adige is the first region for BEV and PHEV registrations with 22% of total registrations. However, if reference is made to what was analyzed in the previous chapter, Trentino was the seventh region in terms of vehicle fleet. In this sense, the vehicle fleet is the most correlated with the use of charging points by users. When choosing installation sites, a preliminary screening of the vehicle fleet by province is carried out: a large vehicle fleet corresponds to a greater need for electric infrastructure.

- *The degree of infrastructure in relation to the vehicle fleet*
  The degree of infrastructure is an indirect figure and is obtained through the ratio of vehicle fleet to infrastructure already present in the area. The ratio has already been analyzed in the previous chapter at regional level: the procedure is the same but is carried out at provincial level. A low degree of infrastructure is the first criterion for choosing to install a charging infrastructure.

- *Income level*
  Another factor to consider is the province's income level or GDP. A higher income, combined with the fact that, to date, eco-incentives are independent of income, results in a higher car change rate and, thus, a higher possibility of electric car adoption. Furthermore, the cost of an electric car is still above the average cost of a combustion car, so a higher level of income also corresponds to a greater economic predisposition to purchase a more expensive vehicle.

- *Population density*

  Population density is a statistic that influences, on one hand, the higher utilization of the infrastructure and, on the other hand, the lower possibility of private charging points.

  Public recharging may be a residual form of recharging: an owner of an electric vehicle will recharge first at home, then at work and finally in public. A high housing density, therefore, indicates a lower possibility of having a private garage in which to install the charging point at home and therefore, in its absence, a higher propensity for public charging. From the study "*Il futuro della mobilità elettrica: l'infrastruttura di ricarica in Italia @2030*" (33), published in October 2020 by Motus-e, it emerges that private garages on the territory are mainly located in smaller cities and suburban areas, where population density is in fact lower. The study shows that in metropolitan cities there are 0.2 garages per inhabitant, while in smaller cities and suburban areas there are 0.3 garages per inhabitant (as of 2019). Furthermore, the study presents the distribution of the percentage of garages per property by geographical area: 63% in the north, 48% in the center and 28% in the south and islands (data as of 2019).

- *Actual delivery*

  Finally, a piece of data that would be desirable to have, is the actual delivery. Assuming that the operator, who has been awarded the concession by the municipality, already has other charging points located in the territory, he could use the data on the actual output of the charging points already in use to infer the propensity for public charging in one area rather than another. The more charging points the operator has and the more these are spread over the territory, the more data it has and the more accurate estimates it can make.

- *Propensity for public charging*

  The propensity for public charging is not measurable, but it can be inferred.
  Essentially this is the result of two factors: necessity and habit.

- *Necessity*

  The need can be deduced from several parameters:

  a. Housing density. As stated above, only in cases of modern construction can citizens equip themselves with a domestic wall box regardless of high population density. Normally, however, for all densely populated urban contexts with non-new construction, the problem arises of physically having the possibility of a home wall box for recharging at night.
  b. Proximity to major traffic routes: here residential users are joined by occasional additional users, such as tourists, medium-range commuters, business users, commercial transport. Typical examples of these are motorway toll stations.

c. Proximity to services and places of attraction: also in this case the need for recharging will be greater. Examples of places of interest are: the presence of public offices, hospitals, coexistence of tertiary activities, shopping centers, meeting and entertainment venues, sports facilities, natural parks, areas of tourist, landscape or archaeological interest, urban centers, even small ones but with commercial services, restaurants, museums, monuments. (5)

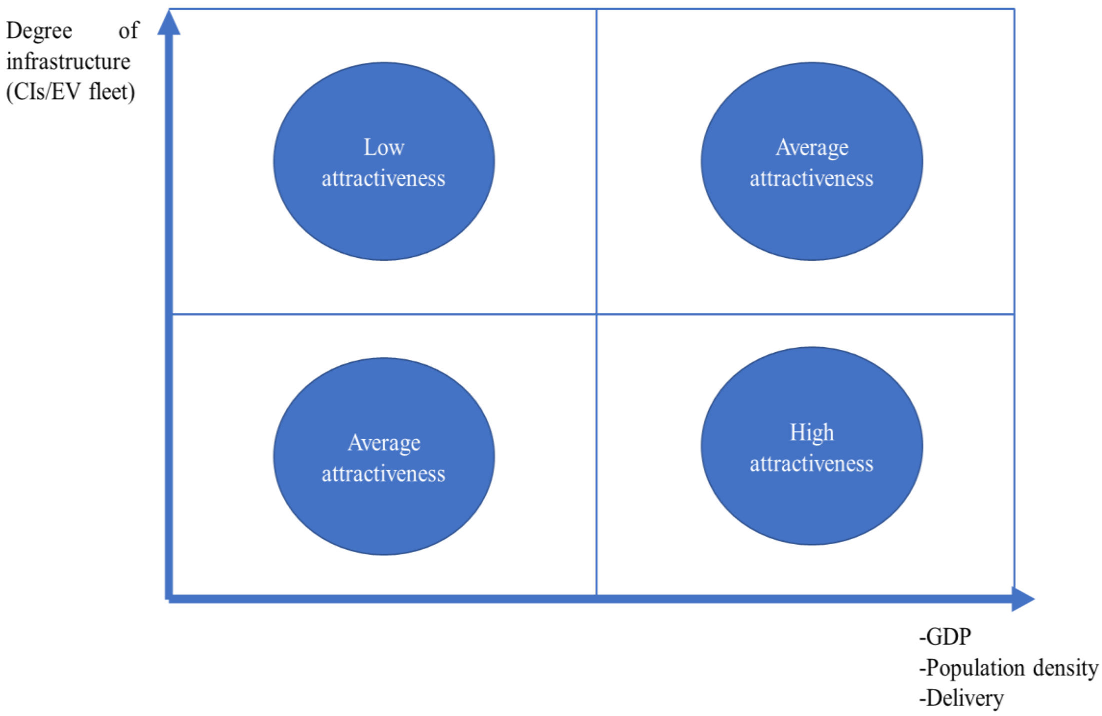
- *Habit*

  Habit can be deduced, as already mentioned, from the average supply in the province. For example, if a province has an adequate degree of infrastructure, with the same population density, but has a high average provision, this indicates a high propensity to public recharging. Thus, for example, an owner of an electric vehicle might have the habit of recharging in the office, or in a transitory point (such as a cinema, shopping center, gym), in a domestic setting, or at a public recharging point.

  Therefore, the propensity to recharge may be dictated by a forced condition, i.e. not recent construction in a densely populated context, or by a voluntary condition, i.e. habitual recharging in public contexts.

In conclusion, having displayed all the statistical factors for the choice of locations, a joint analysis is therefore made to infer the necessity and profitability of the investment.
In the following, it is proposed a graph based on the Boston BCG Matrix model of the joint analysis leading to the choice of infrastructure in a given area according to its attractiveness:

Graph 18: Attractiveness matrix of a site



First, the degree of infrastructure in the area is assessed, whether it is above or below the average degree. Then, data on the GDP, population density and the area's supply are analyzed to understand its attractiveness.

Attractiveness turns out to be:

- Low (top left quadrant), if there is a high level of infrastructure and a low GDP, population density and delivery;
- High (fourth quadrant bottom right), if there is a low level of infrastructure and a high GDP, population density and delivery;
- Average (second and third quadrants), in the intermediate cases: high infrastructure level and GDP, low population density and output or low infrastructure level and GDP, low population density and output.

In the following, an attempt is made to replicate the model to be used for the choice of infrastructure locations based on statistical factors.

Application of the 'choice of locations' based on statistical factors model

In this application estimates are made to obtain the average values of the level of infrastructure, GDP, population density and delivery, to be considered in the "Attractiveness matrix of a site" to benchmark whether to install a charging infrastructure in a particular area.

- *Average degree of infrastructure*:
  Considering the most recent data, the current number of recharging points (given in March 2022 (20)) is 27,857, the current fleet (given in April 2022 Motus-e (34)) is 272,665 (including BEVs+PHEVs), so the current average degree of infrastructure is 0.1:

$$Average\ degree\ of\ infrastructure = \frac{27{,}857}{272{,}665} = 0{,}1$$

- *Average GDP*:
  It can be obtained from the GDP Per Capita, provided by ISTAT (35). The most recent figure for GDP per capita is €27,871 (most up-to-date figure to the year 2020)

- *Average population density*:
  The average population density, updated to 2020, is 195 inhabitants/km^2 (36)

- *Average output*:
  The calculation of the average supply is more complex. First, the annual demand is calculated as the product of the total number of electric vehicles on the road, the total number of kilometers driven electrically per year and the propensity to recharge publicly:

$$Annual\ demand\left[\frac{km\ *}{year}\right] = TOT\ EV \times \frac{TOT\ km\ *}{year * EV} \times propensity\ for\ public\ charging$$

*km traveled in electric

For the number of electric vehicles, the fleet data provided by Motus-e as of March 2022 (20) was taken into account, consisting of 133,500 BEVs and 130,600 PHEVs. For the kilometers traveled, we relied on data published by Motus-e in "*Il futuro della mobilità elettrica: l'infrastruttura di ricarica in Italia @2030*", published in October 2020 (33).
According to the study, there are four types of users of electric cars:

a. The private person with a garage who drives between 10,000 and 15,000 km/year;
b. Private individual without garage driving 10,000 km/year;
c. Business Individual traveling between 10,000 and 15,000 km/year;
d. Shared Business that travels at least 20,000 km/year.

For this reason, it was considered that on average a full electric vehicle travels about 15,000 km/year and that a hybrid vehicle also travels 15,000 km/year, but of these only 3,000 km/year in electric.

Finally, the propensity for public charging was estimated, to calculate how much of the total demand is met by public charging.
Again, this was based on the same study. In particular:

a. Private Garage has a 20% propensity for public charging;
b. Private individuals without garages have a 90% propensity for public charging;
c. Individual business has a 40% propensity for public charging;
d. Shared Business has a 10% propensity for public charging.

A propensity for public charging of 20% was considered.

Then, the average consumption was calculated by multiplying the annual kilometer demand by the electric vehicle consumption per kilometer, which was assumed to be 0.17 kwh/km (37), as published on the Enel X website. The total average consumption, as the sum of BEVs and PHEVs, was found to be approximately 81.5 million kwh per year. Finally, knowing the total average consumption and estimating the percentage of use of the charging infrastructures, it is possible to trace the average consumption by type of CI, depending on the power delivered, through the following formula:

$$Average\ consumption\left[\frac{kwh}{year}\right] = \#\ charging\ points\ \times P \times 24 * 365 * Utilization\ rate$$

The result obtained is shown in the following table:

Table 18: Average consumption by type of recharging point

Type	# Charging points	P<= (kW)	Utilization rate (%)	Average consumption (kwh/year)
Slow	4.293	7	1,25%	3.290.584,50
Quick	20.949	22	1,00%	40.372.912,80
Fast	1.703	50	2,25%	16.783.065,00
Ultra-Fast	912	150	1,75%	20.971.440,00
	27.857			**81.418.002,30**

Having also estimated the average consumption, or usage rate, the model is complete: it can be used by entering the data of a site and evaluating its ranking against the average values found.

It can be seen from the table that the utilization rates are relatively low.
The reasons behind this could be the following: with regard to the slow type, the utilization rate is low because it meets the needs of night-time recharging, and therefore only those users who do not have a garage where they can install a domestic wall box rely on this type; with regard to the quick type, most electric vehicles do not recharge at 22 but at 11 kW, so the real utilization rate is twice as high (2%); finally, with regard to the Ultra-Fast type, the utilization rate is lower than the Fast type because not all vehicles can currently recharge at more than 50 kW.

Finally, in general, the utilization rate is still low since the adoption of electric vehicles is still a developing process, as already examined in the previous chapter. This is confirmed by the same study on the forecast data to 2030 provided by Motus-e (26). By 2030, total average consumption per year will be more than 3 billion kwh, compared to 81.5 million today.

Assuming utilization rates, a possible scenario could be as follows:

Table 19: Average consumption by type of recharging point in 2030

Type	# Charging points	P<= (kW)	Utilization rate (%)	Average consumption (kwh/year)
Slow	13.770	7	1,75%	14.776.587,00
Quick	27.540	22	2,00%	106.150.176,00
Fast	40.230	50	4,00%	704.829.600,00
Ultra-Fast	26.460	150	6,75%	2.346.869.700,00
	108.000			**3.172.626.063,00**

Although there are some assumptions made, utilization rates are all almost duplicated.

Among the assumptions made to find the utilization rates there are the following ones:

- Ultra-fast type will have the greatest development: it is the infrastructure that allows recharging in the shortest time possible and it is assumed that new electric vehicles will adapt and allow recharging at higher powers;
- Slow charging infrastructures will have the least development: it is assumed that apartment blocks and buildings will adapt to current regulations, which will be discussed below, and provide the possibility of home charging.

B. *Dynamic factors*

By dynamic factors, we mean factors on the movement of vehicles. This could be a powerful smart tool for the future.
Given the now widespread advancement on data collection and distribution, there could be companies that provide data on movements, i.e. on entry and exit routes, but more importantly, on vehicle stops. Such companies could sell the data to interested operators, who, through specific algorithms, could have a tool to identify the sites where infrastructure would be most beneficial. In particular, the use of data on traffic flows and the level of traffic would be of great use in analyzing the parameter 'proximity to major traffic routes', described above among the statistical factors, to choose the best site for installation. Pending the development of this type of business, statistics could be conducted on the trips and stops made by a significant sample of private vehicles on the road, to obtain the same results useful for the market analyses described above.

Finally, the last factor to be taken into consideration when choosing where to install is that of the simplicity of obtaining authorization for parking spaces. In particular, areas with landscape, historical, architectural, archaeological or environmental constraints have more complex authorization procedures and installation times are considerably longer and should therefore be avoided.
For this reason, it is preferable to consult the competent administrations and bodies in advance.

3.2.1.2 Choice of power

As far as the choice of power to be installed is concerned, this will be conditioned by the location and the reason that influenced the decision to select the chosen location.

Installation due to one of the following reasons indicates the need for a certain power, and thus, type of infrastructure:

- High population density, combined with non-modern construction, indicates the need to install slow charging points to meet the need for overnight charging.
- Proximity to major traffic routes: this requires the installation of ultra-fast DC systems, which allow charging in the shortest possible time.
- Proximity to services and places of attraction: depending on how attractive the environment is, the dwell time of users follows. Considering a dwell time of one or two hours, an AC quick recharge is necessary. In fact, when the parking time allows, an AC recharge is preferred to a DC recharge because of the greater ease of installation and lower cost (in alternating, the grid connection requires 44 kW for two 22 kW stalls). On the other hand, in the vicinity of other services, such as stations, airports, and commercial loading and unloading areas where parking is short, DC, fast or ultra-fast systems should be installed.
- Dynamic factors: through data on vehicle stops, one could know in which locations vehicles prefer a longer stop, and thus indicate the need for lower power, slow or quick charging; and in which a shorter stop, indicating the need for fast or ultra-fast charging.
- In general, in the case of out-of-town roads, it is assumed that users have no reason to make longer stops and therefore there is a tendency to develop the fastest possible charging solutions. On the contrary, in central locations there is a preference for the installation of charging facilities that allow longer stops.

A summary table of what was exposed follows below:

Table 20: Choice of charging point power

Factors	Determining factor of the charging point	Charging powers
Statistical factors	Population density	Slow
	Proximity to major traffic routes	Fast/Ultra-Fast
	Proximity to services and places of attraction	Quick
Dynamic factors	Short break	Fast/Ultra-Fast
	Long stop	Quick

Finally, the choice of charging points can also be made strategically for better urban planning and urban mobility. A recharging network can serve to direct traffic flows to strategic areas, or, in the vicinity of city centers, it can encourage the use of less congested parking areas and interchange car parks with public transport services.
Once possible sites have been identified, a connection request is made to the DSO and a technical feasibility study is carried out. In fact, a fundamental element in the choice of sites is the verification of availability for connection to the electricity grid, which is why there is the custom to contact the DSO and do the technical feasibility study in advance.

3.2.2 TECHNICAL FEASIBILITY

In the following section, reference will be made to the different roles involved in the value chain, which are: the energy distributor (DSO), the supplier (Trader), the infrastructure operator or manager (CPO) and the infrastructure owner, which may or may not coincide with the infrastructure manager.

The different actors and their respective roles will be analyzed in more detail in the next chapter.

To verify the possibility of grid connection at a given site, and the economic feasibility, the steps to be taken are:

a. Sending of the connection request to the local distributor for the identified points by the private operator;
b. Issuing of the quotation and possible on-site visit(s) with the relevant stakeholders (distributor's technician and private operator);
c. Final decision on the technical feasibility of the sites taken by the owner and approved by the municipality. In the event of technical or economic impossibility on certain identified sites, alternative sites are chosen;
d. Finalization of the agreement with the municipality.

a. Sending the connection request/quotation

Once the site has been identified, the infrastructure owner sends the connection request to the local distributor, i.e. the quote request.
Distribution companies are obliged to connect to their networks all persons requesting this, as is expressly outlined in Article 4 Paragraph 12 of the DAFI[8].
In the connection request, the applicant must provide detailed information on the plant (applicant's data, type of plant, required feed-in power, location, etc.).

[8] "Gli operatori dei sistemi di distribuzione cooperano su base non discriminatoria con qualsiasi persona che apre o gestisce punti di ricarica accessibili al pubblico" (56)

At this stage, the private operator can choose two modes:

a. *Connection + activation mode*
   If one wishes to activate the supply right away, the private operator requests the connection of the charging infrastructure to the electricity grid and activation directly to a sales company, or trader, who will conclude the supply contract. The private operator can choose its trader freely according to its needs. In this mode, the trader acts as an intermediary between the private operator and the distributor, which do not interact with each other.

b. *Pre-layout mode*
   If you wish to obtain a connection to the electricity grid, without the need to immediately activate the supply, you must apply directly to the local distributor. Once the distributor has concluded the connection, the operator then proceeds with the activation request to the trader.

The second mode is the one that has been adopted more recently: in the case of Enel X Way, this mode has been adopted since 2021 and most requests since then have been made pre-placement. The reason lies in the fact that direct contact between owner and distributor makes the procedure simpler and faster, especially in terms of exchanging documents, without the need for the trader to act as an intermediary.

The two ways of applying for connection to the electricity grid are outlined in Act 566/2019/R/eel Annex A (TIQE), Article 81 and Act 568/2019/R/eel Annex C (TIC), Article 4 of Arera. (38), (39)

b. Issuing of quotation and possible site visit with interested stakeholders

Once the request has been submitted, an inspection of the site(s), identified with the distributor's planner and the private operator, may be necessary. During the inspection, both the possibility of connection to the grid and all the works necessary for connection are checked.
The inspection is carried out in cases where the distributor does not already have information on the site required for the connection, or where it is expressly requested by the private operator. This phase also assesses the presence of sub-services and/or interferences that could be present in the area being worked on and that could, therefore, cause subsequent difficulties.

The distributor, either with or without an inspection, issues the estimate within the maximum time limit of 15 days.
The estimate shall indicate the amount to be paid for the requested service and the maximum time allowed for its implementation.

In Act 566/2019/R/eel Annex A (TIQE), Article 84 and Act 568/2019/R/eel Annex C (TIC), Article 6 of ARERA, all the elements that must be present in the estimate are defined more precisely, such as: (38)

- The traceability code identifying the request;
- The date on which the distributor received the quote request and the date on which it made it available to the seller or private trader;
- The type of users;
- Automatic compensation, if due, in the event of failure to comply with the time limits;
- The elements necessary to carry out the required work, including, if applicable, the work to be carried out by the private operator and the concessions, authorizations or easements to be obtained by the same operator, with appropriate technical documentation;
- The documentation that, in the event of acceptance of the quotation, must be submitted for the activation of the supply, if requested, specifying that the activation request must be made through a seller;
- An estimate of the time frame in which the distributor expects to obtain any authorizations for which it is responsible;
- How to communicate the acceptance of the quotation;
- The period of validity of the estimate, which must not be less than three months;
- The name and telephone number of the person responsible on behalf of the distributor in the case of complex works;
- Any request for premises and/or portions of land suitable for the construction of transformer substations, where permitted by law.

For connection and activation requests, the seller has a maximum of two working days to forward the private operator's request to the distributor, and a further two working days to forward the distributor's estimate to the private operator. In cases where the work to be carried out is considered 'simple work', i.e. it is only necessary to lay the meter and work on the socket, and the seller is able to make an estimate of the costs and time required to carry it out, he can communicate these directly to the private operator, avoiding the waiting time for the estimate.

c. Final decision on the technical feasibility of the sites taken by the owner and approved by the municipality

Having obtained the quotation, the private operator decides whether to accept it or let it lapse and proceed to find an alternative site. The estimate has a time validity and a method of acceptance that is indicated in it.
Depending on the work required, the estimate could be onerous. Installation always involves excavation and soil tampering, to which additional network works may be added, depending on the:

a. Power demand. As the required power increases, the need for network works, such as the construction of a secondary substation, increases. This problem arises especially for the installation of high-power DC systems that must be connected directly to a transformer cabin with a power availability of at least 100 kW. Since the transformer cabin has a limited power, if this is saturated, a secondary cabin must be built, which is a more expensive and complex technical solution. AC installations, on the other hand, require less power, up to 44kW, and are therefore easier and cheaper to construct. A case in point are the ultra-fast High Power Charging stations that charge at 350 kW. These require power above 1000 kW: the operator must make the request on medium voltage, instead of on low voltage as is the case with other infrastructures.

   In fact, requests for connection to the electricity grid are divided into:
   - Low-voltage demands: up to 100kW
   - Average voltage demands: up to 6000 kW
   - High-voltage demands: over 6000 kW

b. Distance. The further away the site is from the grid connection point, the more invasive the grid works will be, with a consequent increase in cost.

d. Finalization agreement with the municipality

Once the private operator has accepted the quotation, the sites must then be approved by the municipality and the agreement finalized with the latter.
As analyzed above, depending on the type of agreement, finalization may be quicker or easier.

In the case of the joint memorandum of understanding, for example, a resolution of the Council is sufficient, and the signing of the protocol is done by the CPO and the municipality in the person authorized by the resolution of the Council.
In the case of the expression of interest, once the contracting station, i.e. the one that launches the tender, makes an analysis of the offers and establishes a ranking list, it makes a provisional award and then a final award. The final adjudication takes place with a document sanctioning the cooperation of the parties. The finalization of the agreement with the municipalities that adopt the regulation is even longer.

If the municipality has approved the sites, the private operator and the distributor proceed with their own permitting and authorization processes: the process of connection to the electricity grid is strongly intertwined with the authorization process.
ARERA imposes maximum times for connection and eventual activation. However, these do not consider the time needed by the private operator to carry out the work and obtain its own authorizations (such as the authorization to tamper with the soil), nor the time needed by the distributor to obtain its own authorizations (such as road digging authorizations).

According to ARERA, Act 258/2015/R/com Attachment A (TIMOE), Article 9 bis and Act 566/2019/R/eel Attachment A (TIQE), Article 88 and 101; Table 13, the maximum time the distributor must carry out the connection, once the quote has been accepted, is 10 working days in the case of simple work, and 50 days if complex work is required. As far as activation is concerned, if the user is already connected to the distribution network, as in the case of pre-supply, the seller sends the activation request within two working days to the local distributor, who has five days to activate the supply. If, on the other hand, the user is not yet connected, reference is made to the maximum time allowed for the connection procedure. (38)

In the following, we proceed with the necessary authorization specifications prior to the start of construction and grid connection work.

3.3 AUTHORIZATION PROCESS

Once the sites have been identified, the technical feasibility verified and the agreement with the municipality finalized, the executive design is carried out, followed by the final design and, finally, the authorization processes. The latter involves obtaining documents and permits for the charging station infrastructure.
The authorization process and the necessary documents vary greatly depending on the municipality, but the main authorization steps are listed below:

a. Application for occupation of public land, due only in the case of civil works for installation involving public areas;
b. Notice of commencement of construction work: SCIA or CILA;
c. Drafting of documentation required to obtain permits in the case of areas subject to constraints (e.g. by the cultural heritage superintendency, park authority, port authority, etc.).

3.3.1 REQUEST FOR OCCUPATION OF PUBLIC LAND

The first authorization required is the request for the occupation of public land.
This is a costly concession that requires the payment of some municipal taxes and legislative references can be found in "*conversione in legge, con modificazioni, del decreto-legge 31 maggio 2021, n. 77, recante governance del Piano nazionale di ripresa e resilienza e prime misure di rafforzamento delle strutture amministrative e di accelerazione e snellimento delle procedure*", and in particular in article 32-ter, where it is indicated that the installation of recharging infrastructures of electric vehicles with public access is not subject to the issue of a building permit and is considered free building activity. In addition, the article underlines that the person who carries out the installation of the infrastructures for the recharging service of electric vehicles on public land presents to the body that owns the road the request for the occupation of public land for the recharging infrastructure and the related works for connection to the distribution network.

The procedures are subject to the simplified request obligation and the body carrying out the assessment issues within thirty days an authorization for the construction and occupation of public land for recharging infrastructures, which has a minimum duration of 10 years, and a provision of unlimited duration for the related connection works[9].

The municipality usually requires the payment of TOSAP, *Tassa sull'Occupazione di Suolo Pubblico*, i.e. the tax on the occupation of public land, while in some cases it provides for COSAP, *il Canone sull'Occupazione Suolo e Aree Pubbliche*, i.e. the fee on the occupation of public land and areas.

However, in the Decree Law of 16 July 2020 *"Misure urgenti per la semplificazione e l'innovazione digitale", Article 57: "semplificazione delle norme per la realizzazione di punti e stazioni di ricarica di veicoli elettrici*", paragraph 9, it was introduced the faculty of municipalities to grant the reduction or exemption of COSAP and TOSAP for charging points, where they supply energy from certified renewable energy sources.

In any case, the fee for occupying public land must be calculated on the space occupied by the recharging infrastructure, without considering the parking stalls of the vehicles, which will remain at the user's disposal.

In the case of the Municipality of Turin, in the "*disciplinare l'installazione e la gestione di strutture per la ricarica dei veicoli elettrici ad uso pubblico*", in Article 4 dealing with the Disciplinary Charges, it is established that "the fee for the occupation of public land is due in accordance with the provisions of Regulation no. 257 COSAP. The duration of the concession is 10 years: the concession fee for the recharging station and the parking bays for recharging the cars is permanent, while for the site areas necessary for the installation of the building it is temporary.

In particular:

- In the case of recharging columns with power, per connector, between 20 kW and 40 kW, the COSAP fee for the permanent occupation with parking reserve of the parking bays serving the installation will be free of charge for a maximum of three years from the granting of the concession, for a maximum of two bays per column and up to a maximum of 200 columns for the same subject.
  The duration of the free-of-charge period depends on the percentage of delivered energy produced from renewable sources, as shown in the following table (Table 21). From the fourth year the COSAP fee is due in full.

[9] Translation of the Article 32-ter"ai fini delle semplificazione dei procedimenti, il soggetto che effettua l'installazione delle infrastrutture per il servizio di ricarica dei veicolo elettrici su suolo pubblico presenta all'ente proprietario della strada l'istanza per la manomissione e l'occupazione del suolo pubblico per l'infrastruttura di ricarica e per le relative opere di connessione alla rete di distribuzione, concordate con il concessionario del servizio di distribuzione dell'energia elettrica competente. Le procedure sono soggette all'obbligo di richiesta semplificata e l'ente che effettua la valutazione […] rilascia entro trenta giorni un provvedimento di autorizzazione alla costruzione e all'occupazione del suolo pubblico per le infrastrutture di ricarica, che ha una durata minima di 10 anni, e un provvedimento di durata illimitata, intestato al gestore della rete, per le relative opere di connessione". (59)

- In the case of charging stations with a power, per connector, greater than 40 kW, the COSAP fee for the permanent occupation with parking reserve of the parking spaces serving the installation will be free of charge for a maximum of five years from the granting of the concession.
  The duration of the period of gratuitousness depends on the percentage of energy produced from renewable sources. From the sixth year the COSAP fee is due in full."[10] (40)

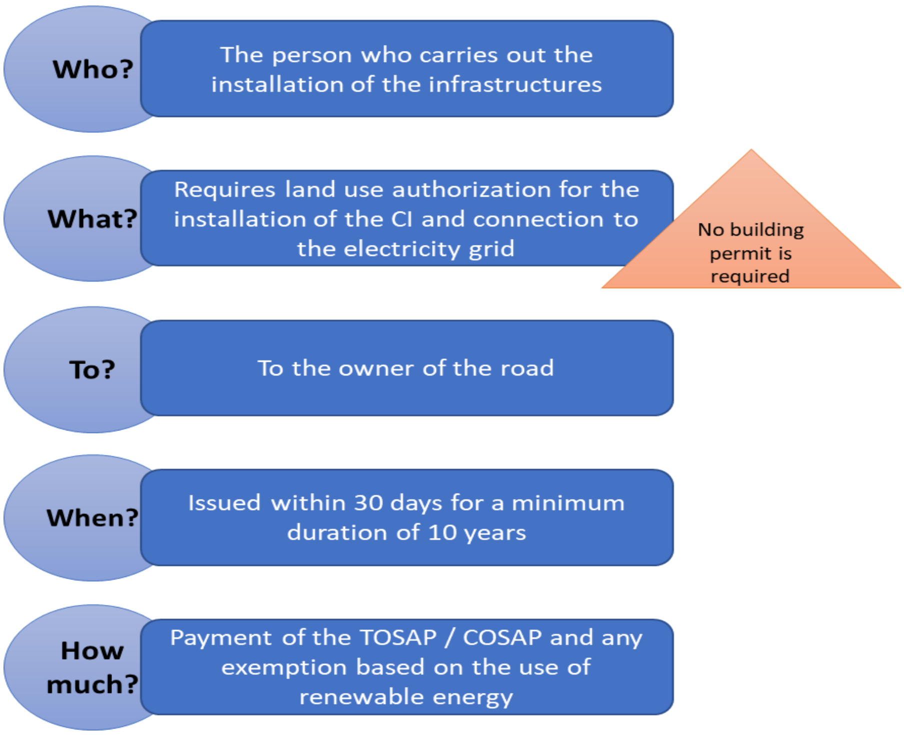
A table summarizing the fee exemption according to the percentage of energy from renewable sources follows below:

Table 21: Exemption from the payment of fees – Municipality of Turin

Power output	Percentage of energy from renewable sources		
	>= 97%	**>=70%**	**<70%**
Power 20-40 kW	3 years	2 years and 6 months	2 years
Power >40 kW	5 years	4 years and 6 months	4 years

To conclude, for the sake of explanation, salient points that emerged from what was analyzed regarding permits for the occupation of public land for recharging infrastructure are summarized in the following graph:

Graph 19: Permits for the occupation of public land for recharging infrastructure



[10] Translation of the "*disciplinare l'installazione e la gestione di strutture per la ricarica dei veicoli elettrici ad uso pubblico*" (40)

Once the request has been made, it is necessary to wait for authorization by the municipality, which, as already seen, is granted within thirty days.

3.3.2 NOTICE OF COMMENCEMENT OF CONSTRUCTION WORK: SCIA or CILA

Once authorization has been obtained from the municipality for the occupation of public land, the SCIA or CILA must be submitted.

SCIA

The SCIA, Certified Declaration of Commencement of Activity, is a permit based on the self- declaration of the private individual that allows, after filing with the municipal administration, the immediate start of work.
However, many municipalities have restricted the start to a period of 30 days from receipt of the SCIA, to allow themselves to carry out the necessary checks.
The SCIA, in fact, must be accompanied by a series of certifications and asseverations by qualified technicians and by the technical documents necessary to allow the verifications for which the administration is responsible.
In particular, with the Decree of 3 August 2017 (41), the Ministry of Infrastructure and Transport identifies the declarations, attestations, affidavits and technical documents to be submitted with the SCIA for the construction of electric vehicle charging infrastructures.

The documents and technical papers to be submitted are identified in Annex 1, and are as follows:

- Project framework document;
- Technical project;
- Report on the technical characteristics of the charging infrastructure;
- Copy of the request for connection to the electricity distribution network or modification of the existing connection, pursuant to the regulation of the Energy Authority.

Specifically, the project framework document contains:

a. The description of the project: EU project, national project, private investment, etc;
b. The number of charging infrastructures envisaged in the project;
c. The rationale behind the choice of the proposed locations;
d. An indication of the total costs broken down into the investment part and the subsequent operation and maintenance parts;
e. An indication of the entity that will be responsible for the operation and maintenance of the charging infrastructure;
f. The information and communication methods and activities envisaged.

The technical project, which must be submitted for each charging infrastructure, includes:

a. Territorial framework and extracts of the main town planning instruments in force;
b. Ante opera photographic documentation;
c. Construction/installation details;
d. Ante and post opera;
e. Horizontal and vertical signs;
f. Chrono program including an indication of the completion time of the works, operation of the recharging infrastructure both in technical terms (functionality) and regulation of the area hosting the infrastructure and the parking space(s) reserved for recharging as provided for in Article 17(1) of Legislative Decree No. 257 of 16 December 2016 (42);

The report on the technical characteristics of the recharging infrastructure, on the other hand, must contain at least the dimensions, colors, user interface, socket standards as annexed to Legislative Decree No. 257 of 16 December 2016 (42), access and payment modalities, possible upgradability of the management system software, and disposal of end-of-life equipment.

Furthermore, it is emphasized in the decree that charging points built in public or private areas open to public use must ensure interoperability between charging systems.

Article 1.3 of the Decree of 3 August 2017 (41), in particular, regulates the cases in which it is not necessary to apply for authorization, nor to carry out the SCIA: "the construction of recharging points in buildings and private areas also open to public use remains a free activity not subject to authorization nor to a certified start of activity report if the following requirements and conditions are met:

a. The charging point does not require a new connection to the electricity distribution network or a modification of the existing connection;
b. The charging point complies with current technical and safety standards;
c. The installation of the charging point is carried out by an authorized person and in compliance with electrical safety regulations;
d. The installer must issue a certificate of conformity of the installation and its operation with the electrical safety regulations".

However, what we have seen so far about SCILA was later amended in the decree LAW of 16 JULY 2020, "*Misure urgenti per la semplificazione e l'innovazione digitale*". (43)
In Article 57: "*Semplificazione delle norme per la realizzazione di punti e stazioni di ricarica di veicoli elettrici",* Paragraph 14 repealed paragraphs 2-bis and 2-ter of Article 23 of Decree-Law No. 5 of 9 February 2012, which provide for the application of the rules of the certified notification of commencement of activities for the construction of electric vehicle charging infrastructures (SCILA), as well as the technical documents, to be submitted in support thereof. Paragraph 15, then, provides for the termination of the

effectiveness of the decree of 3 August 201750 of the MIT (Ministry of Infrastructure and Transport), on the "*Individuazione delle dichiarazioni, attestazioni, asseverazioni, nonché degli elaborati tecnici da presentare a corredo della segnalazione certificata di inizio attività per la realizzazione delle infrastrutture di ricarica dei veicoli elettrici*".

These measures essentially remove the obligation to submit the Notice to Proceed and are a clear sign of the desire to simplify authorization procedures.

Although at the regulatory level the procedures have been greatly simplified, the adoption of these changes at the municipal level is still a work in progress: there are many municipalities that still require the SCIA or CILA and accompanying documents.

CILA

The CILA, certified commencement of work communication, is a simplified authorization procedure belonging to the concept of 'liberalization' of private activities.

From the definition contained in Article 6 bis of the TUE (Testo Unico Edilizia) (44), it emerges that the CILA is of a residual nature, since it can be used for all works for which no SCIA, building permit or free building permit is required.
In general, the CILA authorizes the execution of building works on the property of a limited size and consistency, which are mainly private. Whenever possible, the CILA is preferable to the SCIA, as it considerably reduces preparation time and the volume of documents, and there is no need to wait the 30 days to which many municipalities have tied the SCIA. (5)

A single standard procedure for the authorization of the installation of public charging infrastructures by municipalities is currently being discussed with the relevant ministries (42), confirming the current relevance of the topic.

3.3.3 DRAWING UP THE DOCUMENTATION REQUIRED TO OBTAIN PERMITS FROM THE CULTURAL HERITAGE SUPERINTENDENCY, IF NECESSARY, DEPENDING ON THE SITE

In Article 3 of the Decree-Law of 3 August 2017 (41), it is stated that "if the charging infrastructure for electric-powered vehicles falls in areas subject to constraints, the documentation required by the national, regional and/or local special regulations in force must be produced".

By way of example, one type of constraint is related to cultural goods.
According to Article 21(4) of Decree-Law No. 42 of 2004, "*Codice dei beni culturali e del paesaggio*" (45), the issuance of authorization for the execution of works and works of any kind on cultural heritage (i.e. for buildings both interior and exterior works) is delegated to the Superintendence.

The assessment of works is made following the submission of a project.
The project must normally include:

- Photographic documentation with a plan of the shooting points
- Historical-artistic report
- Technical report including assessments of the findings of the material and degradation survey, execution techniques, materials to be used, structural intervention, plant engineering
- Estimated metric calculation
- General plans
- Geometric survey (plans, sections, elevations)
- Material and decay survey (plans, sections, elevations)
- Survey of static instabilities and/or structural deficiencies
- Materials Conservation Project
- Structural Consolidation Project
- Tables of the reuse project
- Comparative tables (yellow - red)
- Illustrative tables of plant engineering (electrical-mechanical, thermal-hydraulic, special, etc.).

In the event of complete and exhaustive documentation, authorization (or refusal) is granted within 120 days of receipt of the request by the Superintendency.

However, the area may be subject to numerous constraints of various kinds, and, depending on the type of constraint, authorization must be obtained from the competent authority. In general, choosing a site that is subject to any type of constraint causes a longer timeframe and greater authorization complication, so there is a tendency to avoid, where possible, the infrastructure of charging points in areas subject to constraints.

In the following, we elaborate on the authorization process on private land. As mentioned at the beginning of this study, recharging infrastructures for public use can be on public land or on private land. One of the differences between the two types is of an authorization nature and what has been analyzed so far only applies to charging infrastructure on public land. The procedure for infrastructure on private land is discussed in more detail in the next section.

3.3.4 AUTHORIZATION PROCESS FOR THE INSTALLATION OF COLUMNS – REGULATORY REFERENCES PRIVATE LAND FOR PUBLIC USE AND PRIVATE LAND FOR PRIVATE USE (5)

As already mentioned, no authorization and/or SCIA is required with regard to the installation of recharging systems on private land, including land open to public use, as written in Article 1.3 of the Decree of 3 August 2017 of the Ministry of Infrastructure and Transport (41), if the following conditions are met:

a. "The charging point does not require a new connection to the electricity distribution network or a modification of the existing connection;
b. The charging point complies with current technical and safety standards;
c. The installation of the charging point is carried out by an authorized person and in compliance with electrical safety regulations;
d. The installer must issue a certificate of conformity of the system and its operation to electrical safety standards. "

3.3.4.1 Private land for public use

This category includes charging infrastructures located in car parks of shopping centers, resorts, hotels, restaurants, garages and car dealerships.
The DAFI Directive (42) emphasizes that the charging infrastructure for electric vehicles cannot be equated with a distributor. This has two consequences:

a. The first is that, unlike in the case of a petrol station, authorization to install recharging infrastructure on private land open to public use cannot be denied on the grounds that this would change the land use;
b. The second is that it does not require the asseveration of safety measures relating to fuel distributors, as it is not subject to the same risks (such as risk of fire).

3.3.4.2 Private land for private use

With regard to installations on private land not for public use, i.e. for charging systems for domestic use, according to Article 15 of Legislative Decree 257/2016 (42), the installation of the systems is mandatory for:

- New residential buildings with more than 10 residential units must have parking spaces and garages with a charging station in a proportion of no less than 20 percent of the total;
- New non-residential buildings with a surface area of more than 500 square meters;
- For existing buildings subject to first-level building renovation involving at least 50% of the gross floor area and the heating system.

In particular, every car park (covered or not) and every garage in the building must have the infrastructure and charging sockets to allow the connection of at least one car. In particular, in the case of new residential buildings with at least 10 residential units, they must have parking spaces and garages with a charging station in a proportion of no less than 20 per cent of the total. However, as reported by Motus-e, it is up to the municipalities to implement this provision by expressly including the obligation in the municipal building regulations.

For existing buildings, on the other hand, retrofitting is not mandatory. However, in order to stimulate the spread of home recharging also in these places, the latest Budget Law, which aims to strengthen the action taken by the PNRR (46), introduces a tax incentive: 50% deductibility of installation costs over 10 years.
The requirements for access are:

- Installations must be dedicated to the specific use (simple installation of a Shuko socket is no longer permitted, but a wall box with Mode 3 charging technology is required);
- They must be installed by a qualified technician who certifies their conformity.

The owner is then responsible for inspecting the system weekly to check its efficiency. The biggest obstacles in the installation of charging points in the home stem from:

- Condominium regulations. It would be appropriate, as indicated by Motus-e, to regulate in order to facilitate the deployment of installations in existing buildings;
- The second stems from some administrations or the distributor at the time of connection, which may require the SCIA when the user requests an increase in contractual power at the same time

In conclusion, the authorization process can be complicated and time-consuming, however, it is clear from the simplifications made in the regulatory sphere that an effort is being made to lighten the number of documents required and consequently shorten timeframes.
As suggested by Motus- e, it is then necessary for the administrations and the municipality to cooperate in implementing the simplifying regulations and to urge the speeding up of works and practices.

Finally, with a few shrewd nesses in deciding where to install by the operator, simpler and shorter authorization processes can be favored. For example, as seen above, it is important to choose sites that are not subject to landscape or cultural heritage superintendence constraints. Should this be unavoidable, or should they be required by the administration, it would be desirable for the administration to speed up the timetable for obtaining such permits.

Once all necessary permits and documents have been obtained, the CPO deposits the drafted documents with the relevant stakeholders to obtain the green light for construction.

3.4 INSTALLATION OF THE CHARGING UNIT BY A COMMISSIONED COMPANY, CONNECTION TO THE ELECTRICITY GRID BY THE DISTRIBUTOR, TESTING AND COMMISSIONING

3.4.1 INSTALLATION OF THE CHARGING UNIT

The installation activities are entrusted to a party awarded the contract. The construction of the site involves civil and electrical works; during the civil works the excavations are carried out, while during the electrical works the column is laid and the connection to the electricity grid and the meter is prepared. The Customer, the figure identified as the one for whom the works are carried out, appoints a Works Manager or Construction Manager to whom will be delegated the responsibility that safety regulations are complied with and the operational responsibility for the site (5).

3.4.2 CONNECTION TO THE ELECTRICITY GRID BY THE DISTRIBUTOR

Once the construction/electrical works have been completed, evidence of the completion of the site is given to the municipality and the "End of works" form is sent to the distributor, or to the trader, who will then in turn send it to the distributor, stating that the works/preparation are complete and the meter can proceed with the laying of the meter. Having received the End of Works, the distributor starts with its work on the supply of electricity, which is the laying of the meter, but which may also include work on the network (such as excavations, channeling, etc.). Once finished, the trader proceeds with the activation of the supply contract and thus the activation of the POD (the customer number of the meter). Finally, the trader is informed of the possibility of intervention for the activation of the infrastructure, which will be carried out by the installation company.

3.4.3 TESTING AND COMMISSIONING

The activation and commissioning of the charging infrastructure is performed remotely: it is an internal operation in which neither the distributor nor the trader is involved. During activation, technical tests are carried out and the data of the CI are communicated, such as the CI serial number, address, power and type of CI, and coordinates. In the case of Enel X, this is done through remote telephone contact between an on-site employee and Enel X's internal control room.

Once the configuration of the CI is completed, it is inserted into the public electricity infrastructure network and made visible on all interoperable partners' applications.

Chapter 4

THE VALUE CHAIN AND BUSINESS MODELS

Once the charging mode and the infrastructure installation process have been examined, the analysis goes into more detail by investigating the various actors involved in the process and the resulting business opportunities.
The actors involved in the market for electric vehicle recharging are multiple and their role in the value chain is defined by Directive 2014/94/EU "DAFI" (*Directive on the establishment of an infrastructure for alternative fuels*) and its transposition into Italian legislation with Legislative Decree 16 December 2016 n.257, which will be referred to in the following chapter. In particular, the recharging service value chain is essentially divided into:

- Distribution of energy to the infrastructure;
- Management of the infrastructure by the charging point operator;
- Provision of the recharging service by the mobility service provider that retails the recharging service to both B2B and B2C.

In the following pages, we will proceed with a detailed look at the different actors and the ways in which they interact, analyzing, specifically, the interoperability contract. Finally, we will look at the business opportunities that can be established between the different actors involved in the value chain.

4.1 THE VALUE CHAIN AND THE DIFFERENT ACTORS IN IT

In general, in the value chain, there are different actors with different competences with respect to infrastructure.
With reference to the plant architecture, already discussed in detail in the second chapter, the actors and their respective competences are:

- The DSO, distributor system operator, whose competence remains upstream of the meter;
- The trader, whose competence remains upstream of the counter, as with the DSO;
- The CPO, charging point operator, whose competence lies downstream of the meter;
- The owner of the infrastructure, which may or may not coincide with the CPO, and like the latter, the competence is downstream of the meter;
- The MSP, the mobility service provider, who also has the competence downstream of the meter;
- The customer of the charging service.

4.1.1 THE DISTINCTION OF ROLES

The first actors involved in the process are the DSO and the Trader, i.e. the electricity distributor and the electricity supplier respectively.

The two roles were separated following Legislative Decree No. 79 of 1999, the so-called Bersani Decree, which initiated the liberalization process of electricity. Prior to this decree, the distribution, production and supply of electricity were activities that were all carried out by the same entity.
In 2015, ARERA, the Energy Networks and Environment Regulatory Authority, imposed a clear distinction of tasks. In the case of companies that are involved in both distribution and sales, ARERA also required the creation of two separate entities: one pertaining to the distribution and one to the sale of energy.
This is the case with Enel, which has separated the two roles between E-Distribuzione (formerly Enel Distribuzione) and Enel Energia, i.e. distributor and supplier respectively.

The main objective of the liberalization of the electricity market was to allow consumers to freely choose their electricity supplier, thus initiating a regime of free competition between suppliers.
It should be emphasized that the same does not apply to the choice of distributor. The distributor, in fact, cannot be chosen by the consumer, as they manage energy distribution in the territory according to areas assigned by ARERA. Therefore, depending on the area to which they belong, the consumer will interface with a pre-established distributor.

4.1.1.1 DSO

The distributor, otherwise known as DSO (Distribution System Operator), is responsible for the transport of electricity from the transmission network to the end users. Customers are not allowed to choose their distributors and have no contact with them. In fact, distributors are determined - in principle - by tenders called by local authorities and, where they are held, ARERA is responsible for allocating and dividing up the areas.

The distributors are the owners of the electricity meter and, among their competences, include those relating to the reading of consumption, new connections, management, as well as the repair of any breakdowns or interruptions. Furthermore, they are responsible for the activities related to the increases in power of the meter and its closure. (47)
There are approximately 138 electricity distributors in Italy and they are mainly controlled by public bodies. The most important are E-distribuzione, Unareti, Areti and Ireti.
The distribution tariff is set by ARERA and is updated every three months according to market changes. This tariff includes the cost for the transport, operation and maintenance of the local electricity grid. (48)

4.1.1.2 TRADER

The role of the supplier, otherwise known as the trader, is to sell retail electricity to the end customer and is mainly responsible for the administrative and commercial aspects of the supply.
Charging point operators can freely choose their trader, as stipulated in the DAFI directive '[...] operators of publicly accessible charging points may purchase electricity from any supplier in the European Union[...]'. (42)

The main electricity suppliers in Italy are Enel Energia, Sorgenia, Eni Gas e Luce, Edison Energia, A2A Energia, and Iren Mercato. Suppliers operate in open competition with each other and each charge their own tariffs, in a transparent manner. (48)

4.1.1.3 CPO/OWNER INFRASTRUCTURE

The CPO, or charging point operator, is the person in charge of managing, maintaining and operating the charging infrastructure. His tasks include:

- The management of CI
- The management of relations with MSPs
- Billing MSPs for the infrastructure management service under the Interoperability Agreement

The role of the CPO may or may not coincide with the owner of the charging infrastructure, i.e. the one who is in charge of installing the charging station and connecting it to the electricity grid. In fact, the ownership of the CI may also belong to third parties, who then decide to entrust the management of it to a CPO.

Enel X Way plays the role of Charging Point Operator: it manages charging infrastructures that are interconnected and operational, through an integrated platform and may or may not be owned by Enel X Way.
The business opportunities, therefore, are manifold and depend on the variations in the roles of the CPO and MSP, as it will be analyzed below. (49)

4.1.1.4 MSP

The MSP, or Mobility Service Provider, sells charging services and other related products and services to end customers, as well as manages user payments. Its tasks, therefore, include:

- Offer recharging services to the end user
- Manage commercial operability (e.g. contracts, invoicing, customer care)
- Bill the customer for the recharging service on the basis of self-defined tariffs

The DAFI directive distinguished the roles of the CPO and the MSP: the CPO sells the charging service to the MSP, who in turn interfaces with the end customer for the sale. As stated in the DAFI, the collaboration between CPO and MSP is contractual in nature: "operators of publicly accessible charging points are authorized to provide charging services for electric vehicles to customers on a contractual basis, including in the name and on behalf of other service providers". (42)

It is anticipated that, as will be detailed in the following pages, this distinction of roles was necessary to avoid monopoly situations. Should a company, such as Enel X Way, play the role of both CPO and MSP, it will be essential that it does so through two separate corporate vehicles.
In order to sell the charging service to the end user, each Mobility Service Provider must develop a reference app and implement RFID Cards, through which the user can start and stop charging, as well as make payment. As defined in the DAFI "For publicly accessible charging points, payment methods are enabled, which allow all users of electric vehicles to use the charging service ". (42)

The different MSPs and related Apps with which Enel X Way collaborates, through interoperability contracts, are the following:

a. Enel X Way Italy with the Juice Pass App;
b. Bloomfleet with Blumfleet;
c. BMW with BMW Charging;
d. Charge4Europe with CustomerSpecific (DKV);
e. Convergences with EVO;
f. Digital Charging Solution with automotive brand-specific Apps;
g. DVK EuroService with eCharge+;
h. Duferco Energia with D-mobility;
i. Egea Commercial with Egea Green Mobility;
j. Electromaps with Electromaps;
k. Evway with Evway;
l. GoElectric Stations with Nextcharge;
m. Hera Comm with Hera Ricarica;

n. Mini with Mini Charging;
o. Neogy with NeogyMobility;
p. Ressolar with WROOM;
q. Smatrics with Smatrics;
r. Telepass Pay with Telepass Pay;
s. Tico with Ready to Park;
t. Západoslovenskáenergetika with ZSE Drive. (49)

A residual charging solution for all CIs is the so-called 'ad hoc charging'.
In the event that users do not have a contract with any MSP, and therefore do not have any recharge card and App, the CPO can sell the recharge service directly on the CI, without the interface of the MSP.
This operation is rarer and more cumbersome, but some CPOs have adhered to it in order to meet customers' needs. Usually, ad hoc recharging is only possible on CIs that have the QR sticker code. The user scans the QR code, enters the credit card data and starts reloading. For this reason, this solution is also called virtual POS, because of the payment method that is performed online, rather than physically, for example with a reload card. (50)
Usually, since the ad-hoc recharging process is more complex than the normal recharging process with a recharge card, a surcharge is applied.

4.1.1.5 CHARGING SERVICE CUSTOMER

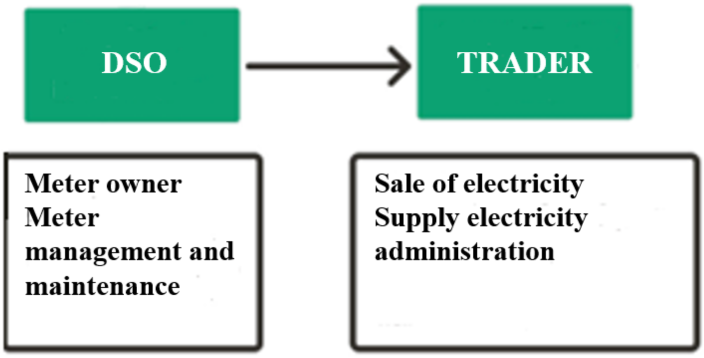
The customer of the charging service is the owner of an electric vehicle who needs to use the charging service on the CI.
The main characteristics of the customer are:

- Interfaces with MSPs
- Charging the electric vehicle through authentication to the MSP platform
- Pay the MSP for the recharging service (49)

Below are two diagrams summarizing the different actors, with their respective roles in relation to the counter.

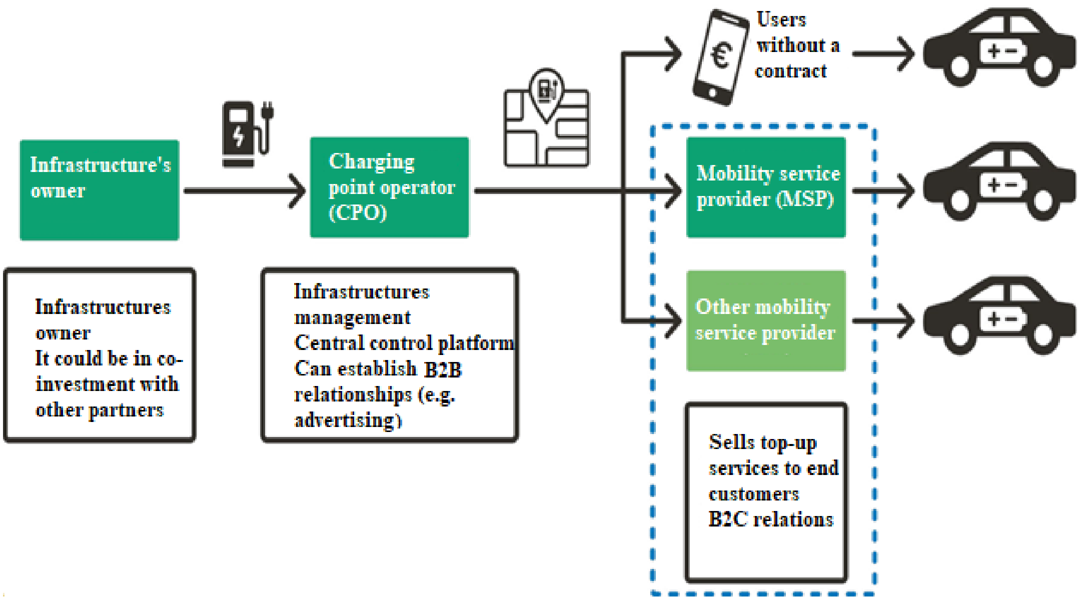
➢ Upstream of the meter: (5)

Graph 20: Different actors and roles upstream of the meter



➢ Downstream of the meter: (5)

Graph 21: Different actors and roles downstream of the meter



Having outlined all the actors, the next step is to understand how they interface and collaborate, and then to identify the different business models that can be established.

4.2 MODES OF INTERACTION BETWEEN DIFFERENT ACTORS AND BUSINESS MODELS

Before business models can be identified, it is necessary to clarify how the different actors involved in the value chain work together.

4.2.1 MODES OF INTERACTION BETWEEN THE DIFFERENT ACTORS

There are many actors involved in the value chain and it is crucial to understand how they interface with each other. In particular, it will be highlighted the ways in which the following actors are linked:

- DSO, trader and infrastructure owner
- CPOs and MSPs

Once the analysis of how these actors collaborate has been completed, it will then be possible to identify the different business models that can be established.

4.2.1.1 DSO, Trader and Infrastructure Owner: DSO network connection procedure

DSO, trader and CI owner interact mainly in the phase of connecting the CI to the DSO's network.
The process of connecting DSOs to the grid is a fundamental step in the electricity infrastructure installation process, which has already been analyzed in depth in Chapter 3. It should be emphasized again that, before the distinction of roles introduced by the DAFI, the roles of DSO, CPO and MSP coincided in a single entity: it was the DSO that installed, managed and sold the charging infrastructure. With the legislation introduced in 1999, the need arose for a specific standardized procedure for the distributor and the infrastructure owner to cooperate.
In addition to the close cooperation in the very first phase of the installation of the CI, the CI owner will continue to interface with the DSO and the Trader during the service period of the CI: more frequently with the Trader, for the payment of the electricity supply; more infrequently with the DSO, in the event of technical problems with the meter or additional work on the network.

4.2.1.1 CPO and MSP: interoperability contract

The CPO and the MSP cooperate with each other through the interoperability contract.
As analyzed above, the actor selling the charging service does not coincide with the one who owns or operates the infrastructure. In this way, owners of electric vehicles can recharge at stations owned by different operators, without the need to conclude a new contract each time, but simply through the single App of the MSP, or MSPs, of their choice. It is then up to the MSP to conclude interoperability contracts with as many CPOs as possible to guarantee its customers recharging over a widespread network. In the DAFI directive, in fact, it is stated that 'the supply of electricity to a charging point must be contracted with suppliers other than the supplying entity of the home or premises where the charging points are located' and continues, 'all publicly accessible charging points shall also provide specific charging arrangements for electric vehicle users, without the need to conclude contracts with the electricity suppliers or operators concerned' (42).

The interoperability contract is a commercial contract governing the mechanism whereby CPOs make their charging infrastructure available and the MSP can sell the charging service on that infrastructure.

This mechanism is carried out through an exchange of information.
Interoperability, in general, is defined as the ability of two or more systems to exchange information with each other and then be able to use it.
For electric charging infrastructure, information is exchanged through roaming, whereby different operators integrate their IT infrastructures to share data and infrastructure.
In particular, the charging infrastructures are remotely connected via a SIM to the CPO's systems. The CPO's systems are then linked to those of the MSP, which have access to information on the infrastructure.
Finally, the MSP makes this information available to its end customers via Apps.
In the DAFI, it is specified that there are smart meters in each CI: "Smart meters are positioned in each charging station for each operator at the point of connection to the distribution network. For the individual recharging points, it is sufficient for each of them to be equipped with a resettable meter, with which the operator can make visible to the users of electric vehicles the information relating to each individual recharging service provided " (42).

Interoperability provides two major benefits:

a. Having more charging infrastructures available for the same end customer;
b. It allows the leveling down of prices for recharging services because it ensures competition between actors who intend to sell recharging services (MSPs), and between actors who plan to make them available (CPOs). If, on the contrary, a CPO were also an MSP and there was no distinction of roles, the CPO could impose that no MSP could use the recharging service on its CI and this could lead to a monopoly situation.

At the financial level, the CPO charges the same fee per kWh to all MSPs, it being understood that MSPs may charge different fees to end customers depending on their strategic choices of market penetration. Other costs such as, for example, the penalty time, i.e. the non-release of the outlet and the occupation of the charging infrastructure, are always charged by the CPO to the MSP, who then passes on the cost incurred to the end customer. Also in this case the DAFI clarifies the modalities: 'Payment methods are enabled for publicly accessible charging points, which allow all users of electric vehicles to use the charging service' and continues, 'the prices charged by operators of publicly accessible charging points are reasonable, easily and clearly comparable, transparent and non-discriminatory'. (42)
In fact, in addition to an extensive network of charging infrastructure, it is important that charging points can be easily managed without the need for multiple cards and applications. Interoperability agreements are a step forward in the development of a standard for top-up payment, as with a single top-up card/app a customer can make payment on several CI.

Also at European level, it is crucial to establish interoperability agreements to avoid 'range anxiety', i.e. concerns about the low autonomy of electric vehicles and their stability. Interoperability agreements do not, to date, cover all MSPs and it can therefore happen that the infrastructure where a user wants to recharge is not interoperable with his app, and is instead interoperable with other circuits. This happens especially with foreign CPOs not operating in Italy.

To avoid these kinds of problems, eRoaming platforms, such as Hubject, have sprung up with the aim of simplifying contract management between MSPs and CPOs and facilitating the spread of interoperability.
In 2020, Enel X Way started its collaboration with Hubject's eRoaming platform.
The platform allows clients to recharge their electric vehicle using a network of more than 250,000 public charging stations worldwide without having to sign any contracts other than the one with their MSP, and to simplify payment transactions.
The new payment procedure makes it possible to settle, in real time, payments between the various operators of the charging points, who own the charging stations, and the companies that charge motorists for services, when a customer charges a vehicle. (51)
Hubject's eRoaming platform is B2B and allows each MSP using the platform to access the networks of the different CPOs. In this way, the eRoaming platform takes care of each redemption transaction, freeing the MSP from having to pay the fee independently and allowing for easier deployment of interoperability between circuits. (52)

Having completed the investigation of the different actors and their modes of interaction, it is now possible to proceed with the identification of the different business models.

4.2.2 BUSINESS MODELS

The identification of business modes must necessarily start from the division of roles. While the division of the CPO and MSP role is inescapable, as far as we have seen so far, the CPO and the owner may or may not coincide. In what follows, the perspective of the CPO is adopted and, therefore, references to the owner as 'client/partner' will be made in cases where CPO and owner do not coincide. Another criterion on which the discrimination of business models is based is the interstation of the POD. The owner of the POD is the one who made the contract with the trader and, therefore, the electricity supply contract is in his name. Therefore, the identification of business models will be conducted from the two factors:

a. Properties of the CI;
b. POD holder.

From this, several opportunities may arise:

1. The CPO coincides with the owner: the CI and the POD belong to the CPO, which therefore also manages the CI. This is the standard and most widespread case of the Italian Plan on public land (B2G) or on private land with public access (B2B). There are no major differences from what has been explained so far.

2. The CPO is different from the owner: the CI is owned by the customer/partner, but its management is entrusted to the CPO. It is quite common for the owner of an infrastructure to entrust its management to a CPO who already performs this role for other CIs. The reason behind the decision to delegate the management of the CI is to take advantage of the CPO's interoperability contracts and thus be able to sell to its MSPs. In this hypothesis, we speak of a "*mandato di CPO*": the CPO takes care of the management, maintenance and making the CI visible through the numerous Mobility Service Providers (MSPs) with which it has signed interoperability agreements.

   Then, depending on the POD header, two distinct opportunities arise:

   a. POD of the Partner/Customer. This is the case, for example, for charging infrastructures on private land for public use, such as in shopping centers, supermarkets, sports centers, restaurants, hotels, or any business with an adequate parking area open to the public. The basic principle is that the owner of the CI and the CPO become business partners: the owner equips an CI with public access in its parking area, providing customers with its energy to recharge their electric vehicles. Within the Enel X Way, this commercial offer is called Recharge partner.

b. CPO's POD: The CPO will take care not only of the management of the CI, but also of the supply of electricity and the contract with the Trader. This case is not very common but is typical for public administrations. If the latter decide to buy an CI, they cannot then register the POD as they would be setting up a charging service that is not in their nature. This business model is the least common case of the Piano Italia on public land (B2G), especially in less strategic sites for the CPO, i.e. those sites where the CPO has no interest in having an CI.

3. The CPO owns the CI, but the POD is in the name of the Partner/Customer. This business is like that seen in point "2 a", but in this case the Partner/Customer does not entrust the management of the CI owned by him to a CPO, but only offers the energy at his private area. This is the less common case of the commercial Recharge Partner (B2B) offer of Enel X Way in strategic sites for the CPO.

These business opportunities represent the logic of the future development of charging infrastructure solutions on private land for public use. The basic principle is the matching of supply and demand and the simultaneous benefit of all parties involved in the value chain:

- The owner of the infrastructure benefits from increased site valorization and visibility. The charging infrastructure increases the attractiveness of the business in question and improves the customer experience. In addition, the presence of MSPs' apps provides high visibility and the possibility to reach new customers and customer segments.
- The end customer can benefit, in general, from having several CIs at his disposal. A customer who has to plan a long journey can benefit from the points of interest in the vicinity of CIs that can be exploited during the charging time.
- The CPO can take advantage of its already established interoperability and asset contracts to expand its CI network, relying on Partners to provide it with the location and energy, without having to enter into a new supply contract. This greatly reduces the CI installation process, as the connection steps to the distributor's network are eliminated.
- The MSP can expand its infrastructure network and meet the needs of a larger number of customers who need to make use of time while parked. This is in line with what was seen in chapter 3, regarding the determining factors for the choice of location for a recharging infrastructure: proximity to services and places of attraction was among them.

Confirming the relevance of these business opportunities, there is now a charging infrastructure search engine, called 'A Better Route planner', which allows you to plan your journey and at the same time proposes points of interest on the selected route. (53)
The strategy to incentivize the use of electric vehicles and charging infrastructure is to make use of parking and charging time, so that for the user it is not time 'lost' but 'invested' in doing something else.

As analyzed, depending on the diversification of the roles and competences of the owner and CPO, different business models may arise, which are summarized in the table below:

Table 22: Business models

Id	Owner and CPO Role	Management and maintenance	Properties	POD holder	Application
1	=	Owner/CPO	Owner/CPO	Owner/CPO	B2G e B2B
2 a	≠	CPO	Client	Client	B2B
2 b	≠	CPO	Client	CPO	B2G less widespread
3	≠	CPO	CPO	Client	B2B less widespread

Having completed the analysis of the electric vehicle charging infrastructure and the installation process, we will proceed in the next chapter with the application of the contents examined in the Turin case study, the result of the experience in cooperation with Enel X Way.

Chapter 5

CASE STUDY TURIN

Having concluded the discussion on the installation of charging infrastructure for electric vehicles, the study proceeds with the analysis of a practical case in order to describe in concrete terms what has been presented at a theoretical level.
The study in question, in fact, in addition to dealing with the technical and theoretical part, has deepened the project in the Municipality of Turin with the help and advice of the Enel X Way Delivery Team

5.1 THE PROJECT

The Enel X Way project in the city of Turin consists of the installation of 200 recharging infrastructures by 2022:

- 152 Juice Pole 44kW, having two Type 2[11] sockets of 22kW each in AC;
- 48 Fast in the 72kW Juice Pump type, with the possibility of both AC and DC charging from CCS or Combo2 and CHAdeMO[11] sockets.

More specifically, in the following analysis, reference will be made to the installation of two specific types of charging infrastructure in the following locations:

- A Juice Pole in Via Carema 2, Turin;
- A Juice Pump in Via Valprato 45, Turin.

The installation of the two recharging infrastructures made it possible to observe, with special on-site inspections, all the infrastructure phases of a CI, as well as to gather specific information on the practices and procedures of the City of Turin. In particular, the entire process was followed with special on-site visits at the different stages:

1. Start of civil works and commencement of excavations
2. Commencement of electrical works and laying of electrical infrastructure
3. Connection to the electricity grid and meter
4. Testing and activation

[11] Reference chapter 2 “The sockets”

In this chapter, we go over the contents covered in the previous chapters, with a special focus on chapter 3 "the installation process", to apply them to the case of the City of Turin. The topics discussed will be the result of practical experience with Enel X Way on the two projects in Via Carema and Via Valprato from which it was possible to draw information, as well as photos and specific documentation, which will be reported on the following pages.

As already highlighted, the installation process differs from municipality to municipality depending on the organizational choices made and the administrative tools used. The practical application of what has already been set out in the context of the Turin Municipality will allow the different phases to be examined in more detail and may be usefully considered, by way of example, for other contexts.

5.2 APPLICATION PROCESS OF INFRASTRUCTURE INSTALLATION

The standard charging infrastructure installation process, analyzed in Chapter 3, includes the following steps:

1. Administrative Procedures
2. Site selection: Site identification and technical feasibility
3. Authorization process
4. Installation of the charging unit by a contracted company, connection to the electricity grid by the distributor, testing and commissioning

5.2.1 ADMINISTRATIVE PROCEDURES

Administrative procedures allow an agreement to be reached between the operator and the municipality. The municipality may choose to adopt one of the following options: the joint memorandum of understanding Municipality - Private operator, the expression of interest / competitive procedure, the predefined regulation.
The City of Turin adopted the regulation as an administrative procedure.

The “*Disciplinare per l’installazione e la gestione di strutture per la ricarica dei veicoli elettrici ad uso pubblico*” provides the criteria for the installation of electric vehicle charging facilities on public areas in the city of Turin. (54)
The document, a summary of which is given below, is divided into two parts:

- In the first one, the general provisions are explained;
- In the second, the technical characteristics of the electric vehicle charging facilities and service.

In the first part, the specifications for the scope of application are defined. The application for installation may be submitted by either a public or private entity and must be limited to a maximum of 200 columns. Each charging station, it is specified, must be positioned at a minimum distance of 250 meters from other electric charging stations, regardless of whether they belong to the same operator or to other operators. The only exceptions to this rule concern car sharing companies and inlets placed on private areas or installed on public land but not for public use (e.g. taxis, company fleets, etc.). Each operator must apply for the installation of at least five inlets, specifying the chosen location for a maximum of four inlets, while for the fifth the location is determined by the municipality. Courtly streets and squares are excluded. If two or more applicants select the same site, preference will be given to whoever submitted the application first, in order of time. The documentation must be accompanied by self-certification with the applicant's personal details.

The specifications go on to specify the nature of the concession: "the occupations for electric vehicle charging structures and adjacent parking spaces are in the nature of temporary occupation of public land with the possibility of renewal". The specifications then states that the realization of the works shall follow the Regulations on the trespassing of public land and other specific regulations and that, in the case of areas subject to historical-artistic or landscape-environmental protection, the realization shall be authorized by the competent authorities, in accordance with what has been seen in Chapter 3.

As far as the procedure is concerned, the proposals submitted, which must be accompanied by technical documentation for the granting of the concession and the building permit, are assessed by a technical round table attended by representatives of the Administration Departments involved.

The duration of the concession is 10 years. The concession fees, i.e. the payment of the COSAP fee, have already been outlined in Chapter 3, where it was seen that depending on the power and the percentage of energy from renewable sources, the municipality may exempt the concessionaire from paying the fee. In any case, the exemption from payment is limited to the first three years.

As already mentioned, a peculiarity of the Municipality of Turin is that the municipal administration reserves the right to choose the site of the fifth column for every four columns installed in the positions requested by the concessionaire. With regard to this issue, the specifications specify that: 'the locations chosen by the administration will be communicated to applicants at the same time as the list of installations deemed suitable on the basis of those presented in the expressions of interest'.
The reason behind this reservation is to be found in the political and strategic choices made by the administration, which aims to support and implement electric mobility in its municipality, also considering the requests of citizens interested in replacing thermal vehicles with electric vehicles.

The second part outlines the characteristics of the type of service. A first key point is that installations must guarantee interoperability between charging systems and between different circuits, "allowing the use of any single installation by users belonging to different circuits or countries". In line with what has been seen in chapter 4 about interoperability contracts and the division of roles between CPOs and MSPs, the document emphasizes that "the recharging service must allow the end user to be able to use the installation without the need for prior signing of a contract with one or more specific suppliers, without the need to have a specific card or smartcard and without the need for prior registration on a site or platform. To facilitate interoperability, the service provider may choose to adhere to national or European networks, but this does not exclude the compulsory requirement to equip the column with an immediate payment system' through credit cards, a residual solution known as 'ad hoc charging', as already mentioned in Chapter 4.

From the point of view of technical characteristics, the specifications stipulate that both charging infrastructures with standard power, i.e. no less than 15 kW per socket, and facilities with high power, i.e. more than 22 kW per socket, can be installed.
In the case of standard power charging infrastructure with charging mode 3, the facility must be equipped with at least two type 2 connectors according to IEC 62196.
In the case of recharging infrastructures with high power, exceeding 22 kW per socket, these must be multistandard and therefore equipped with at least 2 connectors, 50kW DC, which can be used individually: one of the ChaDemo type and the other of the ComboCCS type. In any case, the CEI technical standards currently in force, as seen in Chapter 2, must be complied with.

Article 6, then, deals with the value chain and the division of roles between CPOs and MSPs: "the concessionaire owner of the charging station (CPO) may be the direct service provider or enable his facility to more than one charging service provider (interoperability), also through connection to the European charging hubs, in which case the responsibility for the facility is borne by the concessionaire, while the commercial relations with customers may be the responsibility of the various service providers".

In Chapter 4, it was seen how the interoperability contract between CPOs and MSPs is carried out through an exchange of information. In this sense, the transmission of recharging infrastructure data is crucial, and the specifications stipulate that recharging infrastructures must provide a connection to the PUR (*Piattaforma Unica Regionale*) by means of the OCPI protocol in order to informally transmit data.
The PUR is the database of recharging infrastructures of the Piedmont Region, its main task is the transmission of data to the PUN (*Piattaforma Unica Nazionale*), but at the same time it continuously monitors the evolution and status of the recharging network. Each operator must connect its central system to the PUR in order to transmit the data required by the OCPI protocol, while there is no direct connection to the PUR via the OCPI protocol of the individual recharging sites. The data to be transmitted according to the OCPI protocol are as follows:

- Information about the site (coordinates, address, owner, references, contacts, website, etc.);
- Specific information on each column;
- Status of each column (free, occupied, booked, out of service, etc.);
- Reservation details;
- Type of connectors, power;
- Column capacity and functionality;
- Technology used for charging access and availability access;
- Fees and service costs;
- Hours of operation;
- Supply energy mix.

At the functional level, the OCPI protocol provides for the transmission of information from each charging station about its use and reservations, in particular:

- Tariffs: description of the tariffs applied;
- Sessions: recharging sessions;
- CDRs (Charge Detail Record): required to specify the type of tariff applied to the user.

Regarding energy, the specification specifies that 'connection to the electricity grid and the stipulation of energy supply contracts is the responsibility of the concessionaire', who must also indicate the percentage of electricity used for its facilities from renewable sources for exemption from paying COSAP, as seen in Chapter 3.

Other obligations of the owner are:

1. Provide evidence to the granting administration of the favorable outcome of the inspection of the building and its compliance with the standards in force;
2. Maintain the occupied area in a tidy and clean condition;
3. Maintain the electric vehicle charging facility located on the public area covered by the corresponding supply license in an operational and safe manner;
4. Carry out all maintenance and periodic checks prescribed by the regulations.

Finally, only recharging structures with shape and color characteristics in keeping with the city's décor will be admissible.

5.2.2 SITE SELECTION: SITE IDENTIFICATION AND TECHNICAL FEASIBILITY

5.2.2.1 Identification of sites

Enel X Way identifies strategic points for the installation of recharging infrastructure, although the location of the fifth in every four columns is chosen by the municipality, as stipulated in the regulations. It should be noted that Enel X Way's Turin Project only started in 2020 and, therefore, relatively late with respect to the infrastructure of electric charging stations. Due to the minimum distance, the choice of strategic sites had to take into account the infrastructure already present in the city and owned by other parties.

5.2.2.2 Technical feasibility

Once the strategic points have been identified, the technical feasibility study continues with the request for connection to the local distributor and the final decision on the sites made by Enel X Way and approved by the municipality. In particular, the Municipality's regulations require that concessions be assessed by a technical panel and that requests be accompanied by technical documentation.
For this reason, the steps are as follows:

1. Appointment of a design studio for permitting and authorizations to be submitted to the various bodies. At the same time, the request for a new connection was made to the local distributor, which in Turin is Ireti, which, once the supply is installed, will proceed with activation. The new supply will be registered to Enel X Way.

2. Projects completed and verified by Enel X Way are forwarded to the mobility infrastructure office of the City of Turin.
   In particular, the technical project consists of the following elements:

   a. The title: "*Implementation of an electric recharging network in urban areas*"
   b. The cover, which contains:
      - The working group, i.e. the list of deliverables, the designer and the technical collaborators;
      - The intervention, i.e. the project scope "*Realization of an electric recharging network in urban areas, consisting of a site dedicated to the recharging of electric motor vehicles and motorbikes with a recharging infrastructure*" and the subject of the technical documents "*Request for authorization for the setting up of a site dedicated to the recharging of electric motor vehicles and motorbikes with a recharging infrastructure*";
   c. The spatial framework table, where the spatial distribution of the recharge sites is specified, i.e. the street and coordinates, as well as the map;
   d. General framework and state of affairs;

   e. Design and characteristics of representative elements;
   f. Construction site and excavation area;
   g. Project details and photo-insertion.

3. After an initial analysis carried out by the mobility infrastructure office, the projects carried out by the study are sent to the technical board, where all the entities that identify the underground services in the area to be installed, such as Ireti, Italgas, uni.to, GTT, Smat, Wind, Snam Retegas, Raiway, 5t, Terna, Tim, Fastweb, Iren Ip, Iren Energia (district heating), Openfiber and some municipal offices regarding the services quality to the citizen, will give their positive or negative opinion:

   - Positive opinion: site construction is proceeding
   - Negative opinion: need to redesign in another position
   - Positive with prescription: the project needs to be corrected or modified according to the requests of the bodies that issued the conditional opinion

Once the positive opinion is obtained and the agreement with the municipality is finalized, the authorization process proceeds.

5.2.3 AUTHORIZATION PROCESS

The authorization process in the city of Turin includes the following steps and authorizations:

1. For sites with a positive opinion, a request is made to the tax office, which is in charge of issuing the excavation notes. Once the excavation bills have been obtained, you can proceed with the request for occupation of public land. Afterwards, the charges required by the municipality for temporary occupation and the site area must be paid by means of payment slips;
2. Once all of the above steps have been completed, one must go to the municipal re.ca (*regia cantieri*) office where all individual projects are analyzed and forwarded to: municipal police, traffic, public land and GTT;
3. Once the authorization has been obtained from the re.ca office, as well as the subsequent traffic ordinance and the authorization of tampering with the public, via the municipality's portal, the site can be set up.

5.2.4 INSTALLATION OF THE CHARGING UNIT BY A CONTRACTED COMPANY, CONNECTION TO THE ELECTRICITY GRID BY THE DISTRIBUTOR, TESTING AND COMMISSIONING

Once all authorizations have been obtained, the installation activities are entrusted to the installation company, which starts the site construction. The three phases of installation, connection and testing are shown separately below.

5.2.4.1 Installation of the charging unit by a contractor

The installation of the charging unit is carried out directly by Enel X Way through the installation company, generally consisting of a construction team and an electrical team, to which the technical project is handed over before starting. For each construction site, a professional is appointed to carry out the construction management.
The installation includes:

1. Construction work: the construction team, coordinated and supervised by the construction management, takes care of the excavations where the column is to be placed.

In the following, photos of the construction work in Via Valprato, obtained from inspections with Enel X Way, are attached:

Figure 9: Construction works

As can be seen from the image, the municipality of Turin prescribes that a concrete elevation with an asphalt surface finish, bordered by stone kerbs, on which the column will be installed; in slang, this construction is called '*naso*', nose.
The construction site area is demarcated and marked with appropriate fencing and the relevant signs and documents such as ordinances, authorizations, etc. are posted, as shown in the next picture:

Figure 10: Construction site area signs

2. Electrical work: the electrical team coordinated and supervised by the works manager is in charge of laying the electrical infrastructure, the electrical panel and preparing the connection to the electricity meter.

By way of example, photos taken during inspections in Via Carema during the installation of a Juice Pole will be used. As far as the Juice Pump is concerned, the process is the same: the only element that changes, apart from the pole itself, are the cables which, due to the increased power, will be of a larger section.
The electrical team finds the work completed by the construction team with the counter plate and fiberglass cabinet already in place, as shown in the following pictures:

Figure 11: End of the works by the construction team

The following photo shows what the cabinet looks like when it is still empty. In the upper compartment will go the switchboard, the work of which is the responsibility of the electrical team, while in the lower compartment will go the meter, the work of which is the responsibility of the distributor.

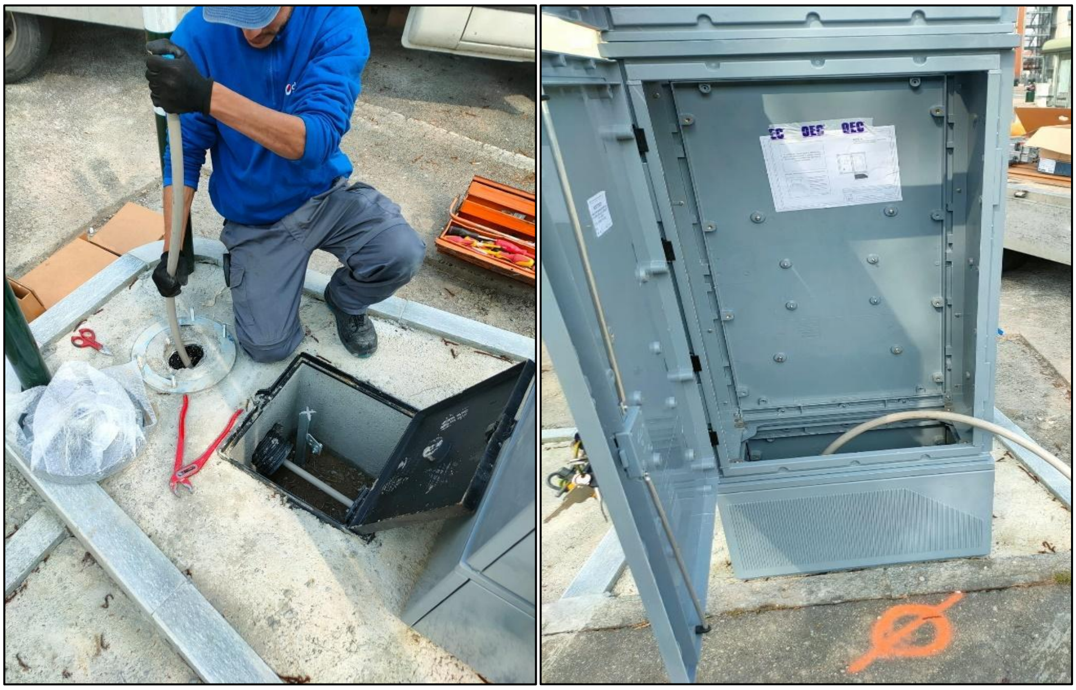
Figure 12: Fiberglass cabinet empty

The construction team then proceeds with the preparation of the piping in which the cables will be laid, connecting the column with the earthing system up to the switchboard. The following picture shows a detail of the earthing system, which consists of the grey picket:

Figure 13: Earthing system

The following photos illustrate the electrical team's preparation of the cables. The first cable, grey-colored, multi-core, encloses within its sheath four cables, i.e. the three phases and the neutral. This cable connects the column to the switchboard, as shown below:

Figure 14: Electrical team's preparation of the cables

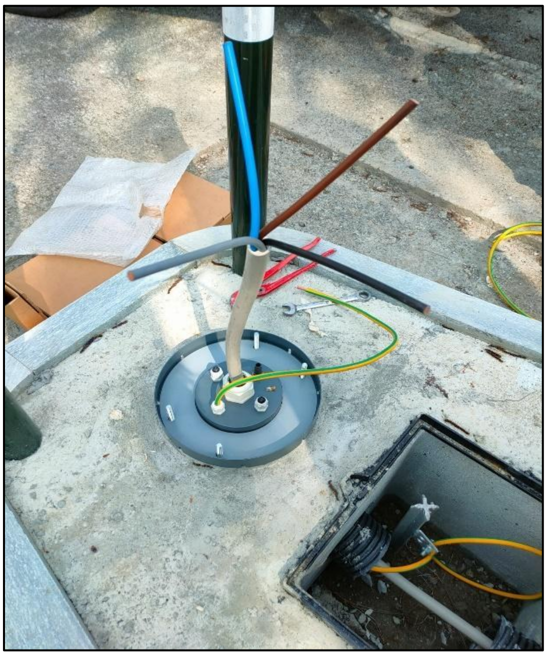


Next, a second cable, yellow and green in color, is laid, which has the function of earthing; this cable is called PE (Protective Conductor) and connects the post to the earth system, which in this case consists of the grey picket as shown in the following picture:

Figure 15: Electrical team's preparation of the cables

The cables are then prepared for connection to the column, as follows:

Figure 16: Electrical team's preparation of the cables

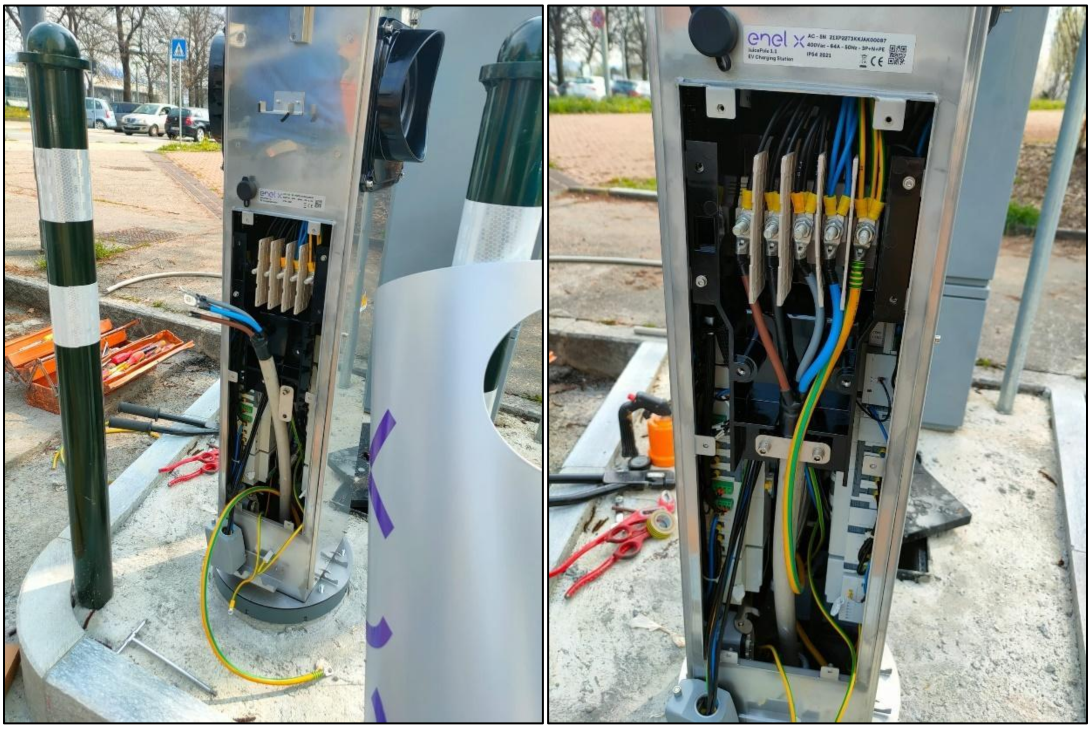


The next step is to place the column on the counter plate and connect the electrical cables to it. After running the cables inside the column, the column is fixed to the metal counter plate:

Figure 17: Positioning of the infrastructure

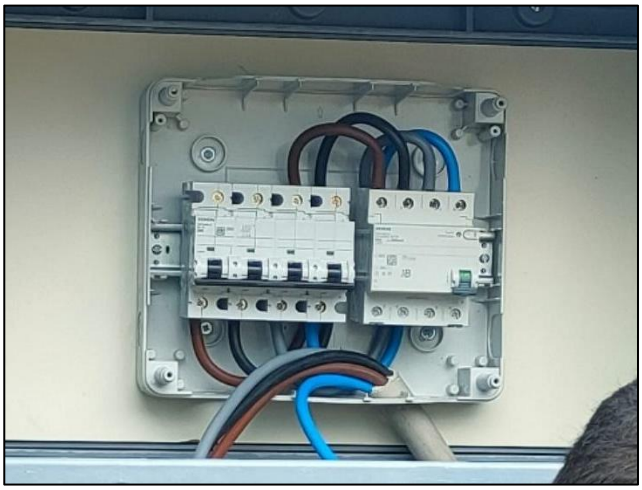
Then the three-phase cable with neutral as well as the earth conductor (yellow/green) of the earthing system are connected and wired in the column, as shown in the photos:

Figure 18: Connection of the cables to the infrastructure



Finally, once the switchboard is mounted, the connection of the multi-core, three-phase cable with neutral is made:

Figure 19: Switchboard



When the work of the electrical team is completed, the charging infrastructure is installed and looks as pictured:

Figure 20: End of the work by the electrical team

The next step is the connection, by the distributor, to the electricity grid. The electrical team leaves the cabinet with the free space for the meter and the switchboard with the cables already prepared and connected.

As an example, here are photos of the Juice Pump cabinet in Via Valprato:

Figure 21: Fiberglass cabinet after electrical team's works

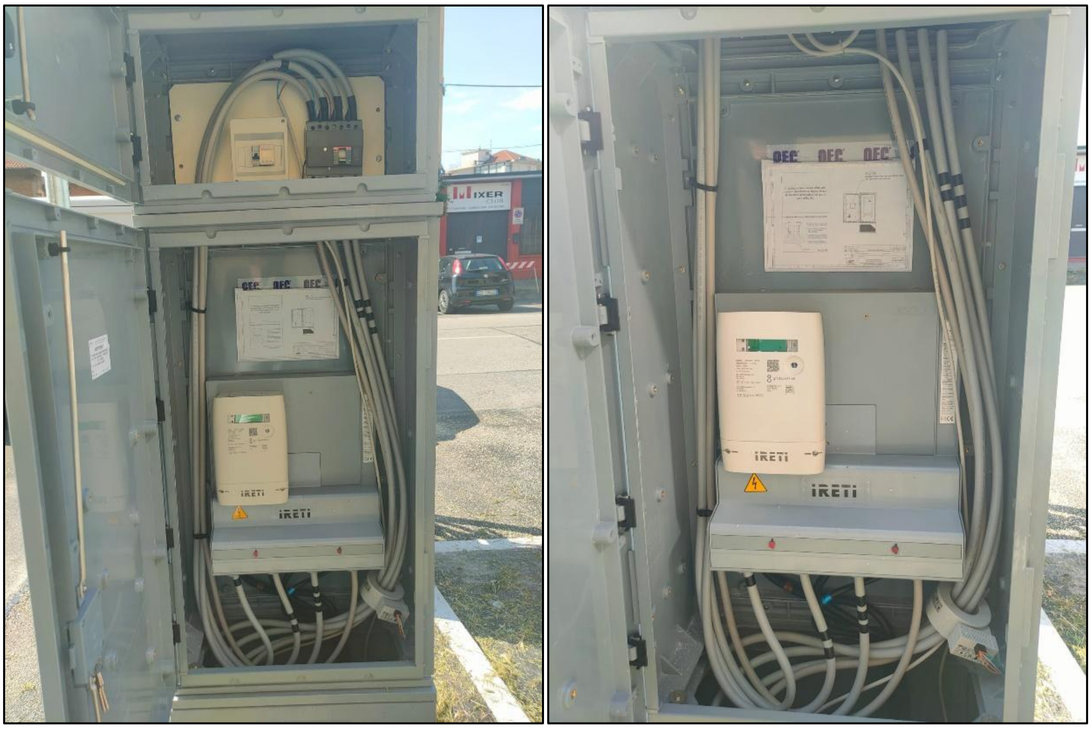
As can be seen from the photos and as previously mentioned, the Juice Pump's cables are of a larger cross-section and of the unipolar type due to the greater electrical power to be supplied.

5.2.4.2 Grid connection by the distributor

Once the electrical construction work has been completed, evidence of the completion of the site must be provided on the user diary of the Municipality of Turin's portal.
At the same time the end of work form is sent to the distributor Ireti, informing it that the works relating to the preparation have been completed and that it is possible to proceed with the installation of the meter.

Once the iReti distributor has installed the meter, the cabinet looks like the following photo taken at the Via Valprato site:

Figure 22: Fiberglass cabinet after meter installation by the distributor



Each supply has a customer number, i.e. the POD (point of delivery), which is indicated on the meter, as shown in the following picture:

Figure 23: POD

The POD code is a mandatory element of an electricity supply. The Point of Delivery is an alphanumeric code, in the example in the picture "IT020E00800675", which uniquely represents a supply and consists of:

- Prefix representing the country of the point of delivery, in the case of Italy it is 'IT';
- Three figures representing the identification of the company providing the energy service;
- It is followed by the letter E, with national conventional function, to indicate the supply of electricity;
- This is followed by eight digits, which serve to indicate the specific national sampling point. (55)

Once the distributor has completed the meter-laying work, Enel X Way is notified of the possibility of intervention to activate the infrastructure, which will be performed by the installation company and, in particular, by the electrical team, so that it can intervene in the event of technical problems; this part of the process is also coordinated by the works manager for the performance of visual inspections, plant verifications and functional tests.

5.2.4.3 Testing and commissioning

Activation and commissioning of the charging infrastructure is performed by contacting the Enel X Way control room and providing colleagues with site and IDR data:

- The serial number of the IDR;
- The address;
- Power;
- The type of IDR;
- The coordinates of the site.

Finally, a test is carried out by recharging an electric vehicle to make sure that everything is working properly. Below there are pictures of the testing and commissioning phase on the Juice Pump in Via Valprato:

Figure 24: Testing and commissioning

In addition, in the case of POLE-type charging infrastructure, supervision of the infrastructure is carried out remotely via a data connection with a SIM card, which in the case of Enel X Way, is called a Customer SIM card. Through the Customer SIM card, it is possible to verify both the quantity of energy supplied by the infrastructure and the relative billing, and to monitor the state of operation and functioning of the CI.

In the case of the Juice Pump, unlike the Juice Pole, there is a double SIM card: one is the Enel X Way "Customer SIM Card", the second SIM is that of the supplier Alpitronic. Alpitronic is the company that manufactures and produces the Juice Pump type columns and supplies them through a dedicated contract to Enel X Way. With this contractual relationship, in the event of a failure of the column, the Alpitronic company can intervene directly.

Below there is a sample photo of the SIM cards:

Figure 25: SIM cards

Once the configuration of the CI is complete, it is made visible on all the applications of interoperable partners such as Juice Pass, Becharge, Duferco, etc. in order to allow all users to view and use the infrastructure available in the area they have identified. The customer will then be able to virtually access the infrastructure by interrogating it to see if the type of CI reflects their charging needs.

5.3 VALUE CHAIN APPLICATION AND BUSINESS MODELS

5.3.1 BUSINESS MODELS

Enel X Way's role in the value chain is that of CPO/Owner.

The Turin Project is on public land, so, with reference to what was seen in Chapter 4, the only business opportunities are B2G ones. However, the Turin Project envisages that all 200 recharging infrastructures are based on the classical business model: Enel X Way is the owner, CPO and holder of the supply. Therefore, other business types, such as Recharge Partner, do not apply, although there are recharging infrastructures with this business type in Turin, but they are not part of the specific project.

5.3.2 VALUE CHAIN

At the level of interactions with other actors in the chain, Enel X Way interfaces with the distributor in the Turin area, which is iReti. Concerning the choice of the trader, i.e. the supplier, the supplier of the Enel group, Enel Energia, is preferentially chosen.

Finally, through the various interoperability contracts with different MSPs, Enel X Way can make its infrastructure visible on the various Mobility Service Provider platforms. Enel X Way itself is an MSP, through a separate corporate vehicle, with its JuicePass App.

There are several ways for a customer to activate a charging station with Enel X JuicePass:

1. By registering on the app, entering your personal data and a payment method;
2. By applying via an app for a recharge card, also linked to a current or rechargeable account.

Photos of the JuicePass application and the Enel X Way card follows below:

Figure 26: JuicePass App

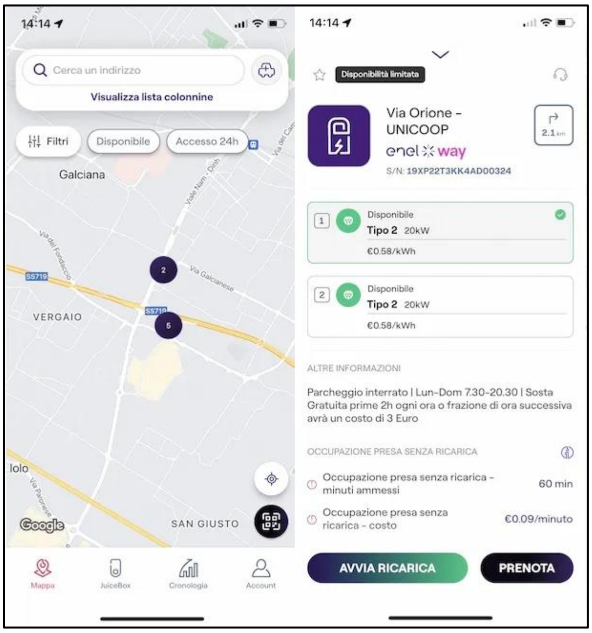
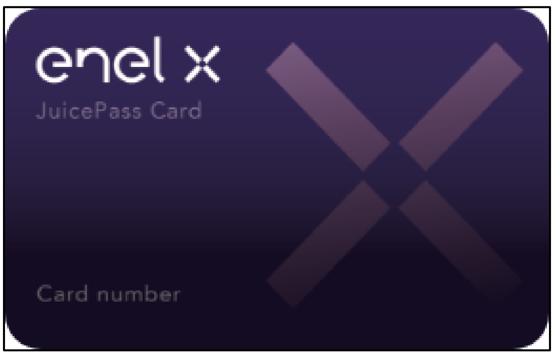


Figure 27: JuicePass Card



Chapter 6

CONCLUSION

At the end of this elaboration, we can now give an overall view on the possibility of outlining a transition towards zero-emission mobility, in line with the European objectives from which the study began.

The first consideration was to verify the adequacy of the charging infrastructure in consideration of the development of electric vehicles. Based on the market analyzes carried out in the discussion, it is possible to state that ***the infrastructures are actually adequate in relation to the number of vehicles***. In fact, it has been observed that recharging infrastructures are growing strongly, confirming how the sector has undergone a strong acceleration. In particular, it was seen that the analysis should take into account not so much the absolute number of charging infrastructures, but the ratio of these in relation to the number of electric vehicles in circulation. Through a comparison made at a European level, it was possible to highlight how, although Italy is not among the first countries for the absolute number of charging infrastructures, it is, on the contrary, if we consider the ratio of infrastructures / electric vehicles in circulation.

This consideration inevitably leads to the conclusion that today the critical point regarding the transition to electric mobility does not lie in the lack of infrastructure, but in the reduced adoption, and therefore use, of electric vehicles. Also through a comparison at the national level it emerged that the regions with the lowest number of recharging infrastructures are also those where there is a smaller fleet of vehicles. What has just been stated should then be read in an economic key: a charging infrastructure is installed where there is then an effective use that can generate an economic return compared to the initial investment.
To date, therefore, the reduced presence of complementors compared to Europe, such as charging infrastructures, should not be interpreted as a negative conditioning, but an alarm bell about the scarce use of electric cars.

It is necessary to encourage the use of electric vehicles by proposing economic incentives from the government, waiting for the development of technology to lower their price. In this transition phase, the adoption of an immature and still expensive technology for the average consumer at the time of purchase must be supported by financial aid which will in turn generate greater profit and consequently an improvement in the technology itself.

Another topic that was debated throughout the study was ***interoperability***. To date, the main problem is to make the infrastructures interoperable, that is to say, guaranteeing customers to be able to recharge their vehicle at all the charging infrastructures regardless of the type of vehicle or the charging infrastructure. Confirming the importance of this issue, the various regulations supporting a charging network that is interoperable, both at a technical and operational level, have been seen.

The topic was dealt with in the second Chapter, where the charging methods and technologies defined by European regulations and in particular by the standards of the IEC (International Electrotechnical Commission) were discussed. In this context, the importance of a globally recognized standard was underlined and, by way of example, the case of sockets was reported. Then, the issue was addressed again in the discussion of business models from an operational point of view. It has been seen that at the regulatory level the roles of the CPO and the MSP have been distinguished to ensure that a user can recharge the vehicle at infrastructures of different operators, without having to sign a separate contract each time. The mechanism takes place through the contracts between CPO and MSP which take the name of interoperability contract.

After a period of initial uncertainty, standards are consolidating. However, it was examined how even the plant architecture has undergone changes over time, changes that have also affected the charging infrastructures of Enel X, which have changed version over the years. The rapidly growing sector means that ***technologies also develop and improve continuously***, and that the charging infrastructures operate in ever shorter times and at ever higher powers.

Furthermore, these innovations are strongly encouraged by the objectives contained in the PNRR which has allocated funding for Fast and Ultra-Fast infrastructures. It was examined how the whole market, as well as the Enel X Way infrastructure plan itself, will have to adapt to regulations by installing high-power DC infrastructures. However, even in this case, if electric vehicle technology does not develop with that of infrastructure, vehicles may not accept high-power charging, so progress would be slowed down not by infrastructure but by electric vehicles with obsolete technology.

On the other hand, ***charging infrastructures in the motorway sector represent an obstacle*** both in terms of the number of infrastructures, which are still too small, and in terms of procedures, which are not yet regulated despite numerous regulatory efforts.

Finally, from the market analysis, an important fact has emerged that is worth investigating: ***12% of the charging infrastructures in Italy are not usable***. This is essentially due to two reasons: the inability to connect the charging infrastructure to the distributor's electricity network and the lack of the necessary authorizations.
Hence two important conclusions that were reached after outlining the installation process are the following ones:

- ***The importance of making an informed decision about the place to install and the power of the charging infrastructure***. It is no coincidence that in the thesis an applicative study of the selection criteria was carried out on these two variables. In fact, this decision has important consequences both on the connection to the electricity grid and on the authorization permits. It is essential to choose sites where no additional work on the electricity grid is required by the distributor in order not to lengthen connection times and increase costs. This evaluation, as we have seen, is carried out during the technical feasibility study and must consider the two main factors: the demand for power and the distance from the connection point to the electricity grid. In addition, areas with landscape, environmental, archaeological, historical or architectural limits should be avoided in order not to run into more complicated authorization procedures that would take much longer.

- ***The need for a simpler and faster authorization process***. At the regulatory level, various simplifications of the authorization process have been introduced such as the law of 16 July 2020, "*Urgent measures for digital simplification and innovation*", which abolished the need for SCILA or CILA and the related technical documents to support. However, the simplification measures have not yet been adopted by all municipalities. Furthermore, although the charging infrastructures on private land are beyond the main argument of this elaboration, even on this issue the regulatory introductions have not yet seen full application by condominiums or administrations. In conclusion, the authorization process can be complicated and long: there are many efforts that have been made at the regulatory level and that must now be put into practice by administrations and municipalities.

Finally, the analysis of the various players who take part in the value chain has made it possible to highlight another central theme in the management of charging infrastructures: ***free competition and transparency***. It has been analyzed how the division of roles, between CPO and MSP, but also between Trader and DSO, avoids monopoly situations, allows free competition between players and applies prices transparently. Also the regulatory effort to guarantee the same conditions on motorways have been discussed and it is hoped that this will be the point of arrival in this context as well.

To conclude, it was conducted an analysis of the various business models that can be established and their respective applications, ***underlining the benefits that derive to all the players involved***. Electricity infrastructures, like any other sector, must guarantee economic, visual or network returns to all the players involved, otherwise no one would have an interest in being part of the industry.

In conclusion, what emerges from the study is that the charging infrastructures and their installation process are developing, technologically, first of all, but also politically, socially and economically. These are all plans that must converge and proceed together in a single direction. In the introduction, the three main points of Motus-e in the adoption of electric cars were seen, which were: development of technologies, introduction of new European and national legislation and changes in consumer purchasing behavior.
At the political / legislative level, the choice was made first at the European level, envisaging in the European Union program, known as the Next Generation EU, objectives that would encourage the ecological transition, allocating part of the recovery fund to electric mobility. In Italy, then, this goal was reported in the PNRR.
Social involvement, on the other hand, must provide advantages both in terms of maintaining the performance of the vehicles in use today, and in terms of compensating for the economic gap that is still high today if a comparison is made between an older generation car and the electric one. A guarantee in this sense can be achieved mainly by the development of technology and therefore by strong investments in research. To date, the convenience of the electric vehicle over the thermal one exists only on the new one and if we consider the total TCO (total cost of ownership) from the moment of purchase and in presence of incentives.
Ultimately, it will be possible to operate on the behavioral change of consumers which will take place as a last step only after the economic advantage has been achieved.

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