The role of electric mobility in the energy transition and the "Enel X" case study

AWARE

AUTHORS

Chiara Celesia

Silvia Martella

Giulia Salis

CURATOR

Alessandra Diori

THANKS TO

Alessia Sementilli

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EXECUTIVE SUMMARY

This paper addresses the issue of electric mobility, analysed in the context of energy transition. This form of alternative mobility represents a central innovation in the current economic, social and environmental context. The drive towards a shift of paradigm in the conception of car mobility derives mainly from the major criticalities presented by the traditional means of transport: cars with internal combustion engines, whose negative impacts are underlined from the very beginning of the following analysis.

The analysis also examines the Italian context and the most recent data on the electric car market are reported, including developments linked to the recent pandemic crisis. In addition, it mentions the most relevant policies pushing for a greater diffusion of electric cars and infrastructures necessary for their efficient and sustainable development.

Moreover, as highlighted in the analysis, electric mobility is a central factor in the completion of energy transition, playing a pivotal role as an enabler through the possibility of storing electrical energy and releasing it into the system when necessary, through two-way charging systems. However, vehicles with electric batteries present particular criticalities especially in terms of environmental impacts: if analysed over their life cycle, they entail an increase in indirect emissions caused by the extraction of minerals, such as lithium, which are essential for their production.

The need for a greater diffusion of charging stations is a fundamental issue to be tackled to allow a reduction of the main barrier in the social acceptance of electric cars: range anxiety.

Finally, the paper analyses the case study of Enel X, a division of the Enel Group, whose mission is to become one of the key players in the transition to electric mobility, aiming at the creation of an effective public and private charging infrastructure.

INTRODUCTION

In recent years, there has been an increasing interest in one specific innovation believed to represent a turning point in the fight against climate change: the electric car. Due to the pressures on natural systems resulting from human activities, humans have been looking for alternative solutions to allow them to continue carrying out their actions without renouncing the convenience and ease of the instruments we use in our everyday life, such as the car. Technological progress has made it possible to create zero-emission means of transport, as the battery that enables its movement is electric. This means that the car's engine, no longer powered by internal combustion, can be powered by completely renewable sources. In view of the great environmental impact of the transport sector, there is no doubt that this innovation is a significant step forward. The complete replacement of conventional cars with electric cars would represent a major breakthrough in terms of environmental, economic and health consequences.

Thanks to the use of electric batteries, electric mobility is part of a broader shift: the energy transition. Indeed, electrification is one of the main means for achieving the goal of decarbonisation and zero net emissions, two important objectives in the energy transition process. Moreover, the integration of electric mobility tools with a crucial enabling factor, namely digitalisation, would result in a faster, more efficient and sustainable transition.

However, the interest in this new technological paradigm is not only directed to its merits, but also to the analysis of its criticalities. Electric mobility is undoubtedly a key element for innovation, climate and energy policies, but its multidimensionality also requires an understanding of what lies beyond 'the veil'. As mentioned above, it is necessary to take into account not only the benefits of electromobility, but also the problems and negative consequences linked to numerous factors, one of which, paradoxically, is also an element for which electromobility is praised: its environmental impact.

With this in mind, the following aspects are addressed in this analysis:

- How does electric mobility fit into the energy transition process?
- What are the environmental, social and infrastructural criticalities related to electric mobility?
- The virtuous example of Enel X.

The study has the following structure: in section 1 the centrality of electric mobility in the current circumstance is analysed, considering the energy transition and the Italian context. Subsequently, section 2 attempts to identify the role of electric mobility in the energy transition by highlighting its main criticalities: pollution, social acceptance and infrastructure. Finally, section 3 analyses the virtuous example of Enel X in the context of electric mobility.

1. ENERGY TRANSITION: THE IMPORTANCE OF ELECTRIC MOBILITY AND THE ITALIAN CONTEXT

1.1 Energy transition

The increasing exploitation of natural resources and the resulting rise in emissions has dramatic environmental impacts and consequences which are crucial for the immediate future. [1] The Paris Agreement on climate change, adopted in 2015, established a single direction in order to focus on the efforts of signatory governments on limiting human impact on the planet. The aim is to keep the increase of the average global temperature below the 2°C threshold. This goal is the starting point that led to the identification of several critical areas in need of immediate action, and the efforts of 196 countries have followed this direction, with the European Union at the forefront. As it is argued by DNV GL in the Energy Transition Outlook 2020, estimates[2] indicate that to date action is not strong enough to meet the maximum threshold. Despite the fact that the efforts are not ambitious enough and the level of international coordination is insufficient, change is certainly underway.

In this context, the energy transition plays a key role. The concept, based on the pillars of electrification, decarbonisation and energy efficiency, points to a process of transformation of the energy system that can facilitate the transition from a non-renewable-source-based energy production, as it currently is, to one that relies on renewable ones.

The necessary reduction in emissions would be impossible if a traditional approach to mobility is maintained. Since technologies, plants and sources, currently in use, cannot guarantee the required developments, the only option for the stabilisation of the CO2 concentration is to radically change the energy system. [3]

The transition will achieve two critical objectives on the path to greater sustainability. First, the targeted use of renewable resources helps significantly limit emissions of carbon and of other pollutants and climate-altering substances, which are among the major causes of the ongoing climate change. Secondly, it provides an alternative to the dependence on fossil and non-renewable energy sources such as oil, gas and coal, which are responsible for more than 80% of global energy consumption[4] and whose limited presence is insufficient to cover the growing future energy demand.

1.2 Electric mobility - its role in the transition

The transport sector, which has a significant impact on energy consumption and total emissions, has not remained immune to this shift, and the introduction of electric vehicles in the market is key to energy transition developments.

According to the International Energy Agency (IEA), emissions from transport are growing steadily and are responsible for 28% of global energy demand and 24% of total direct CO2 emissions. In particular, three quarters of these emissions come from road vehicles. [5] The increase is due not only to the trend of buying larger and heavier vehicles, but also, and more importantly, to the growth in global GDP which has led to greater demand for vehicles and road transport more generally.

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[1] For a detailed analysis look at David Wallace-Wells, 2019, *The Uninhabitable Earth*.

[2] DNV GL, 2020, *Energy Transition Outlook*

[3] TERNA Lightbox, *La transizione energetica, cos'è e perchè è tanto importante*. A

[4] TERNA Lightbox, *La transizione energetica, cos'è e perchè è tanto importante*. B

[5] International Energy Agency, 2020, *Tracking Transport*.

The significant impact of the sector has prompted increasing electrification and investment in technological development to make electric mobility a viable alternative to vehicles powered by petroleum derivatives. As a result, sales of electric vehicles are increasing year-on-year and in 2019, the number of electric vehicles exceeded 7 million, with the Chinese market in the lead, followed by the European Union, where the record goes to Norway. The number of electric vehicles, which rose further in 2020, despite the impact of the pandemic crisis, accounts for 2.5% of the total number of road passenger vehicles and is estimated to increase dramatically to 73% by 2050. [6] This development will have a great impact on the future demand for electricity, which will increase by 79% in 2050, with the total electric energy demand rising from 18% to 28%.[7] This demand will indeed have to be managed in parallel with developments in the decarbonisation of the energy sector through renewable energy. To this regard, forecasts claim that 63% of the electricity required will come from alternative energy sources, including solar photovoltaic and wind farms.
Additionally, the spread of electric vehicles is increasingly associated with a smart mobility model, a new way of conceiving and organising mobility that would allow to meet the changing needs in an effective, safe and sustainable manner, optimising the use and development of resources and ultimately aimed at making physical movements and energy flows more efficient and less polluting.[8]
Private vehicles are on average used for only 5% of their lifetime, and smart mobility provides some tools to exploit this apparent weakness. Strategies can be aimed at increasing the use of vehicles, as in the case of Sharing Mobility, or exploiting them while unused to make the remaining 95% of the time functional. To this latter category correspond several unique electric charging modes defined as Vehicle to Everything (V2X). These two-way charging technologies enable an extremely efficient use of the batteries electric vehicles are equipped with by interconnecting the entire electrical network and the information derived from it, as well as integrating the elements within it.[9]

This system has several variants: Vehicle to Home, Vehicle to Building and Vehicle to Grid. The latter is based on a system for storing energy in vehicle batteries which allows it to be fed back into the national redistribution system.

1.3 The Italian context

The Italian market for electric cars is growing year by year. Nevertheless, our country lags behind many other European nations, ranking tenth in terms of number of electric cars on the road. In 2017, Italy accounted for less than 2% of the European electric vehicle market. [10] Already in 2019, there has been a 111% growth over the previous year thanks to the registration of 10,666 vehicles exclusively powered by batteries. However, this increase is unevenly distributed across the territory, with 70% of registrations recorded in northern Italy.

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[6] DNV GL, 2019, *Energy Outlook.*

[7] Richard Baron, OECD, September 2016, *Energy Transition after the Paris Agreement: Policy and Corporate Challenges*, Background paper for the 34th Roundtable on Sustainable Development.

[8] Ministry of work and social policies, Project Green Jobs, *Smart Mobility, Scheda 6*.

[9] Energy and Strategy Group, 09/2018. E-mobility report. Le opportunità e le sfide per lo sviluppo della mobilità elettrica in Italia, Politecnico di Milano. A

[10] Energy and Strategy Group, 09/2018. E-mobility report. Le opportunità e le sfide per lo sviluppo della mobilità elettrica in Italia, Politecnico di Milano. B

2020 represented a turning point in the sector, as indicated by the Smart Mobility Report. The exceptional measures linked to the pandemic have clearly influenced the automotive market: registrations of traditional fossil-fuelled cars have fallen by 34%, while the opposite trend has been recorded for electric vehicles, which have grown by 150% in the first nine months, accounting for the registration of almost thirty thousand cars. [11] While considering the peculiarities of the developments in the unique context of the Covid-19 Crisis, this increase is due to several factors, such as the increase in recharging points thanks to the commitment to infrastructure development, first and foremost by Enel X, which will be discussed in detail in section 6 of this analysis, the incentives through the "Ecobonus" and a wider offer of electric models by car manufacturers.

For a consistent and steady development of this trend, the regulatory context is of crucial relevance. The integrated National Energy and Climate Plan (NECP) is the italian strategic proposal for achieving the European environmental objectives. The national regulatory context, in fact, has developed mainly since 2014 as a result of the european Alternative Fuel Infrastructure Directive[12], more commonly known as DAFI, which sanctions various basic principles for the development of electric mobility in Europe. Among other things, it states that the development and management of charging infrastructures must be guided by the principles of a competitive market and open access, limiting barriers to use through, for example, the interoperability of charging stations.

On the basis of these European guidelines, the integrated NECP has set the target of 6 million electric vehicles by 2030, a very ambitious goal which is still a long way off if we consider the current 70,000 units. In addition, the PNIRE, the National Plan for Electric Charging Infrastructure, was introduced in 2012 to provide guidelines for infrastructure planning at national level in order to boost the development of mobility through low-emission vehicles. The Plan was strengthened and integrated into the National Strategic Framework from 2016, thus becoming the reference annex for the development of electric mobility infrastructures. [13]
The Italian strategy decreed by the NECP is mainly developed through the use of a particular economic instrument: the incentive, provided by the 2019 Budget Law in relation to the three-year period 2019-2021. However, it cannot be considered sustainable, since further support measures, such as the reduction of traffic costs through targeted exemptions, are decided heterogeneously and at the discretion of the local administration. The objective must therefore be a more ambitious and structured revision of the Italian legislation to ensure a strong improvement on the current trend.

2. THE WEAKNESSES CONNECTED TO THE ELECTRIC MOBILITY

2.1 The role of electric mobility in the process of energy transition

Electric mobility is one of the most important innovations related to energy transition. The main driver for the diffusion of electric mobility has been the awareness of the damages vehicles' conventional polluting engines cause to the environment. Indeed, this problem has been discussed

[11] Energy and Strategy Group, Politecnico di Milano, 2020, *Smart Mobility Report*.

[12] Direttiva 2014/94/UE

[13] Ministero delle Infrastrutture e dei Trasporti, Marzo 2019, *Mobilità elettrica in ambito stradale per il modo privato*.

in the previous part of this paper. Concerning this, according to the ISPRA report[14] published in 2020, conventional mobility is responsible for 43% of the emission of nitric oxide, which is toxic for the environment and human health. Thanks to the report, it is possible to notice that the trend of gas emissions is decreasing in comparison to previous years, but their impact is still harmful to the healthiness of the air. Therefore, electric mobility has been promoted for both ethical and economic reasons, since it is considered more sustainable than conventional mobility. Indeed, electric vehicles do not produce direct emissions of toxic gasses. However, electric mobility is based on a paradox: the process to create the energy, necessary for the functioning of the vehicles, is based on the combustion of carbon or gas in the thermoelectric power stations. According to this, even if the electric vehicles' engine does not produce gas emission, its environmental impact is negative, due to the indirect emission produced during the combustion of fossil fuels. [15] Moreover, Italian energy production is still largely based on non-renewable sources.[16] According to the Terna Report published in November 2020[17], it is possible to notice that 54% of produced energy derives from non-renewables while only 30% is based on renewable sources. Moreover, Italy imports 16% of energy from other countries, so it is not possible to define whether the production of energy is sustainable or not.[18] According to the report, in November the production of energy from renewable sources decreased concerning wind power. Nonetheless, in comparison with the previous years, the renewables sector registers a positive and increasing trend: photovoltaic has increased by +10,6% and hydroelectric has increased by +3,5%. However, these increments appear to be marginal, since the amount of energy produced from non-renewable sources is still the highest one (54%). Italy is deeply dependent on fossil fuel's combustion for the production of energy and a minor quote of the energy derives from renewable sources. If we consider the Italian dependency on non-renewable sources for the production of energy, is the promotion of electric mobility undisputedly desirable, then? Is it possible to stimulate the increase in the number of electric vehicles, without taking into account the possible negative effects this can produce? The boost in the electric vehicle market is presented and considered as a positive aspect. Notwithstanding, it is pivotal to consider that the increasing demand for electric vehicles would raise energy requirements. If this supplement of energy will not be provided through renewable energy sources, the development of electric vehicles is likely to enhance the dependency on non-renewable sources, intensifying the indirect negative effect of electric mobility.

It has previously been discussed that the number of electric vehicles in Italy is increasing. [19] However, it is relevant to analyse whether this process would cause shortcomings. The promotion, the sale, and the use of electric vehicles have to be supported by a broader commitment to ensure an efficient energetic transition, which could promote more sustainable systems from the energetical supply. In light of this, electric mobility can be considered an opportunity for the country if the expansion of the vehicle fleet is endorsed through a shift in the systems of energy production.

[14] ISPRA, Italian Emission Inventory 1990-201, Informative Inventory Report 2020, Rapporto 319/2020, pag. 49.

[15] Grattieri, D. 17/01/2019. Energia elettrica, utilizzarla inquina?, In Soloecologia. A

[16] Grattieri, D. 17/01/2019. Energia elettrica, utilizzarla inquina?, In Soloecologia. B

[17] TERNA, Novembre 2020. Rapporto Mensile sul sistema elettrico. A.

[18] TERNA, Novembre 2020. Rapporto Mensile sul sistema elettrico, pag. 7. B.

[19] Per un riferimento all'incremento delle auto elettriche in Italia, vedere paragrafo 1.3

Indeed, to consider optimistically the data about the rise in the number of electric vehicles' sales is inaccurate, since the inefficiency of the national energy distribution system could cause an increase in the exploitation of non-renewable sources and could deepen the dependency of Italy on foreign energy exportation. According to this, electric mobility has to be both produced sustainably and managed smartly[20] intending to compensate the growth of the demand of energy generated from the multiplication of electric vehicles. [21] If the diffusion of electric mobility is not stimulated according to a broad understanding of its shortcomings, it will risk exacerbating the dependency on fossil fuels for the production of energy. Electric mobility has to be promoted considering the necessity of ensuring energy transition, exclusive usage of renewable sources of energy, and developing technologies aimed at integrating the evolution of electric mobility with technologies that could enhance the smart management of mobility.

2.2 The dependencies of the future: lithium and rare earth metals

The dependency on lithium and rare earth elements is another crucial question to tackle regarding the criticalities of electric mobility.

Lithium - which is generally called "white gold" due to its bright color – is a metal used to make the batteries of electric vehicles function. The exploitation of lithium batteries has increased in the previous years, as they are more efficient than conventional alkaline batteries. However, lithium production has several negative impacts on the environment. The metal can be extracted according to two different techniques. The first one is based on the acquisition from mineral rocks of pyroxene of lithium and aluminum which are mostly available in China. This process enables the extraction of the raw material only and it provokes the emission of 9 tonnes of CO2 for each ton of refined lithium carbonate. Moreover, this calculation about the polluting emissions generated from the process of extraction does not consider the release of CO2 during the transportation of raw materials to the refineries[22]. The second extraction technique provokes 1/3 of the emissions generated from the one described previously. However, even this one has damaging effects on the environment. The lithium is obtained by perforating the salt pans which are mostly located in the south American seas. Successively, substances containing mineral salt called "brine" are brought to the surface and filtered allowing the extraction of lithium. [23] According to this, the increase in the demand for electric vehicles would foster the demand for lithium, amplifying the CO2 emission and devastate the environment from which the lithium is drawn out. Additionally, the requirement of rare earth metals for the production of electric vehicles aggravates this scenario. Indeed, the production of electric devices (vehicles, smartphones, and computers, for example) is grounded on the dependency on these metals, which are deeply affecting world geopolitics. Among rare earth materials, it is possible to find: lanthanum (La), cerium(Ce), neodymium (Nd), europium (Eu), and

[20] For a reference to the V2G technology and to the smart mobility, look at the section 1.2

[21] Orecchini, F. 28/05/2019. Vehicle-to-grid, la tecnologia che integra la casa e le auto elettriche. in Il Sole 24 Ore.

[22] Redazione Ansa, 08/10/2020. Produzione litio, nel 2030 possibile crescita di CO2 di 6 volte. In ANSA.

[23] La Repubblica, 21/07/2020. Auto elettrica e il caso delle batterie al litio. In La Repubblica.

terbium (Tb). These have many employments, for example, car batteries, audio system speakers, glass components (such as mirrors, lens, and windshields). The adjective "rare" does not refer to the low quantity of metals on the planet. Instead, it refers to the scarce concentration of the metals in the reserves and this makes the costs of extraction soaring. [24]

The main problems related to the exportation of rare earth metals are the negative effects the extraction process has on the environment and the fact that China holds the 90% of the world's offer of the metals. Indeed, the problem has to be analyzed through a geopolitical approach. The unfair competition of China has affected the attempts of independence of resources of the Californian mine called Mountain Pass. The Chinese monopoly of extraction and production of rare earth metals risks evolving into a brand-new form of dependency, while attempting to emancipate mobility from fossil fuels. Indeed, the new challenges Europe and Italy will face in the future are political and strategic, as well as strictly environmental. [25]

The European Commission has yet started proposing its plan to formulate an efficient solution for the dependencies of the future. In the Communication "Resilience of critical raw materials: tracing a path towards greater safety and sustainability",[26] the Commission has revised the list of the raw materials which are critical for the European Union. The strategy of the Commission aims at increasing awareness about the problems related to rare earth metals. Moreover, the Commission fostered the commitment to ensure resilience concerning the growing demand these materials will be affected from in the future. The fragility of the EU and Italy is more broadly connected to the dependence on foreign energy supply and on obtaining the materials necessary for the production of electric vehicles. The dependence on China alarms the EU leaders also when considering the fragility of the globalized, deeply interconnected markets. The problems related to trade connection emerged clearly during the crisis, such as the current one caused by the Covid-19 pandemic. The scenario cannot help but worry, in the face of times to come, in which electric mobility appears to be linked to resources whose control must be managed prudently, both because of the environmental impact produced and because of the Chinese control on substances of the future.

2.3 The social acceptance of electric mobility

Electric mobility raises problematic issues also from the social point of view. Indeed, structural inadequacies affect individual perception obstructing the buyer to choose an electric vehicle instead of a conventional one. Concerning this, it is possible to notice that the results published from ICRIOS[27] support this thesis. According to the report, car price, battery life, time spent for recharging the vehicle and the possibility to employ efficient recharging methods, even without possessing a private garage and the power of the vehicle, are aspects which can be concretely affected from improvement strategies and can affect the buyers toward an electric vehicle's purchase rather than

[24] Richiello, A. 23/03/2018. Questi 17 metalli rari decideranno chi sarà il padrone del mondo. In L'Espresso. A

[25] Richiello, A. 23/03/2018. Questi 17 metalli rari decideranno chi sarà il padrone del mondo. In L'Espresso. B

[26] Commissione Europea, 03/09/2020. Resilienza delle materie prime critiche: tracciare un percorso verso una maggiore sicurezza e sostenibilità.

[27] Corrocher, N. 27/11/2019. The diffusion of green innovations: a cross country perspective. ICRIOS, Bocconi University.

a conventional one. It is necessary to consider such criticalities to provide a broad analysis of the shortcoming of electric mobility.

According to a detailed study carried out by the Politecnico di Milano[28], "E-mobility report, le opportunità e le sfide per la mobilità elettrica in Italia" the biggest concern for buyers is the cost of electric vehicles, higher than traditional ones. Furthermore, while the economic barrier can be considered a relative and surmountable problem through actions aimed at ensuring everyone's access to t electric vehicles, the most notable argument to analyze is the "range anxiety", or the perception of the inadequacy of vehicle charging systems and the limited autonomy of electric vehicles[29], which concerns those who already own an electric machine. The range of anxiety is perceived as a problem from 49% of the respondents to Politecnico's survey. The range anxiety has to be tackled taking into account the organization of the recharging system at the urban level and enhancing the batteries of the vehicles.

Moreover, the report's results show that most users use the domestic recharge (66%), compared to the 34% of the users who recharge the vehicle in the workplace, while 16% use the public charging network. Therefore, from the data it is possible to assert that to overcome the range anxiety it is necessary to strengthen both the domestic recharging system and the public one, the latter considered inadequate by the 60% of the users, 30% consider it partially inadequate and only the 10% of the users consider it adequate. In addition to this, the problem related to the unequal distribution of charging stations in Italy worsens this scenario. Indeed, according to the data of the report published from Motus-e in collaboration with Legambiente, [30] it is possible to highlight that during the years the installation of charging stations has favoured North regions of the country, to the detriment of those of South and Centre. For example, while in Lombardy the amount of charging stations is 1134 columns installed with a power greater than 11kw, Basilicata only possesses 27. Moreover, the correlation is similar between other regions: Trentino Alto-Adige has 709 charging stations, Abruzzo only 48, Tuscany 524, Sardinia instead 76.

The problems related to electric mobility in Italy must take into account both the lack of efficient energy systems at the national level and the necessity of equalizing the number of recharging points per region, without transcending territorial inequality which emerges from the data of the Legambiente and Motus-e report. Indeed, the lack of efficient recharging points has a double negative consequence: buyers will be less likely to prefer electric vehicles and it will dissatisfy those owning an electric car.

It is also useful to specify another type of social implication linked to the energy transition, which has been discussed in the first paragraph of the third part of this paper. [31] As Carrosio points out, [32]

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[28]Energy and Strategy Group, 09/2018. E-mobility report. Le opportunità e le sfide per lo sviluppo della mobilità elettrica in Italia, Politecnico di Milano.

[29] La range anxiety e l'assenza di una rete di ricarica pubblica e diffusa è considerata uno dei maggiori ostacoli che frenano lo sviluppo del mercato elettrico in Italia, come verrà approfondito attraverso l'analisi del caso studio su Enel X nella terza parte di questo elaborato.

[30] Legambiente, Morus-e. Aprile 2019. CittàMEZ. Mobilità Emissioni Zero.

[31] *Quanto incide la mobilità elettrica nella transizione energetica? Pag. 5.*

[32] Carrosio, G. 2014. Energia e scienze sociali. Stato dell'arte e prospettive di ricerca. In *Quaderni di Sociologia*, *66*, pag. 107-116.

the debate regarding the abandonment of fossil fuels should not be addressed considering only the path of improving the efficiency of the energy installation, which is still a deeply relevant objective to reach due to the growing demand for energy expected in the future. Indeed, while the modernization process is likely to be long and complex and it will compete for a long time with the conventional systems of energy supply, it must be supported from the awareness that saving energy is an equally mandatory purpose to ensure a proper response to the growing demand for energy in further time. Energy transition has to aim both at reducing energy consumption avoiding dissipation and waste of energy and at ensuring it will be systematically managed.
To conclude, energy transition has to be sustainable, smart, and digital, taking advantage of modern technologies to ensure the abandonment of fossil fuels and a beneficial energy administration.

2.4 Italian charging network

The electric car market is in constant growth and in Italy Enel X represents a primary player in overcoming the e-charging hurdle. While innovation and technological optimization of electric cars allowed to achieve a high level of performance, the recharging network for electric vehicles is still in the developmental phase. This, as already explained, generates the so-called 'range anxiety' and, in turn, a strong resistance by the public, which is held back by the lack of a widespread public charging infrastructure that guarantees fast and functional recharging. This aspect represents the fundamental prerequisite for the growth of the electric car market. Indeed, the process has to be further developed until recharging will be comparable with refuelling in terms of timing and simplicity.
In Italy, the charging infrastructure is growing. Nevertheless, there are still disparities with some northern European countries that have a more developed infrastructure network supporting the transition to electric mobility. At the moment, in Italy, there are about 15,000 charging points, 11,000 of which are operated by Enel X. In particular, according to a study conducted by Motus-E, out of 13,721 publicly accessible charging points (+3074 compared to 2019), 73% are public infrastructures with public access, such as those found on streets, and 27% are situated on private land for public use, such as those installed in the parking lots of supermarkets and shopping malls.[33]
A charging point can offer standard power (such as Enel X's Juice Pole, which is set to become the most widespread infrastructure in Italy), high power (fast columns) or ultra-fast (super fast columns, such as Tesla Superchargers and those operated by the IONITY consortium of which Enel X is a member). Most charging points are currently standard power columns and there is a shortage of charging points on highways. This represents one of the most critical factors for the diffusion of electric mobility in Italy. As previously explained, the Italian territory is characterized by a great disparity between the North and South, with five regions in the center-north covering 50% of the total number of charging points and with a growth rate of recharging infrastructures significantly higher than the rest of the peninsula.

A strong impulse to the process can be found in the contents of the Italian Legislative Decree "Semplificazioni", [34] according to which the authorizations required to install the charging columns have been reduced from 18 to 1 and which introduces the obligation for service areas on highways

[33] Pini S., Settembre 2020. Auto elettriche e reti di ricarica, com'è la situazione in Italia. In Il Sole 24 Ore.
[34] Decree-Law No 76 of 16 July 2020, Urgent measures for simplification and digital innovation.

and major roads to be equipped with a recharge point. Moreover, according to this Decree, municipalities must have at least one recharging infrastructure per thousand inhabitants. The obligations recently introduced, together with the incentives provided by the "Ecobonus", are likely to constitute a significant boost for the increase of charging points in Italy.

3. CASE STUDY: ENEL X

3.1 Enel X' s Business Model

Enel Group's division, Enel X, whose mission is to become one of the leading players in the transition to electric mobility in the world, represents a virtuous example. The company, indeed, directly contributes to the spread of the phenomenon of the diffusion of electric mobility in Italy, and in all countries where it operates. Enel X aims at creating an effective public and private charging network allowing to decrease the entry barriers and generating innovation and sustainable value, not only for all stakeholders involved, but also for the development of territories and societies where it operates.

Within the Enel Group, Enel X deals with the innovative products and services and digital solutions not strictly connected with the traditional production, distribution and sale of energy. Its main objective is to offer high-performance energy products that guarantee energy savings and a functional interconnection between urban ecosystems, industrial districts, mobility needs and individuals. The strategy of Enel X is based on digitization, sustainability and innovation and it aims at exploring new lines of business and at driving the transformation of the energy sector through the creation of a New Power Economy. In order to concretely pursue this objective, Enel X acts within the areas of the energy sector with the greatest transformative potential. In particular, Enel X's business model is outlined in four main divisions dedicated respectively to: businesses (e-Industry); electric mobility (e-Mobility); homes (e-Home); and cities (e-City).

3.2 E-mobility revolution and Enel X's charging network

In Italy, Enel X is the protagonist of the so-called e-mobility revolution since it contributes to the creation of an effective charging network, both public and private. This with the aim of eliminating the resistance of the public due to the fear of not being able to recharge the electric vehicle. To pursue this important goal, Enel X is investing 300 million euros for the installation of 28,000 charging points by 2022, creating a capillary recharging network composed of quick columns in urban areas and fast and ultra fast columns in non-urban areas. This recharging network also includes the 180 charging stations provided by the EVA+ (Electric Vehicles Arteries) project, coordinated by Enel, Verbund, Nissan, Renault, BMW and Volkswagen and co-financed by the European Commission. Moreover, thanks to the collaboration with IONITY, Enel X will install up to 20 high power charging sites in Italy, allowing to recharge electric vehicles in just 15-30 minutes.
It is important to emphasize that Enel X's charging points are part of the system of the so-called smart grids, 'intelligent' energy distribution networks, which operate through technological solutions, such as IoT systems, which make it possible to collect, send and analyze in real time data relating to consumption and electricity needs. In this way, when there is an excess of energy production, it can be transferred to the batteries of electric vehicles, with a lower environmental impact and significant savings in economic terms. In particular, the initiative of Enel X,

Nissan and RSE to start the first experimentation in Italy of the Vehicle to Grid (V2G) technology is a significant milestone for the enhancement of energy efficiency. This technology allows the transfer of unused energy from electric vehicles to the public and domestic grid. In this system, the user is also transformed into a potential supplier, facilitating the maximization of self-consumption of renewable energy, energy flows and continuity of energy supply in case of interruptions.
Furthermore, Enel X creates synergies between the implementation of public charging infrastructures and the contribution to the creation of smart and sustainable cities. This also through a cutting-edge solution: the JuiceLamp, a street lamp that, beside performing the innovative function of adaptive public lighting, is used for the installation of two fast electric recharge points.
An important tool for the strategic placement of charging points and the capillarity of the network within cities is Enel X's City Analytics service, a set of digital solutions based on the use of Big Data that aims to plan public services and optimize urban infrastructures, including recharging points, on the basis of the city's real needs.

3.3 Overview of Enel X's offer for electric mobility

The products and services offered by Enel X to support the diffusion and enhancement of electric mobility can be divided into four main categories, based on the type of customer.
For private individuals and, therefore, for what concerns business to customers (B2C), the main product is the charging infrastructure for domestic use, such as the JuiceBox, an advanced solution for domestic fast charging of electric vehicles. Moreover, Enel X together with ALD Automotive, with the Juice Motion service, offers innovative long-term rental solutions for electric cars. Finally, in order to ensure convenience in charging, Enel X has also introduced the Enel X Juice Pass App, allowing users to easily manage both public and private charging services.
As far as the Business to Business (B2B) is concerned, Enel X presents a wide range of offers for companies. In addition to charging solutions for electric vehicles such as Juice Box, Juice Pole, Juice Pump and Juice Lamp mini, which can be adapted to the different needs of companies and their employees, Enel X offers services and products to design and manage companies' electric fleets. This is also enabled by the use of the Enel X Juice Pass Business App and the related Juice Net Manager, which allows a functional monitoring and management of the electric fleet. Another offer dedicated to businesses is the possibility of becoming a Recharge Partner of Enel X through the placement in their parking areas of charging infrastructures managed by Enel X. In this context, an important milestone is the partnership between Enel X and McDonald's Italy, which provides for the installation by 2021 of 200 charging points (Juice Pole and Juice Pump) for electric vehicles distributed in 100 McDonald's restaurants in Italy. The idea behind this strategic partnership is the capillarity of the network of McDonald's restaurants and their presence in great vehicular transit pints. This allows to considerably expand the charging network on land on private land for public use.
For the Public Administration, beside the same products and services offered to companies, Enel X offers innovative solutions for a sustainable public transport. This is particularly relevant in the current historical period in which Public Administrations are rethinking their strategies for urban mobility to promote the ecological transition and the pursuit of the United Nations Sustainable Development Goals. In this context Enel X plays a key role, aiming to improve the urban environment through innovative solutions based on technology, efficiency and integration.

3.4 Circular Economy approach

With its charging services for electric vehicles, Enel X qualifies as the first service provider concretely applying the pillars of the circular economy to its offer. The 5 fundamental pillars of Enel X' s circular economy strategy are: sustainability of resources; an offering of products as services and therefore rethinking of the concept of purchase and ownership; the promotion of sharing economy platforms; the extension of the life cycle of products/services, and recovery and recycling.

In this analysis, the contribution of electric mobility to a sustainable energy transition and the related downsides have been addressed. In this context, it is important to underline that Enel X, through its platform and sharing economy-based business model, positions itself as an accelerator of circularity within its network of suppliers, partners, installers and customers,

With particular reference to electric mobility and in line with modern business offers, Enel X public charging points are an example of Product-as-a-Service (PaaS).

This type of offer ensures greater flexibility for users, who do not necessarily have to to purchase products in order to use them, but also important advantages in terms of energy savings and environmental sustainability. Further enabling factors for the improvement of circularity are the two services mentioned above offered to businesses and the public administration: the fleet electrification management and the JuiceNet manager, which allow to deploy and manage fleets of electric vehicles and the relative recharging infrastructure. Furthermore, Enel X offers to its customers the opportunity to improve their circularity, also providing directions to support strategies for saving energy and reducing the environmental impact.

Moreover, the smart grids project, at the heart of Enel X's strategy, fits perfectly into the perspective of a collaborative and circular economy, in which various players interact for the creation of value and the pursuit of the common goal of energy efficiency.

It is clear that Enel X's circular strategy is not only beneficial from an environmental environmental point of view, but it also generates important advantages in terms of economic growth and new business opportunities through the whole value chain.

As regards circularity in the context of electric mobility, a fundamental aspect is the recycling of batteries. This aspect is not directly included in Enel X' s activities. Nevertheless, the business line of Enel Group, Global Thermal Generation, is involved in the recycling and reuse of lithium batteries, which, as already explained, will play a fundamental role in the transition to electric mobility. In particular, Enel Group has launched the Second Life project, which involves the recycling and reuse of end-of-life electric vehicle batteries in other applications. Furthermore, it is necessary to evaluate the impact of the technological solutions and business models used for the production of lithium batteries and their potential reuse. To this end, Enel Group started a process for assessing the impact of the production of batteries on the United Nations Sustainable Development Goals. In this regard, Enel X is also one of the many companies involved in the Important Project of Common European Interest (IPCEI) authorized by the European Commission for the development of innovative and sustainable techniques for the production of lithium batteries. The objective is "to reduce the carbon footprint and the amount of waste - says the Commission - that are produced in the different stages of production and to develop sustainable and environmentally friendly disassembly, recycling and refining processes in line with the principles of the circular economy''.

4. Conclusions

Electric mobility plays a key role for the energy transition, moving the transport sector away from total dependence on non-renewable energy sources, thereby reducing CO2 emissions. In this regard, the European Union has moved swiftly to meet the objectives of the Paris Agreement. Italy has proposed its own national plan, which, however, requires a more ambitious and structured implementation to ensure the achievement of the objectives. Electric mobility can make a decisive contribution to the energy transition, nevertheless, in light of the analyzed critical issues, the phenomenon must be managed with a broader vision than what is usually proposed. In particular, the promotion and implementation of electric mobility must also take into account the issues related to the increase in the number of cars powered by electricity, or rather the dependence on non-renewable sources, lithium and rare earths. This is necessary to mitigate the potential negative effects that the diffusion of electric mobility could entail in the future. In this regard, the European Commission's action to ensure a prompt response from Europe, also to stem the dependence on China for the materials needed for the production of electric vehicles, is a path in which Italy must take part. In this regard, Enel X' s commitment to the sustainable production of lithium batteries with the so-called Airbus of batteries, and of Enel Global Thermal Generation to the recycling and reuse of batteries are important steps towards the development of a sustainable electric mobility.

Furthermore, Italy's delay in pursuing the objectives of the NECP compared to some European countries, which is also expressed in the inequalities across the country in terms of distribution of charging infrastructures, could be used instead as an opportunity for improvement. By installing latest-generation recharging infrastructures, characterized by technologies even more efficient than the existing ones, it would be possible simultaneously to bridge the infrastructural gap between regions and to provide the entire territory with a diffuse and efficient recharging network. In particular, the new charging points could be directly enabled for the bidirectional charging technology, which ensures a more efficient use of renewable energy sources.

In line with Enel X' s strategy, the development and diffusion of electric mobility must be accompanied by a system of technological solutions to support the various phases of the process, from battery production to end-of-life management and, possibly, recycling. This requires a circular economy approach, oriented towards energy efficiency and energy savings. In this way, the benefits linked to the phenomenon of electric mobility can be enhanced in a self-reinforcing system.

Finally, it is deemed desirable to raise awareness on the importance of electric mobility for the energy transition through a public information campaign at the national level. This also topromote a green approach to electric mobility, underlining the undeniable benefits but also the downsides and how these can be overcome. This campaign could be promoted by the Ministry of Infrastructures and Transports in collaboration with the Ministry of the Environment. Moreover, raising buyers' awareness on the initiatives and solutions adopted to overcome the obstacles that hinder the transition to electric mobility, would also benefit the electric car market in Italy.

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awarepec@outlook.com