1ST BRAZILIAN ELECTRIC MOBILITY ANNUAL REPORT

CHANGING THE LANDSCAPE
TOWARDS FLEET ELECTRIFICATION

BRAZILIAN EV OUTLOOK 2020

IN THE WAY TO BOOSTING ELECTRIFICATION

PNME
Plataforma Nacional
de Mobilidade Elétrica

Published by

PNME
Plataforma Nacional de Mobilidade Elétrica

In collaboration with

german cooperation
DEUTSCHE ZUSAMMENARBEIT

Implemented by:

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

iCS instituto CLIMA e SOCIEDADE

CONTACT • National Platform for Electric Mobility (PNME)
Marcus Régis, Marcel Martin • **contato@pnme.org.br** • Brasília and Rio de Janeiro, Brazil

Authorship
Edgar Barassa, Robson Ferreira da Cruz, Henrique Botin Moraes • Barassa & Cruz Consulting

Editing and production coordination
Fabiana Dias • Mais Argumento

Technical review
Marcus Régis, Bruno Carvalho Doberstein de Magalhães • GIZ

Graphic design
Luciano Arnold, Gabi Rocha, Bia Gomes • Desformatados

Translation
Isabela Moreira • Mulberry Translations

Foreword

In a globalized, interconnected, complex world where there is such intense information exchange, knowledge management and organizational memory have been playing more important roles in decision-making processes and in fostering sustainable development.

This is one of the objectives of this first-ever edition of this E-Mobility Annual Report: to manage knowledge so as to promote market development, to foster learning in the sector, to provide information for public policies on e-mobility to be formulated, to map new opportunities for research and development and to work more at synchrony with civil society organizations acting for or tangentially with e-mobility.

This Annual Report was produced with hard work and dedication over months of work by experienced specialists who know the sector deeply, under the guidance of the National Platform for Electric Mobility (PNME). We would like to take this opportunity to hereby thank the authors and their research teams who provided us with very high quality materials.

This Annual Report was built so as to present a general outlook of e-mobility in Brazil. In its first chapter, we address e-mobility drivers and levers. In Chapter 1 you may find information about vehicle electrification technologies and their correlation with energy security, the environmental agenda, public health, the ecosystem of e-mobility innovation, public transportation and a global view of the market.

In Chapter 2, we set e-mobility and its interrelations in the national context followed by reflections upon the current ecosystem of e-mobility in Brazil and what is yet to be developed. In Chapter 3, we present actors, public policies and instruments of promotion and the business environment, with special attention given to battery suppliers and the role of accumulators in Brazil's commodity chain.

It is in Chapter 4 that we study the impacts of COVID-19 on e-mobility in Brazil by presenting an analysis of barriers and opportunities identified in this scenario. In Chapter 5, we present a vision of the future for e-mobility in Brazil, we address perspectives on market growth and infrastructure for Horizon 2030. At last, we conclude the main study with Chapter 6 and its governance structure and collaboration of actors.

Additionally, you may find extra data presented in the three Appendices that are complementary to the manufacturing, market, research, public policies and civil society's part on e-mobility. Yet, you may find a Glossary with terms

that facilitate the understanding of expressions and concepts connected to e-mobility.

We hope that this E-Mobility Annual Report will encourage the development of the e-mobility ecosystem as a whole and that it stimulates activities undertaken by actors and others interested in the topic.

Getting to know the National Platform for Electric Mobility (PNME)

The mission of the National Platform for Electric Mobility (PNME) is to contribute to the implementation of practices for sustainable development of e-mobility in Brazil.

The Platform was created as a space for articulation of important actors in the universe of Electric Mobility, such as representatives of the Government, Industry, Academia and Civil Society to build long-term goals guided by technological advance, governmental public policies and market development.

The PNME encourages networking, the exchange of information and knowledge and it contributes to mechanisms for learning and training skills.

The Platform, which was co-created by actors in the sector, brings together more than 30 institutions under the leadership and strategic planning also drawn up collectively by a Steering committee. The coordination of activities are performed by the Secretariat, with thematic Commissions and Working Groups (WGs) participating in reaching the Platform's objectives as well as working on their individual agendas.

Hence, the development and publication of this Annual Report, for which we expect updated editions to be published regularly, materializes one of the main contributions of the PNME to the ecosystem of e-mobility. For said reason, we are very grateful and pleased to present the Brazilian E-mobility Annual Report to each and every one of those interested in Electric Mobility and its important role in sustainable development.

Marcus Regis and **Marcel Martin**
PNME's Secretariat

E-mobility general outlook 2020: drivers, market and perspectives

1

WHAT ARE THE DRIVERS TO E-MOBILITY?

WHAT'S ITS CONTEXT IN A GLOBAL PERSPECTIVE?

HOW HAS E-MOBILITY BECOME KEY TO TRANSPORT DECARBONIZATION?

1.1 Introduction

E-mobility refers to the concept of applying and using vehicles with one or more electric motors for propulsion in at least one of its wheels and whose primary source of power is electricity (CHAN, 2007).

In such cases, electricity is stored in embedded systems, widely known as batteries and their cells, charged by external power sources.

E-mobility is a set that comprises components and technologies that collaborate to make electric vehicle traction work. Not only does the set consist of said batteries and electric motors, it also embraces integration technologies and connectors, hybrid systems – if applied – and other support systems, such as charging stations and their infrastructure.

Moreover, it is arguable that e-mobility goes beyond the propulsion system itself. In fact, by applying such disruptive technologies over the traditional one a new perspective of appropriation and use of mobility is provided by its users and consumers.

Vehicle electrification, for example, involves a whole new way of supplying the vehicle, which implies changes in the user's mindset as the supply model shifts from liquid or gas fuels to electricity from the grid. That results in different parameters, such as longer charging periods and directed accessibility for recharging infrastructure.

Electrification offers a bewildering array of opportunities to recharging service operators, refueling points can be found in varied places, including homes, workplaces and leisure spaces. Considering that access to the grid is a prerequisite to the recharging infrastructure and that the power grid is widespread in urban areas and highways, recharging can be done in different locations. That factor is also key to the consumer mindset and service availability.

Gas stations must comply with a series of regulations that apply to their operations – strict security measures, for instance – that restrict gas stations to function in specific venues, not to mention those moments when stations run out of fuel and service is suspended. Well, electric recharging is about more capillary and distributed charging systems with no service suspension.

Being open to automotive connectivity is also a relevant factor, whether between vehicle and user or between vehicles and their local neighborhoods. Considering that electric vehicles (EVs) are mainly composed of electrical and electronic components, they can smartly connect to information and communication technologies, which can be mutually explored under varied approaches.

> ***"It is evidence that clean energy transitions are underway – and it's also a signal that we have the opportunity to meaningfully move the needle on emissions through more ambitious policies and investments."***
>
> **Fatih Birol**
> IEA's Executive Director (IEA, 2019)

With such features, connectivity enables users to access car-sharing services via applications in an independent manner, without the need of any support in the choosing of the vehicle and the payment being done by clients themselves. Connectivity also allows vehicles to be connected to different entities in cities through an approach based on the concept of smart cities, by which a channel of communication is established between vehicles and cities.

In addition, e-mobility must be seen as a multimodal choice model, in which varied applications and available technologies are connected to mobility in a complementary manner.

From the urban mobility point of view, the integration of different vehicles to be operated via multimodal platforms is a possibility to be explored. For instance, users can plan their trips by using a combo of public transportation options in a specific stretch, or even shared vehicles or electric bicycles. Those elements converge to the vocation of e-mobility, that goes way beyond the concept of vehicles and their technologies.

Such transformations illustrate the impact of e-mobility in the ownership of vehicle culture and car fueling.

Another series of aspects that involve, for example, the supply-driven business are to be considered since said aspects impact the supply chain and new business models. In this annual report we focus on the changes in production brought by these new technologies that, when considered by market actors, imply targeted strategies. As for the Brazilian scenario, we dive deeper in it in Chapter 2.

In order to promote and structure such an effortful change, our start point is the basic concepts and aspects of mobility. We are aiming to broaden the understanding of users about the dynamics of mobility on a global scale.

In the first part of this annual report we present a global panorama of e-mobility. As a kickoff, we address the general definitions of different vehicle types that compose said propulsion system, which brings us better understanding of the international scenario. We also address the market layout of vehicles used by the main countries considered leaders of the electrification race.

By doing so, we identify and place the growth of such development on a global scale and we likewise identify the locus where electrification occupies a prominent place in the agendas of said countries. Moreover, we can better understand which drivers promote correlated investments.

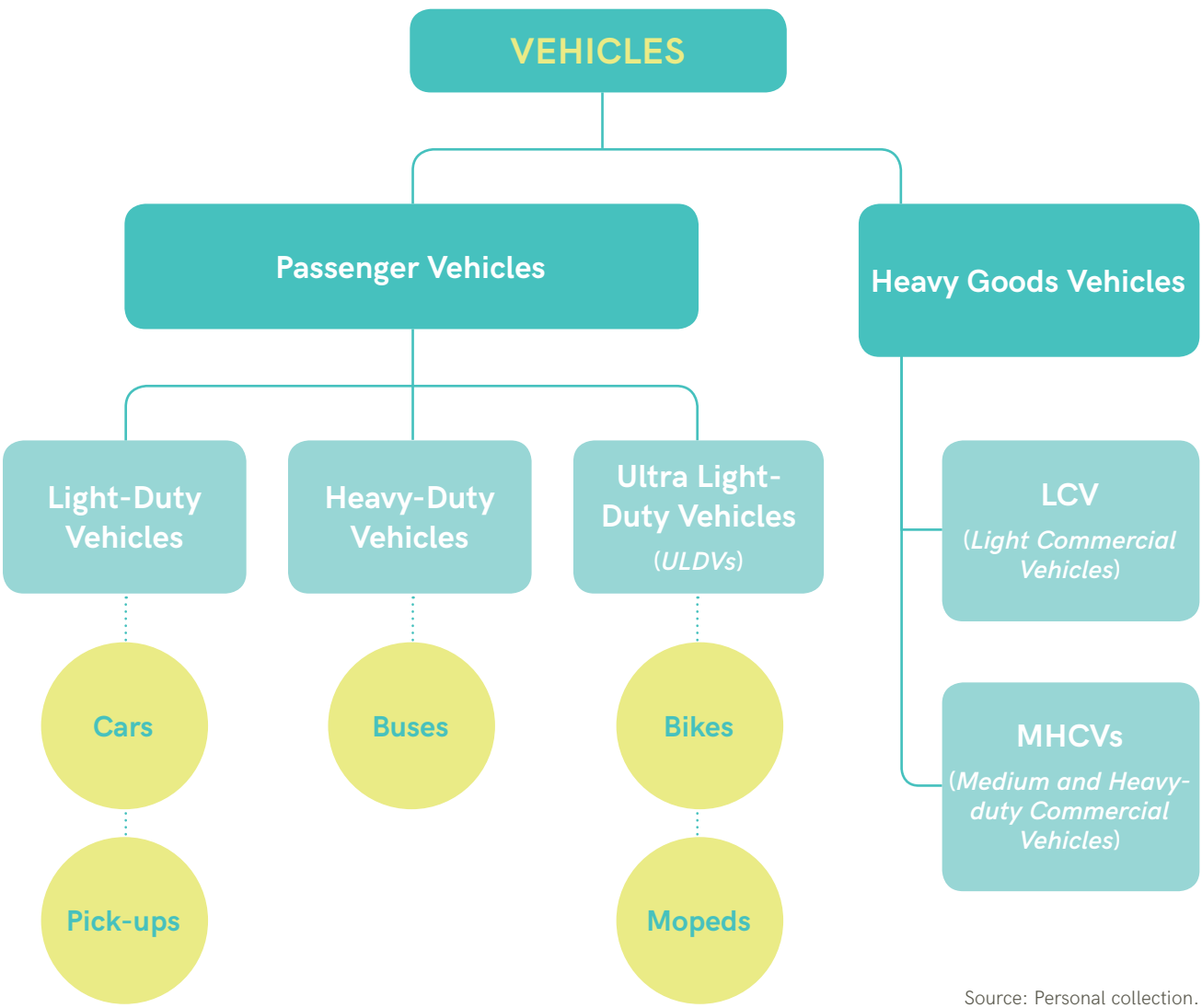
Besides all that, drawing such a profile comes in handy since it scaffolds our comprehension of how advanced the expansion of e-vehicles in Brazil is, a topic to be presented in Chapters 2 and 3.

1.2 Vehicle electrification technologies and their corresponding modes of transportation

In the universe of e-mobility, the vehicles labeled as **Passenger Vehicles** are classified in the following categories: Light-Duty Vehicles (LDVs, e.g. cars and pick-ups), Heavy-Duty Vehicles (HDVs, e.g. buses) and Ultra Light-Duty Vehicles (ULDVs, e.g. bikes, mopeds and other small two-seater vehicles).

Another label is **Heavy Goods Vehicles**, classified in Light Commercial Vehicles (LCVs, e.g. commercial carrier vehicles in activity in urban areas) or Medium and Heavy-duty Commercial Vehicles (MHCVs, e.g. trucks used in logistics operations).

Figure 1. Classification of vehicles



Source: Personal collection.

The categories referred to above are also related to low-carbon propulsion technologies and are classified in four main configurations, categorized according to their technological settings that involve different possibilities for the electric powertrain interface: Battery Electric Vehicles (BEVs), Hybrid Electric Vehicle (HEVs), Plug-In Hybrid Electric Vehicles (PHEVs) and Fuel Cell Electric Vehicles (FCEVs). Table 1, below, shows more information on low-emission vehicles.

Table 1. Classification of low-emission vehicles.

ELECTRIC VEHICLE TECHNOLOGIES	CHARACTERISTICS
Battery Electric Vehicle (BEV)	BEVs are electric propulsion vehicles with an external electric power supply. Powered solely by an electric battery, with no gas engine parts. All energy to run the vehicle comes from the battery pack which is recharged from the grid.
Hybrid Electric Vehicle (HEV)	HEVs have both an electric motor, powered by an electric battery, whose energy is gained through regenerative braking, and a traditional internal combustion engine, powered by liquid fuels (fossil fuels or non-renewable energy sources).This type of technology has many available options of drivetrains (e.g. micro-hybrids, series hybrids and parallel hybrids), since the combustion engine can be powered by a variety of fuels – the latest models aim to be powered by biofuels.
Plug-in Hybrid Electric Vehicle (PHEV)	PHEVs combine elements from regular hybrids and pure EVs. Their batteries can either be powered by an internal source, like regular hybrids that recharge their battery through regenerative braking , or by an external source, in which case the battery pack is recharged from the grid.
Fuel Cell Electric Vehicle (FCEV)	FCEVs are electric propulsion vehicles powered by fuel cells, mainly hydrogen, instead of liquid fuels. They are similar to traditional cars, but their technology is rather advanced. Their cutting edge technology is called fuel cell stack and is designed to produce electricity from hydrogen. In addition, there are many available options to produce and store hydrogen – including renewable resources like ethanol fuel.

Source: Barassa, 2019.

In this context of such diverse categories, it is important to highlight that all of them have their market to be explored in the Brazilian scenario. In addition, those categories bring the possibility of new business models, creation of market niches and new solutions to urban mobility.

In fact, it is noticeable that support for e-mobility has been stimulated by the growing perception of the economic opportunities created by the development, production and commercialization of EVs.

In this way, besides the possibility of creating a new model of sustainable mobility, the opportunity for new players to enter a sector they were not part of now exists. Let's say, for instance, the electric power sector, fundamental to the recharging infrastructure; or even the supply chain of electronic components such as electric motors, inverters and batteries.

1.3 E-mobility drivers and levers: the main conditioning factors and their corresponding examples

E-mobility is not a genuinely new phenomenon. Despite its emergence between the end of the 19th century and the beginning of the 20th century being concomitant with that of the automotive industry, it was the internal combustion engines that established the technological paradigm shift for the sector from the 1920s on.

It was in the 1970s that countries like the United States, France and Japan started considering and implementing measures that repositioned electric propulsion system vehicles in the scenario as an option to mobility. This process of technological change was boosted by a series of conditioning factors in the international sphere of influence and it was captained by a vast array of policies and instruments to stimulate the development of the sector mainly structured by said countries in order to promote technological advances and the growth of the EVs market.

More precisely, it was especially after the 2000s that this movement started gaining speed, it had its goals established and instruments selected in the direction of e-mobility. This trend is guided by pressure and the search for energetic efficiency and also by the reduction of vehicular air pollutant emissions, it aims to make vehicles more compatible with the new demands of our society, less hazardous to the environment, its purpose is to reduce urban air pollution and provide more comfort and interaction with other modes of transportation and information technology services.

A significant part of the conditioning factors that (re) inserted e-mobility as a viable technological path for the automotive industry is associated with the widespread diffusion that internal combustion engines cause negative impacts for the environment and public health in urban centers. We are aware of the effects of greenhouse gas emissions and air pollutants such as particulate matters (PM) and nitrogen oxides (NO_x), and others.

Another key factor is the high dependence on fossil fuels – notably those obtained from oil – as the main sources of energy used in the traditional transportation system.

"As in the 1920s, one century later we are about to go through a radical transformation that will soon leave behind those who are not attentive, those who cannot adapt, those who do not dare. Not only does that apply to the automotive industry, but to our society as a whole."

Luiz Carlos Moraes
Chairman of Anfavea (ANFAVEA, 2020)

Next, we reflect on some aspects of those motivations and levers that reestablished e-mobility as a valid technological route for the automotive industry in general.

1.3.1. Energy Security

After the 1973 and 1979 oil crisis, society realized its dependence on fossil fuels as energy sources resulting in concern towards diversifying such sources. The main reason for developing energy security strategies is to protect national economies against geopolitical instabilities, especially the economies of those countries that import fossil fuels.

Reproduction

The Longyangxia Dam Solar Park, one of the largest solar farms in the world, has solar panels covering 27 square kilometers (10 square miles or the equivalent to three thousand Brazilian football fields), which at peak operation can produce energy to supply two thousand houses.

In the years that followed, many countries began to incorporate in their strategies the debate on energy security. An example of such is China, which has made several investments seeking to diversify its energy matrix, mainly based on coal (thermoelectric plants) and oil (petroleum fuel). The country started advancing towards renewable sources such as solar photovoltaic energy.

1.3.2. Environmental Agenda

The transportation sector is largely responsible for energy-related CO_2 emissions. In 2017, the sector accounted for about a quarter of total global CO_2 emissions (BRAZIL, 2018), intensifying the effects of global warming. The reduction of these emissions, particularly that of CO_2, is fundamental for the fulfillment of the goals related to climate change outlined in the Paris Agreement.

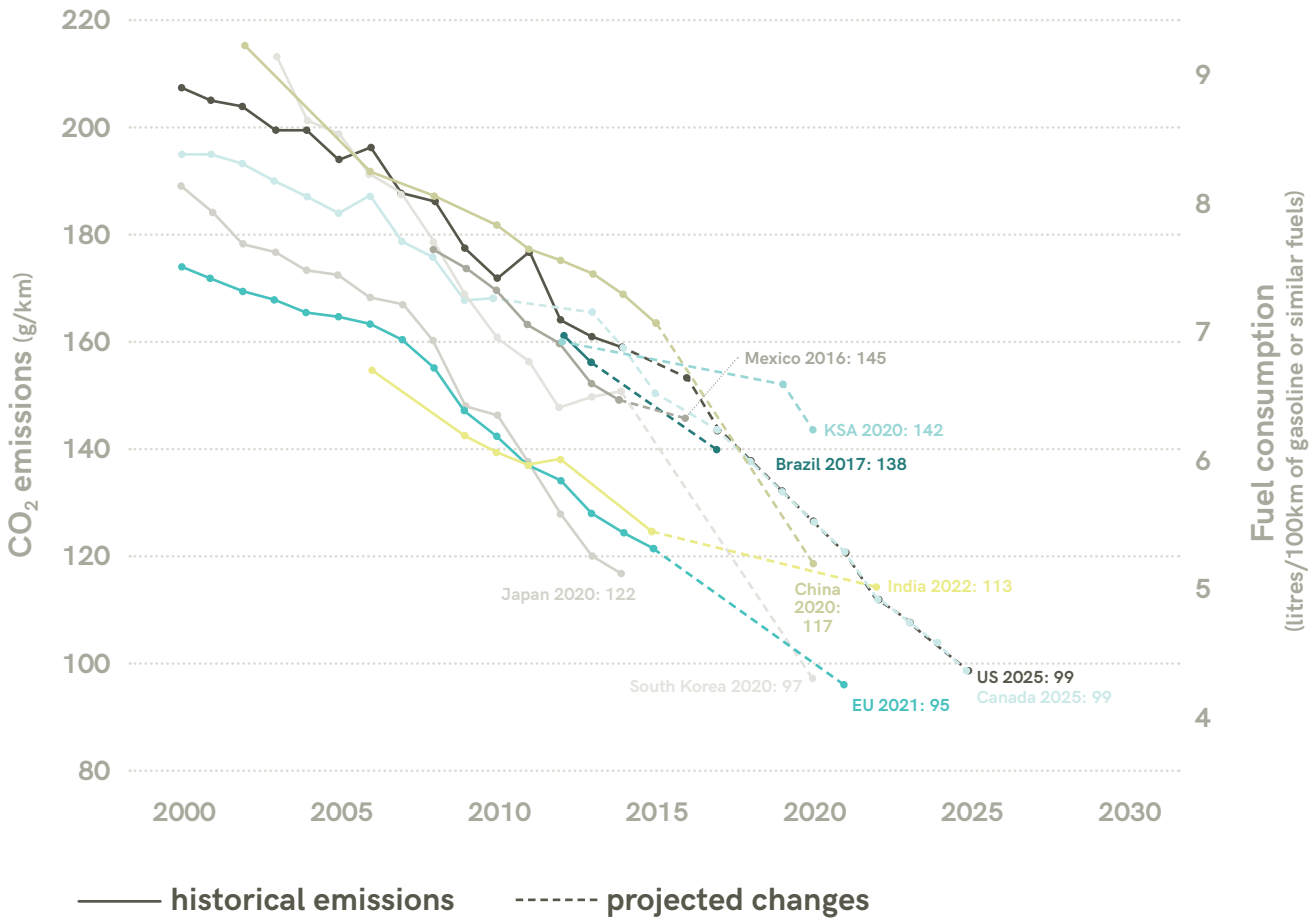
In 2019, the global CO_2 emission remained at the level of 2018, configuring the maximum peak already reached.

Considering that the discussion on sustainability has been one of the pillars of contemporary economic development, many European countries, for instance, have signed policies that are targeted for e-mobility. Norway targets for new passenger cars and new LCVs to be zero-emission by 2025; the United Kingdom's target is 2035; France, on the other hand, aims to end sales of internal combustion vehicles by 2040.

The interaction between these aspects highlights the importance of designing and implementing an increasingly strict regulation of vehicle fleet air pollutant emissions. It is an ongoing challenge for automakers and auto parts manufacturers to produce vehicles and equipment that meet the intended targets. In this process, e-mobility is a fundamental

The **Paris Agreement**, adopted at the United Nations Climate Change Conference (COP 21/UNFCCC) in Paris speaks of measures to reduce GHG emissions in order to limit global warming. The Agreement reinforces the need for an international response to global warming by maintaining the world temperature below 2, preferably to 1.5 degrees Celsius, compared to pre-industrial levels. Brazil is one of the signatories to the Paris Agreement and its Nationally Determined Contribution (NDC) commits Brazil to a 37% cut in emissions below 2005 levels by 2025 and achieving climate neutrality (net-zero emissions) in 2060. That indicates accelerating transformations in favor of maintaining adequate living conditions on Earth.

Figure 2. CO_2 emission standards (g/km of CO_2) and fuel economy standards (L/100 km) by country (2000-2030).



Source: Amended from ICCT, 2019.

Aggressive emissions targets pose challenges to the improvement of traditional technologies and lead to the prospect of new alternatives.

element when we consider its diverse technologies, such as hybrids and their types of hybridization, as well as battery electric vehicles (BEVs). All of those as part of this technological mix that is to meet the world's growing demands.

Considering the targets previously mentioned, automakers face a continuous challenge of sustainably undergoing a technological transition that is capable of meeting the new requirements. By having stricter emissions limits and the 2020/2030 target on the horizon, we can see that developing and refining low-emission vehicles is a legitimate demand.

Particulate Matter ($PM_{2,5}$), is a harmful air pollutant consisting of particles less than 2.5 micrometers in diameter that can penetrate deeply into the lung and enter the blood circulation, which is associated with the increase of respiratory and cardiovascular diseases.

1.3.3. Public Health

According to the World Health Organization (WHO), deaths associated with exposure to Particulate Matter ($PM_{2.5}$) and other local air pollutants correspond to one of the main risk factors for premature deaths in the world, it kills an estimated seven million people worldwide every year.

Furthermore, according to WHO, respiratory diseases make up two of the ten most common causes of death in the world: chronic obstructive pulmonary disease (COPD) is third and lower respiratory tract infection is fourth. The problem is even more serious in urban areas. WHO shows that more than half the world's urban population is exposed to levels exceeding at least 2.5 times WHO guidelines.

Adopting e-mobility can be one of the keys to mitigating said levels, resulting in better quality of air for the urban population.

Table 2 presents the number of deaths caused by air pollution in selected countries. It also shows some of the main Brazilian cities and how the level of air pollution due to $PM_{2.5}$ varies in relation to WHO limits.

Table 2. The impact of air pollution in populations of selected countries (2018)

Country	Total Annual Premature Air-Pollution-Related Deaths	Premature Deaths Attributed to Pollution per 100,000 inhabitants	Selected city	Ambient air pollution level by city compared to the WHO Air Quality Guidelines
China	1,944,436	139.6	Beijing	7.3 times above AQG
			Shanghai	4.5 times above AQG
			Shenzhen	2.7 times above AQG
India	1,795,181	132.7	Delhi	14.3 times above AQG
			Bombay	6.4 times above AQG
United States	81,899	25.0	New York	30% below AQG
			San Francisco	20% below AQG
Brazil	66,633	31.8	Sao Paulo	60% above AQG
Japan	58,287	46.1	Tokyo	70% above AQG
Mexico	41,723	33.1	México City	2.2 times above AQG
Germany	37,281	45.0	Berlin	70% above AQG
South Africa	33,680	58.3	Johanesburg	4.1 times above AQG
United Kingdom	20,711	31.3	London	10% above AQG
France	16,507	24.7	Paris	40% above AQG
Argentina	14,763	33.2	Buenos Aires	20% above AQG
Chile	6,503	34.7	Santiago	2.9 times above AQG

* a cada 100 mil habitantes no país

Source: Amended from BreatheLife, 2020.

Divulgation/Tesla

An example of e-mobility innovation and its supply chain is the case of Tesla Gigafactory, which produces electric motors and battery packs. Tesla broke ground on the Gigafactory in 2014, Nevada, USA, and it is currently under construction. In 2018, battery production at Gigafactory 1 reached an annualized rate of roughly 20 GWh. With the Gigafactory ramping up production, the cost of battery cells will significantly decline. The plant is powered by renewable energy sources and was designed to be a net zero energy factory upon completion (TESLA, 2020).

1.3.4. A new ecosystem of e-mobility innovation

Brazil is in with a chance of playing an important role in the world's technological transformation, a period called by some as "The Fourth Industrial Revolution". In addition to worrying about cleaner energy, making digital media technologies part of people's everyday life is also a priority. In such a context, besides making way for exploring new industrial processes, e-mobility also allows new business models to be developed, new services to be offered and new job opportunities to be created. This is about a partnership between transportation services and their new trends, working with the connectivity brought by the advance of information technologies.

An innovation process of this kind can result in a synergistic modernization of the transportation sector.

1.3.5. Modernizing Public Transportation

In Latin America, especially in the mid-twentieth century, increasing urban development resulted in rural to urban migration, and consequently in higher demands of urban services.

Said development and the advance of public transportation did not happen at the same intensity. As a result, traffic jams became more common and the need for better quality, less polluting transportation became a reality. Within this context, electrification can be a means to modernize public transportation, since we expect the sector to adopt EV technology faster than the passenger fleet.

From a more comprehensive perspective, said aspects sparked general interest in e-mobility and provided a better direction for those efforts concerning the implementation of alternative propulsion systems, which produce less carbon and can support a more sustainable mobility pattern.

In the global scenario, we can identify different countries inclined to the diffusion of e-mobility and driven by motivations concerning their own geopolitical and socio-economic realities (see Table 3, below, for more examples). This path is determined by varied connected reasons those countries have for the adoption of e-mobility. Said motivations increasingly enable the development of the global e-mobility agenda and provide reflections about how those variables fit the Brazilian context.

Not only is it such an important discussion for the State as a regulatory body, that promotes and manages policies that stimulate e-mobility, but it is also fundamental for the private sector to participate in it. Stakeholders in the private sector play an

Table 3. Examples of selected countries and their motivations for the adoption of e-mobility

COUNTRY/ REGION	PRO E-MOBILITY MOTIVATORS
United States	Their biggest concern is energy security, so they aim to overcome historical problems concerning oil-imported supply.
European Union	Inserted in a context of sustainable economy, Europeans debate and develop actions towards decarbonization along with e-mobility. Their goal is to become a low-carbon economy by reducing greenhouse gas emissions by 80% – 95% by 2050 compared with 1950 levels.
China	The country promotes policies that stimulate e-mobility in order to reduce greenhouse gas emissions and mitigate climate change, also to reduce air pollution in urban areas and improve energy security standards given the possibilities of reducing fossil fuels (coal and petroleum fuel) demand.

Source: Barassa, 2019.

Can Pac Swire / VisualHunt

The city of Shenzhen in China is an example of that. Close to realizing the full electrification of its bus fleet, it has the world's largest electric bus fleet (some 16,000 buses) and its taxi fleet isn't far behind. Another city stands out: Santiago de Chile, in South America, with 413 electric buses, accounting for 6% of the city's fleet.

essential part in the process of adoption of these new technologies. At different global scales, said actors have been investing and committing to leading and promoting research and development projects, besides building recharging infrastructures. Those are a fundamental part in this paradigm shift in low carbon propulsion technologies in our society.

1.4 E-mobility market trends (vehicles and infrastructure): by main countries/regions in million vehicles and their growth

According to data from IEA (2020), e-mobility continued to advance in 2019, albeit at a slower pace when compared to 2018, EV sales accounted for 2.6% of global car sales in said year.

With such a growth, the global EV fleet grew to 7.2 million electric cars, which registered a 40% year-on-year increase. Taking these numbers, nine countries had more than 100,000 electric cars on the road. At least 20 countries reached market shares above 1% in 2019.

Nowadays, there are about 7.2 million electric passenger vehicles on the world's roads. The EV market is set in a triad: China, Europe and the United States.

China leads this market, with more than 1 million EVs sold in 2019, which accounts for 3.4 million EVs in their national territory (that is almost half of the global stock). Then, the European market comes in second with a stock of 1.7 million EVs. The Europeans are followed by the United States, with a total of 1.5 million vehicles in its stock. Figure 3, below, shows this evolution through the historic period of 2013-2019.

Still according to IEA (2020), the highest levels of market share of electric passenger light-duty vehicles were registered in the following countries: Norway, as the leader, reached 13% in 2019; Iceland, in second place, reached 4.4%; in third place, the Netherlands achieved 2.7%; coming in fourth, there is Sweden with 2% and in fifth, China and its 1.6% market share.

Micro-mobility, composed by Ultra Light-Duty Vehicles (ULDVs), has been taking a path of growth since 2017. It is a reality in more than 50 countries and 600 cities around the globe. China occupies a central place in this market, in which sales figures are in the tens of millions per year, which makes the Chinese micro-mobility market the biggest in the world.

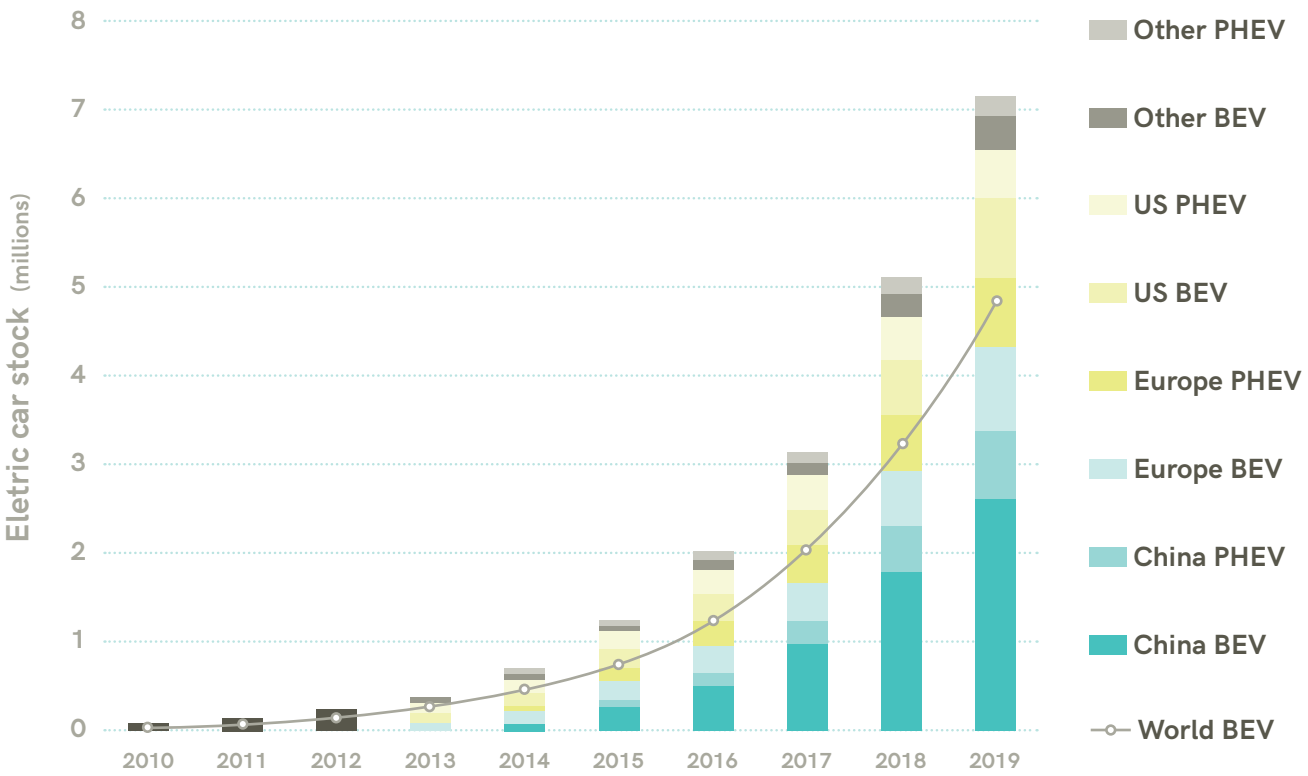
As for e-buses, a raise of 75,000 vehicles in its fleet was recorded in 2019 when compared to 2018. Out of those buses registered in 2019, 95% were China's. The Heavy Duty Commercial Vehicles (HCVs) accounted for more than 24,000 vehicles in the global stock and are especially concentrated in China as well.

The updated mapping of charging stations for passenger vehicles by IEA (2020) shows that 862,000 public charging stations were constructed in 2019, adding up to a total of 7.3 million preexistent units.

By 2040, we expect 57% of all passenger vehicle sales, and over 30% of the global passenger fleet, will be electric.

Bloomberg New Energy Finance (BLOOMBERGNEF, 2020)

Figura 3. Global electric car stock by country/region and EV technology (2010-2019)



Source: IEA (2020).

China also has the biggest share of e-buses, followed by Europe; Latin America started to show interest in using these technologies as well.

Most of those are slow chargers and fast chargers located in residential areas or in commercial areas. Globally, there are 264,000 public rapid chargers. On top of those, there are 184,000 rapid chargers mostly in China mainly used by e-buses.

Conclusions 1.5

In this chapter we aimed to present and analyze e-mobility and its possible uses and applications, as well as reflect upon drivers and levers of the sector, which become more consistent in numbers in this present journey.

A variety of aspects exerted influence in the retaking of vehicle electrification, from those we highlight the following:

- Pressure that comes from the environmental agenda, whose aim is to cut greenhouse gas emissions and limit emissions from the transport sector. That means ongoing challenges for companies to go through a technological transition that is capable of meeting the new global requirements;

- As for public health, we learned about the big impact of air pollution the transportation sector is responsible for and the deaths by respiratory diseases caused by the inhalation of greenhouse gases thereof. Adopting e-mobility can be a solution to mitigating said levels, resulting in better quality of air for the urban population;

- E-mobility makes way for exploring new business models, offering new services and creating new job opportunities. This is about a partnership between transportation services and their new trends, working with the connectivity brought by the advance of information technologies;

- Electrification can be a means to modernize public transportation, since we expect the sector to adopt EV technology faster than the passenger fleet.

This set of factors has been boosting projects and actions towards e-mobility. It is known that "electrified" vehicles have the power of solving challenges or at least reducing negative impacts of the context hereby presented.

We can further conclude that the drivers we mentioned in this report have been corroborating the expansion of e-mobility and its various modes, likewise, the leadership of the EV market triad China, Europe and the United States exercises must be appraised.

By observing the discussion on where world leaders stand concerning the adoption of e-mobility, the following question then arises: **how about Brazil? What's the country's attitude in this context?**

Chapter 2 is dedicated to presenting Brazil's context of e-mobility. Said scenario shows a very different picture of development from that of the international leaders, but it still points towards development.

Urban mobility in Brazil: a look into the national context and its common drivers for the adoption of e-mobility

WHAT ARE THE DRIVERS TO E-MOBILITY IN BRAZIL?

CAN E-MOBILITY REALLY OFFER THE COUNTRY OPPORTUNITIES?

HOW HAS THIS TECHNOLOGY BEEN ADVANCING IN THE VARIOUS BRAZILIAN STATES AND CITIES?

2

2.1 Introduction

In this context of growing e-mobility activities worldwide, it is up to Brazil, as one of the main automobile markets in the globe and as an important automaker and auto parts manufacturers, to follow trends as well as identify and grasp possible windows of opportunities in the supply chain and in new businesses.

For motivations to stimulate and direct activities pro e-mobility are indeed a reality in Brazil, it is in such a context that Chapter 2 is placed – it presents the conditioning factors for exploring EV-related activities in the country.

It is essential that we have a good understanding of which elements demand the country's productive capacities and which competency profiles are needed for the development and use of technologies, components, systems and vehicles in question. The end point of this exercise is to achieve the right interpretation of how to strengthen the automotive industry and related service sectors' competitive position in the market by gaining economic advantages in the development of the EVs supply chain.

Moreover, in a context like this, which fosters different expertise and knowledge exchange, there is a shift of competencies, so well-established companies can collapse if they do not explore or join this new trend, either because they have their technological paradigms already established from their consolidated products rooted within their structures, or because they do not believe in joining the trend because of its demand. Hence, we emphasize the importance of directing our attention to the motivations for the adoption of e-mobility in Brazil.

Having established the profile of the interfaces that justify our study of the national context in this chapter, we will then dive deeper into the elements that provide motivations for e-mobility in the country.

This is a necessary analysis which builds a strong base to the understanding of efforts devoted to the sector. In the following section, aspects of this growing market will be presented, as well as some numbers and data from the segment concerning its expanding infrastructure, for instance, and the number of EVs in Brazil, shy, yet rising.

Motivations for Brazil to promote e-mobility

2.2

"The international experiences to stimulate electromobility have indicated a wide range of alternatives to be considered in the Brazilian context. [...] Subsequent steps will naturally arise from coordinated efforts, and mechanisms for monitoring and evaluation of results may require adjustments to the routes adopted as an evolutionary process of public policies." (SLOWIK et al, 2018)

2.2.1. Brazilian Consumer Market

The total population of Brazil was estimated at around 210 million inhabitants. 2019 marks the third consecutive quarter of positive Gross Domestic Product (GDP) growth, which amounted to R$ 7.3 trillions in current prices. The country's GDP per capita (per person) for 2019 was R$ 34,533.

Considering the pre-COVID-19 socio-economic scenario, Brazil's economy has always shown, despite weaknesses common to emerging markets, growth potential and, above all, a potential consumer market to be explored by e-mobility.

It is important to highlight that Brazil has always been one of the biggest automakers in the world, with its relevant consumer market that stands out among the 10 largest on Earth, as shown in Figure 4.

It is nevertheless noteworthy that Brazil's Motorization Rate is relatively low in relation to other countries with similar consumer markets or similar socio-economic characteristics, as presented in Table 4. In other words, the expansion of the domestic consumer market when compared to the average consumption in other countries is a reasonable possibility.

Historically, the Brazilian mobility sector exerts great influence in its GDP and in its role as a global productive protagonist.

Besides that, the recent Brazil-Uruguay free trade agreement for the automotive sector signed in 2015, the Brazil-Argentina in 2019 and the Brazil-Paraguay in 2020 during Mercosur negotiations offer national stakeholders even greater possibilities of market gain.

Table 4. Motorization rate of selected countries

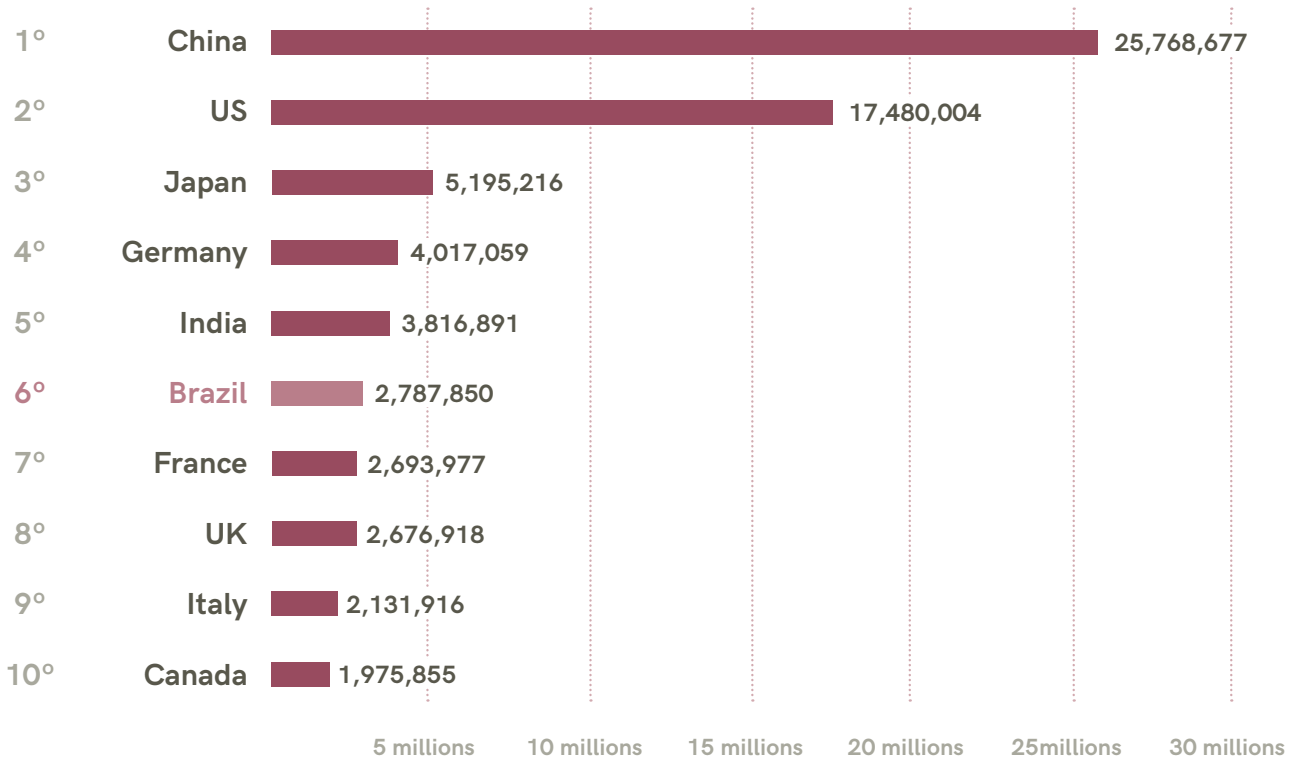
World Ranking Position	Country	Motorization Rate/ 1,000 inhabitants
2nd	United States	821
15th	Japan	609
16th	France	598
19th	Germany	593
21st	United Kingdom	587
42nd	South Korea	417
51st	Russia	358
55th	Argentina	316
57th	Mexico	294
62nd	Chile	248
71st	**Brazil**	**206**
78th	South Africa	176

Source: OICA, 2017.

Motorization Rate is defined by the number of registered vehicles (nv) in the country divided by its total population (tp) and multiplied by 1,000; MR = (nv/tp) x 1000.

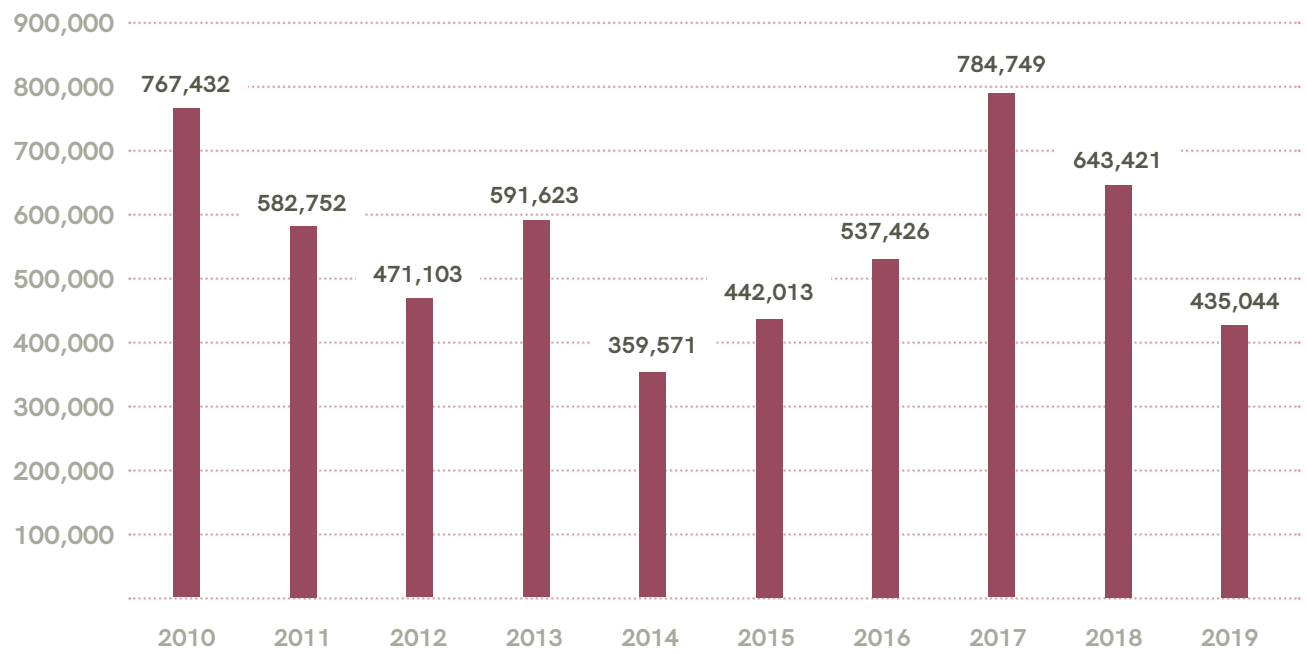
By considering all categories of vehicles, except Ultra Light-Duty Vehicles, Brazil exported 435,044 assembled and unassembled vehicles in 2019, which is low when compared to the historical mark of 2017, but it still indicates the business potential of the national automotive sector in South America.

Figure 4. Top countries in sales or registrations of new vehicles (all vehicle categories) in 2019 ranking



Source: OICA, 2017.

Figure 5. Assembled and unassembled vehicles • Brasil (2010-2019)



Source: ANFAVEA, 2020.

Relevant markets in Latin America, such as the Chilean and Colombiam ones, have been investing in e-buses for their municipal fleets, aiming, among other things, to be recognized as the cleanest and most sustainable South American cities. Given this scenario, we can spot a window of opportunity for the automotive sector to thrive as a strong regional player, an exporter of EV technologies.

We bear in mind that the economic effects caused by COVID-19 are yet to be felt by Brazil and its place in the automotive industry. However, the aspects mentioned before are remarkable and lead us to action in a scenario of recovery.

2.2.2. Energy Security

The **energy security** debate in Brazil goes beyond the matter of having a cleaner energy matrix from hydropower, solar and wind energy. The Brazilian market took a peculiar path when it started using biofuels – more specifically sugarcane ethanol fuel – in its fleet. That was how the flex-fuel technology was employed in mid 2003, and in 2019 more than 67% of Light-Duty passenger vehicles ran on ethanol fuel.

In this context, e-mobility can add up to biofuels, rather than immediately substitute fossil fuels, which brings us back to the discussion that it is not about having a single solution, but finding complementary ways to promote action for the development of a sustainable urban mobility model instead.

Therefore, there's a disruptive technological option that suits the Brazilian reality: the development and commerce of a hybrid electric system that runs on ethanol fuel as well. In such a system, both the country's productive and technological capacities can be explored, so that flex engine technologies – which run on gasoline and ethanol – can be combined to electric powertrain technologies. The synergistic effect

To invest in electrification is one of the means to leverage local businesses and boost goods exports.

that can be produced by said alternative integrates electrification demands with ethanol's strong and well-structured industrial base. This is a bet on national scientific and technological knowledge, which required investments and appropriate resources to grow and also took decades to be firmly established in Brazil, and that still nowadays receives help from instruments of promotion by the government, like the RenovaBio program.

2.2.3. Environmental Agenda

Brazil's commitment to its **environmental agenda** took an important step on September 12, 2016, when the National Congress ratified the Paris Agreement, on the 21st of the same month the document was delivered to the UN. From that moment on, the country's goals were no longer pretensions, but official commitments. In its Nationally Determined Contributions (NDCs) Brazil intends to commit to reduce greenhouse gas (GHG) emissions by 37% below 2005 levels in 2025; and reduce GHG emissions by 43% below 2005 levels in 2030. Among other commitments made by the country, Brazil intends to achieve 45% of renewables in the energy mix by 2030, such a measure is directly connected with the perspectives on e-mobility in the country.

According to the Brazilian National Balance, in 2017 the country generated 437 million tons of CO_2, 46.6% of which came from the transportation sector. In 2018, 391.5 million tons of CO_2 were generated, out of which 48.7% were again from the transportation sector. Despite this small decrease, Brazil

For Heavy-Duty Vehicles, **Proncove's P-8** phase is being developed and is in accordance with the Euro VI program for emissions standards. All new type approvals from 2022 on and all sales and vehicles registrations from 2023 on shall respect the limits set by Resolution n. 490, November 16, 2018. As for passenger vehicles, according to Resolution n. 492, December 20, 2018, Proconve L7 determined the maximum of 80 mg/km for the emission of nitrogen oxides from 2022 on. In the P-8 phase, which will go into effect in 2025, the limit drops to 50 mg/km; then in 2027 to 40 mg/km; and from 2029 on the limit will be 30 mg/km.

still has challenges ahead of it when it comes to reducing these emissions, so the country must take into account the contribution of the transport sector to fulfill the goals outlined in the Paris Agreement.

In its regulatory context, the Motor Vehicle Emission Control Program in Brazil (Proconve) was created in 1986 and sets emission targets for the automotive industry.

Given this scenario, the adoption of e-mobility can contribute to the reduction of air pollutants and the decarbonization of the Brazilian economy, honoring the commitment made by the country to fulfill the goals outlined in the Paris Agreement. Brazil has a vast repertoire when it comes to clean electric energy generation within the global context due to its hydroelectric power plants and, more recently, its increasing use of wind power and solar power.

Vehicle emissions are one of the major causes of deaths by air pollution in Brazil.

2.2.4. Public Health

The Ministry of Health of Brazil released a report on public health in the country that stresses a rise of 14% in the number of deaths associated with air pollution in 10 years, from a total of 38,782 in 2006 to 44,228 in 2016. As well as the number of preventable deaths caused by respiratory diseases, the number of population exposure to O_3 (ozone) and PM2.5 (inhalable particles of air pollution, also known as fine particulate matter) is also rising, especially in big urban areas and regions that suffered from wildfires. The Ministry also published that more than R$ 1.3 billion was spent in hospitalizations for respiratory problems in 2018 alone, and it estimated that more R$ 14 billions was spent between 2008 and 2019.

In Brazil, out of its estimated 210 million inhabitants 85% live in urban areas, according to its National Household Sample Survey. As presented in Table 5, big Brazilian metropolises show levels of air pollution way above WHO guidelines.

As for the city of São Paulo, in particular, Saldiva (2019) reveals the average annual concentration of inhalable particles is 29 micrograms/m^3 (which is equivalent to a person smoking 4 or 5 cigarettes a

day, either passively or not). In this regard, projections released by the São Paulo Medical Association (2018) show that if the level of $PM_{2.5}$ pollution stabilizes to 2018 levels, there will be 51,367 deaths associated with air pollution in the São Paulo metropolitan area between 2018 and 2025. On top of that, there will be 31,812 hospitalizations or respiratory problems in the public system in the same period, which is an estimated R$ 58.7 millions bill to the Unified Health System of Brazil (R$ 1,845.22 per capita). Such a problem is closely related to respiratory and cardiovascular diseases as well as to lung cancer, which means that those together can be more fatal, for instance, than road traffic deaths in the country.

The data presented above can guide the debate and the formulation of public policies that foster strategic actions to improve air quality in cities, which would consequently result in better quality of life to citizens and public expenditure reduction, more specifically in regards to the hospitalizations previously mentioned. Although this impact will be most keenly felt by the healthcare sector, joint effort is essential to find a way around this problem and that includes the participation of both the energy and the transportation sectors, as well as the development of sustainable urban mobility and low emissions technologies.

2.2.5. A new ecosystem of e-mobility innovation

Having a robust **ecosystem of innovation** is closely related to going through an intense process of qualification of human resources to work, for instance, in the development and production of vehicles and their components, or even in vehicle maintenance and repair or the design of new business models. Consoni et al. (2019) point out the evolution over time of specific training activities to knowledge

Table 5. Levels of air pollution compared to WHO guidelines in selected Brazilian municipalities (2018)

Municipality	Level of air pollution
Brasília	540% above WHO limits
São Paulo	60% above WHO limits
Belo Horizonte	40% above WHO limits
São José dos Campos	40% above WHO limits
Campinas	30% above WHO limits
Rio de Janeiro	10% above WHO limits
Salvador	within WHO limits
Curitiba	40% below WHO limits

Source: Amended from BreatheLife, 2020.

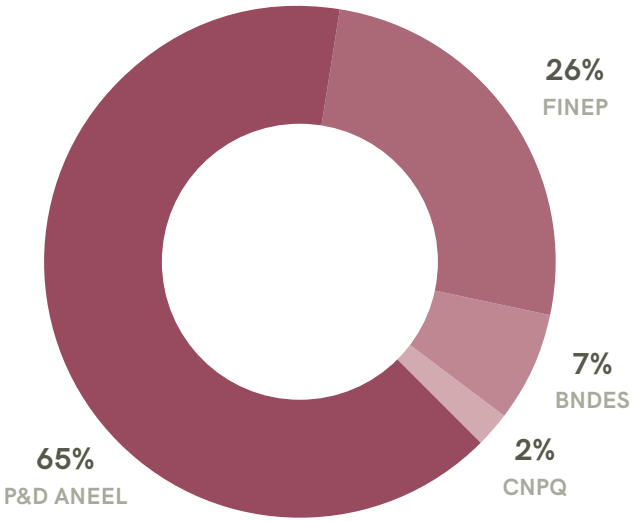
The **innovation index**, according to the Brazilian Institute of Geography and Statistics (IBGE), consists of the percentage difference between the number of **companies that fostered innovation** and the total number of **participant companies** in the research.

generation. Then, again, we come across a window of opportunity to stimulate coordinated actions that foster technological competencies development in the e-mobility sector.

According to PINTEC, 2017, between 2015 and 2017, the Brazilian innovation index in motor vehicles, trailers and truck bodies production was 34.3%, which is higher than the country's average index of industrial innovation of 33.9%. When we consider only automakers of cars, pickup trucks, utility vehicles, trucks and buses, the innovation index average rises to 69.5%.

Moreover, under the e-mobility perspective, this ecosystem is chiefly composed by the energy sector, whose major representative is the Brazilian National Electric Energy Agency (Aneel), the leading institution in fostering research and development projects on e-mobility when compared to the latest efforts made by the public sector in stimulating such activities. Figure 6 provides clear evidence that the projects carried out by ANEEL represent 65% of the total contributions to projects on e-mobility made by development agencies, banks and other institutions that support research in Brazil.

Figure 6. Amount invested by government agencies



GOVERNMENT AGENCIES	AMOUNT INVESTED
FINEP	R$ 53,294,485
BNDES	R$ 13,800,000
CNPQ	R$ 3,164,874
ANEEL R&D	R$ 131,743,372

Source: Barassa, 2019.

The **R&D program of ANEEL** aims to allocate human and financial resources to R&D and Energy Efficiency projects. In this regard, the section "Public policies and government instruments of promotion" will provide more details about said program and its connection with e-mobility.

2.2.6. Modernizing Public Transportation

Another relevant aspect to boost e-mobility is the **modernization of the Brazilian transportation** sector, since it is involved in the development of both pilot and demonstration projects. Bermudez (2018) suggests that different actors, such as local governments, energy companies, universities and R&D centers, automakers and components makers, vehicle fleet operators and others have been forming partnerships in projects aiming to expand the benefits of those low emissions technologies.

In general, this modernization of public transportation involves not only the vehicles, but also the way services are offered, which means to afford opportunities in the public-private sphere for the development of new business models. Hence, the Brazilian population can be offered a more comfortable, more environmentally friendly public transportation service, that is also more connected to the new information and communication technologies.

Imagem ilustrativa • Reprodução/YouTube

In some capitals of Brazil, political efforts are being devoted to the implementation of low GHG emission technologies, such as the São Paulo Climate Change Policy. Said Policy targets the reductions of emissions in the municipality, which includes the reduction of fossil fuels use in public transportation. The Bus Rapid Transit (BRT) electrification initiative in Salvador, Bahia, and the e-buses pilot project in Belo Horizonte, Minas Gerais, are also underway.

E-mobility in Brazil: statistics, market growth and infrastructure

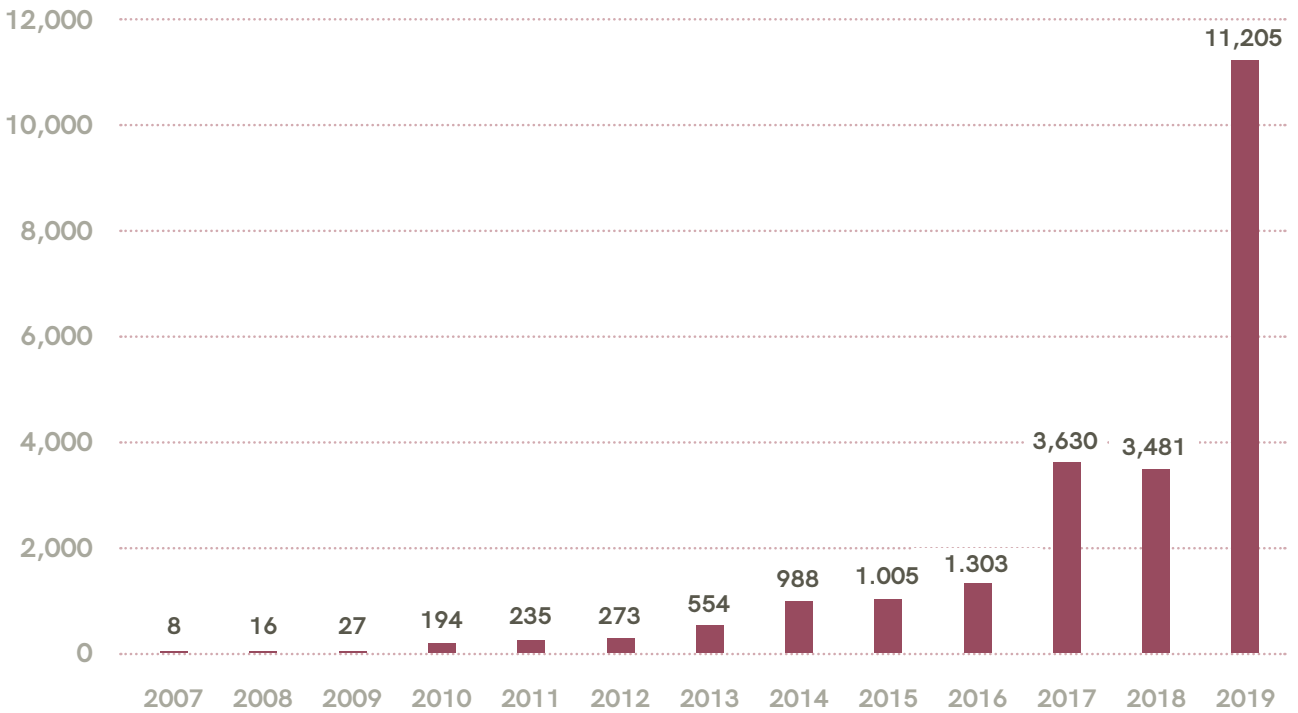
2.3

"The question ahead is no longer whether electric mobility will reach a large scale in Latin America and the Caribbean, rather when."

UN Environment (REICHENBACH, 2018)

The Brazilian e-mobility market is in its early stage of development and its numbers are still low when compared to those of the largest EV markets or even to its number of internal combustion vehicles. Yet, 2019 was a relevant year for the national e-mobility market, with registrations of new electric passenger cars and Light Commercial Vehicles three times bigger than 2018's.

Figure 7. Registration of electric passenger Light-Duty Vehicles and Light Commercial Vehicles in Brazil (2007-2019)



Source: Ministry of Infrastructure, 2020.

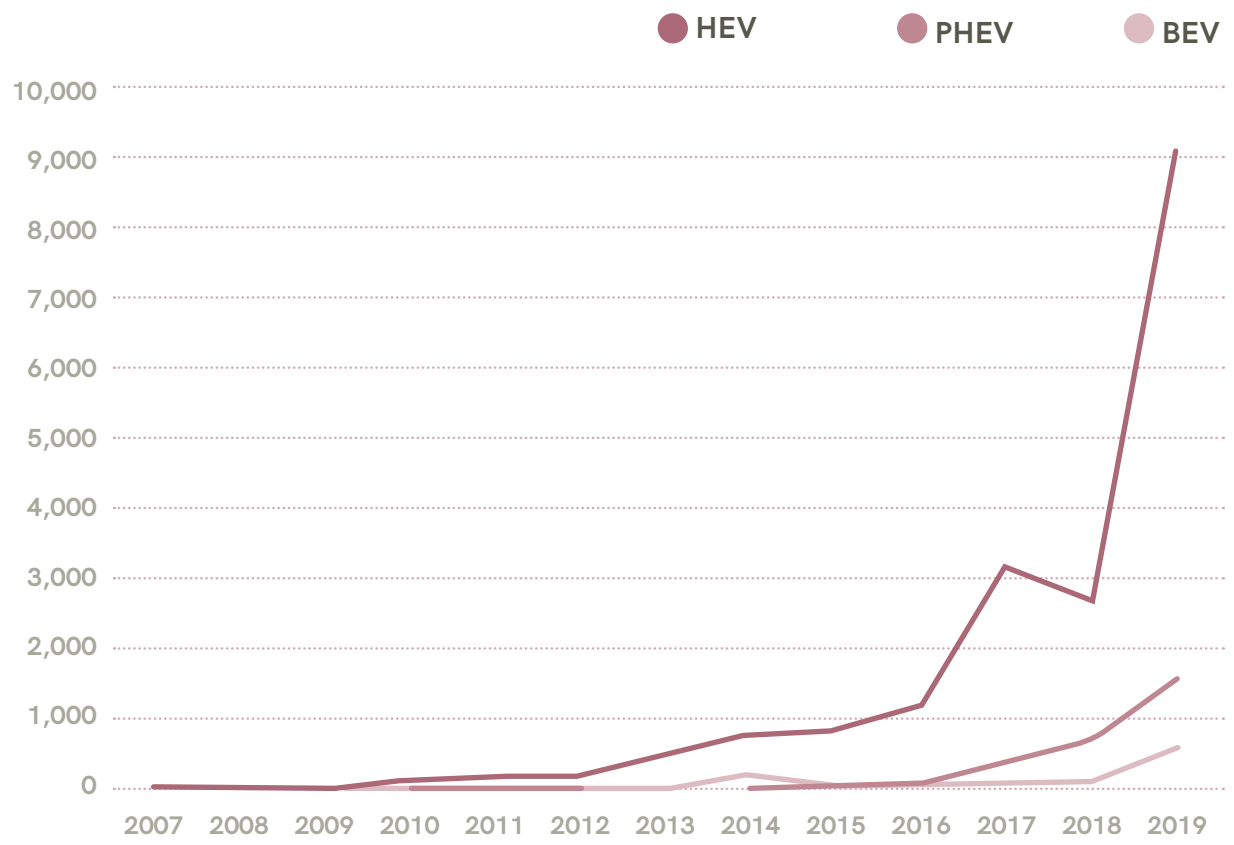
According to the data collected up to December 2019 in the records of the National Traffic Department of Brazil (DENATRAN), we see an exponential growth curve regarding the increase in sales of new electric passenger LDVs and LCVs, with emphasis on regular Hybrid Electric Vehicle (HEVs), which cannot plug into the grid to recharge, and the mark of 19,000 units sold. Plug-In Hybrid Electric Vehicles (PHEVs), on the other hand, reached 3,000 units sold and Battery Electric Vehicles (BEVs) totaled around 1,000 units. The total of the electric Light Commercial Vehicles fleet is 22,919 units in Brazil.

The Brazilian e-mobility market is in its early stage of development and hybrids are still the preferred electric propulsion system.

All data presented in this section refer to a Covid-19 pre-pandemic period. The phenomenon of social distancing and quarantine caused by the need to control the virus has impacted forecasts of coming periods.

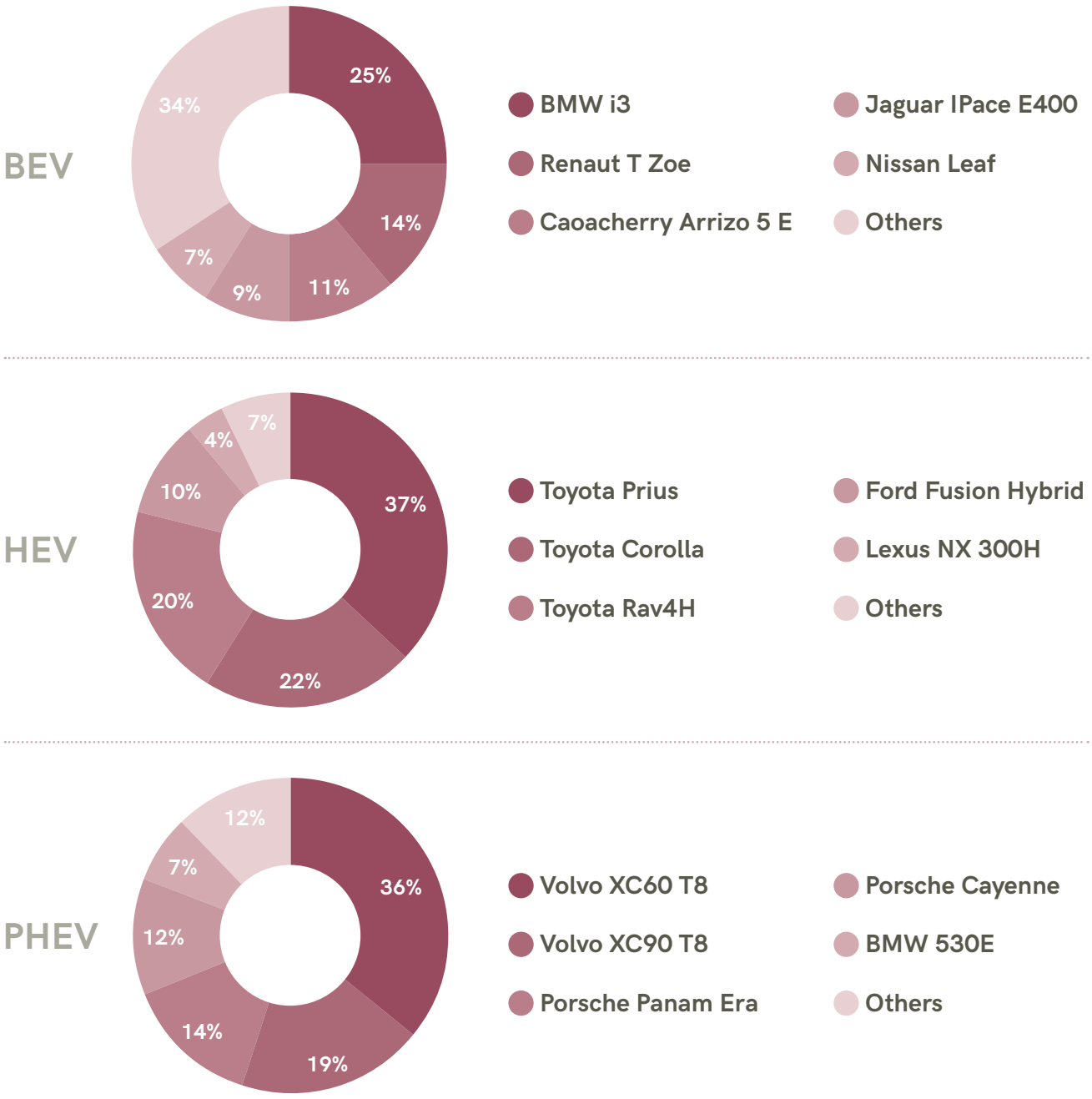
As for each category of EVs, as shown in Figure 9, we can see many automakers offer BEV models, predominantly the BMW i3 model with 25% of market share. When it comes to HEVs, Toyota is the leader with almost 80% of market share – notice that the RAV4H and the Corolla Hybrid Flex were launched in the Brazilian market only in 2019. As for the PHEVs, the Swedish company Volvo and the German Porsche came on top.

Figure 8. Types of registered EVs in the Brazilian fleet (2007-2019)



Source: Ministry of Infrastructure, 2020.

Figure 9. Best-selling EV models in the Brazilian market by categories of EVs (2007-2019)

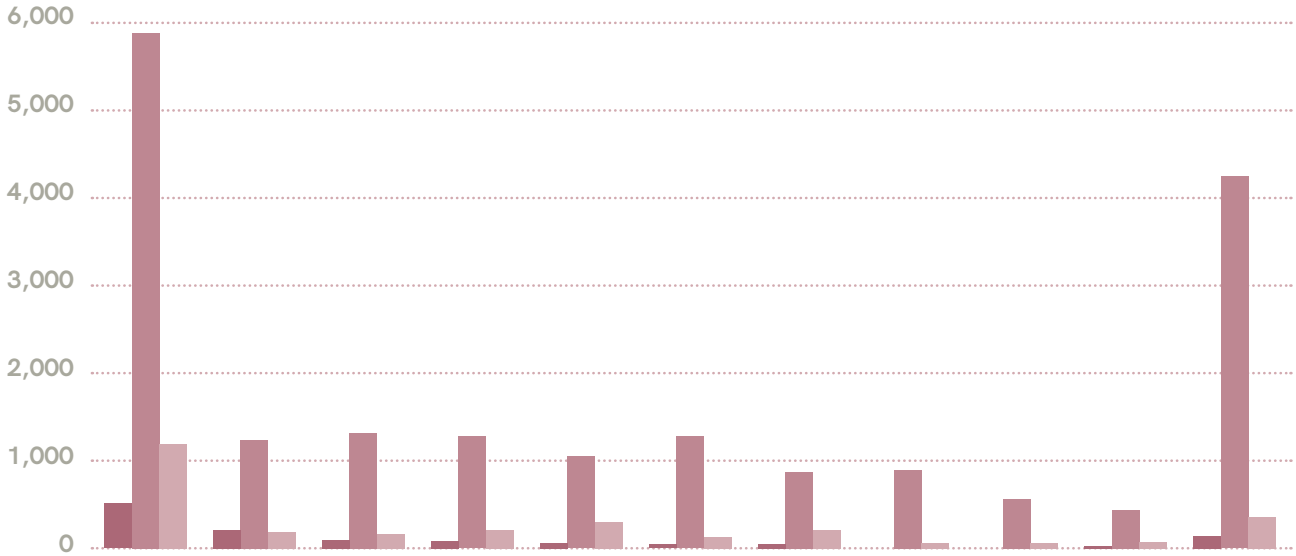


Source: Ministry of Infrastructure, 2020.

Figures 10 and 11 show the 10 biggest Brazilian electric LDVs fleets by states and municipalities, respectively. In this context, we can see that numbers are higher in the South and Southeast regions of the country. The state of São Paulo stands out both among leading states and cities, which is represented by its capital São Paulo and countryside city Campinas.

As for buses, it is noteworthy that e-buses have paved their market especially in bids for fleet op-

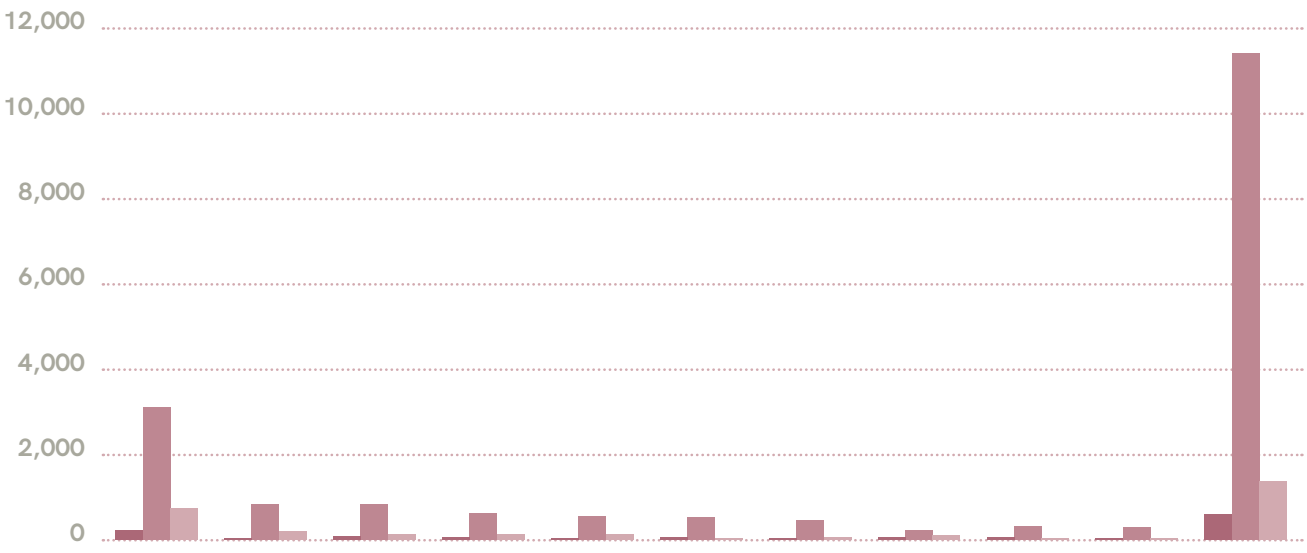
Figure 10. Top 10 biggest Brazilian EVs fleet by states (2007-2019)



	SÃO PAULO	PARANÁ	RIO DE JANEIRO	MINAS GERAIS	SANTA CATARINA	RIO GRANDE DO SUL	DISTRITO FEDERAL	BAHIA	ESPÍRITO SANTO	PERNAMBUCO	OTHERS
BEV	518	210	81	75	68	23	38	8	7	26	133
HEV	5,850	1,234	1,295	1,273	1,046	1,242	856	876	547	434	4,198
PHEV	1,187	186	164	192	303	138	192	39	59	67	354

Source: Ministry of Infrastructure, 2020.

Figure 11. Top 10 biggest Brazilian EVs fleet by municipalities (2007-2019)



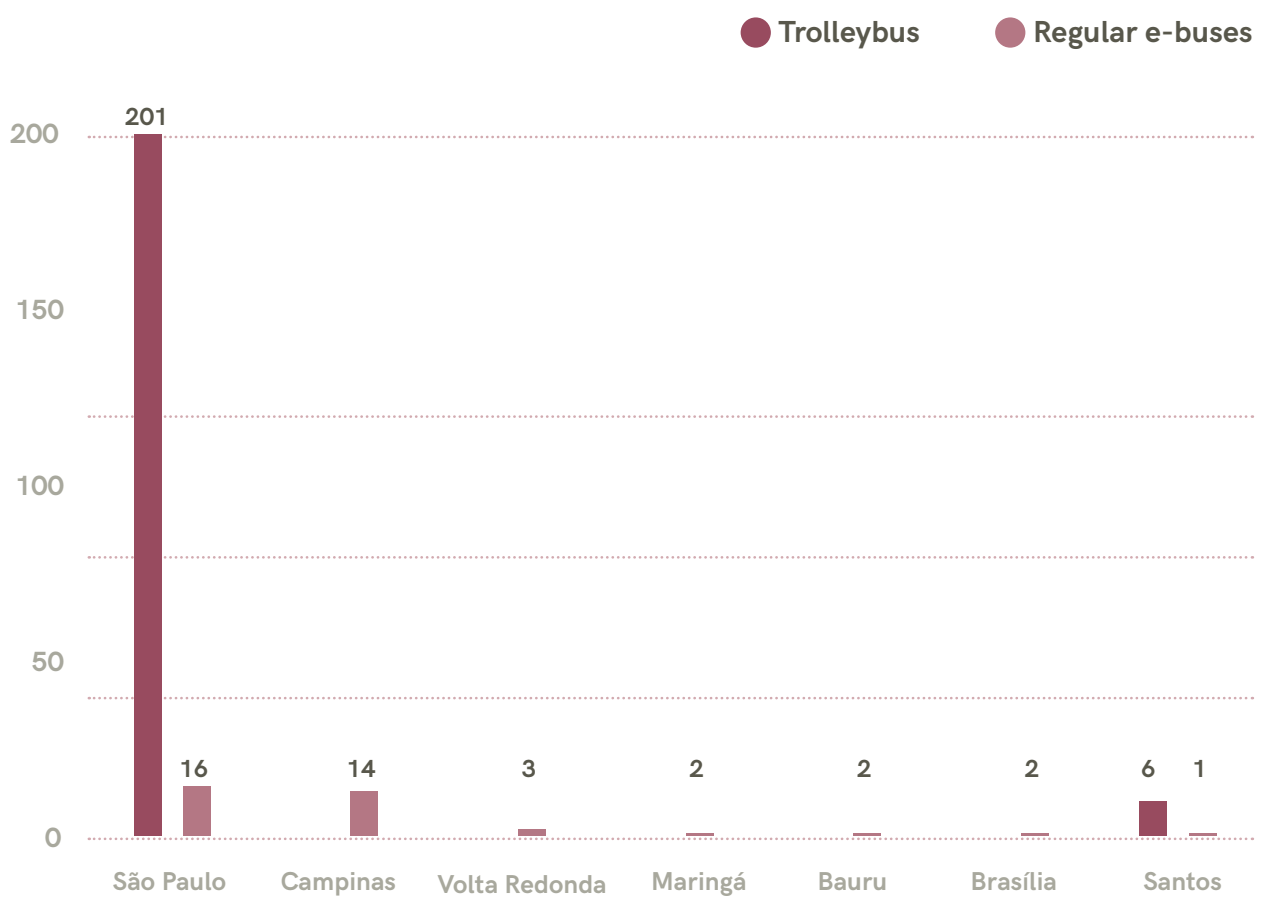
	SÃO PAULO	BRASÍLIA	RIO DE JANEIRO	CURITIBA	BELO HORIZONTE	SALVADOR	PORTO ALEGRE	CAMPINAS	FORTALEZA	RECIFE	OTHERS
BEV	227	38	62	57	49	5	9	87	23	24	606
HEV	3,074	856	798	592	536	489	416	220	315	272	11,283
PHEV	740	192	131	112	122	24	59	59	17	51	1374

Source: Ministry of Infrastructure, 2020.

eration in cities and in demonstration projects. The E-bus Radar portal, an initiative that maps the Latin American fleet of e-buses, shows that there are 247 e-buses operating in Brazil, including trolleybus, which account for the majority, and regular buses connected to the grid and fed by an overhead line (see Figure 12).

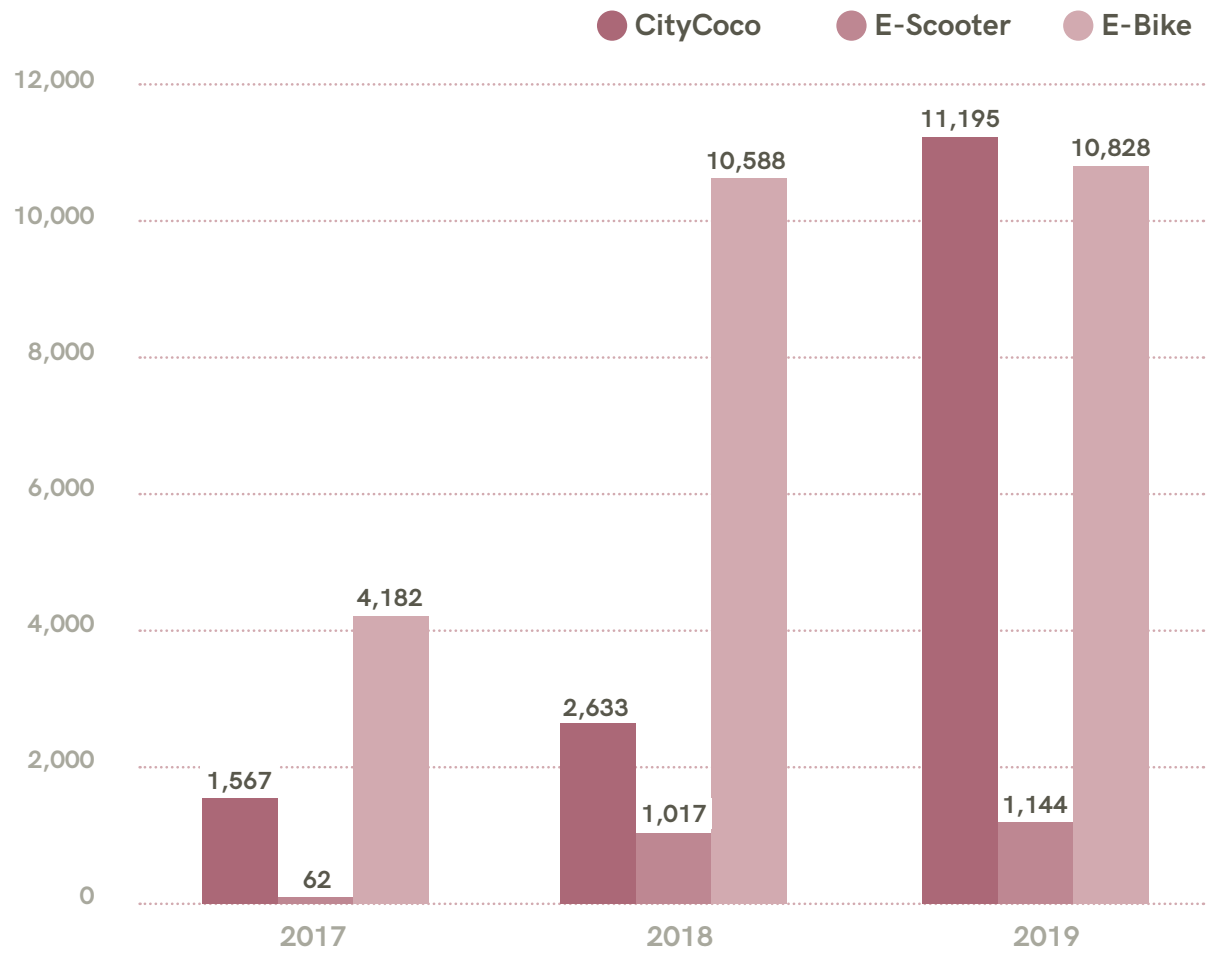
As for electric Ultra Light-Duty Vehicles (ULDVs), a recent report released by the Brazilian Association of ElectricVehicle (ABVE) presented growth in the sector. The e-mopeds sales were higher, including CityCoco models, which are fat tire electric scooters similar to mopeds but whose use is not yet regulated in Brazil, from 1,629 units sold in 2017 to 12,339 in 2019. By quantity, the number of e-bikes comes on top, accumulating sales of around 25,000 bicycles over the 2017-2019 three-year period. Figure 13, below, shows such growth patterns of said categories.

Figure 12. E-buses in Brazilian municipalities.



Source: RADAR, 2020

Figure 13. Growth in sales of electric ULDVs in Brazil (2017-2020)



Source: Amended from ABVE , 2020.

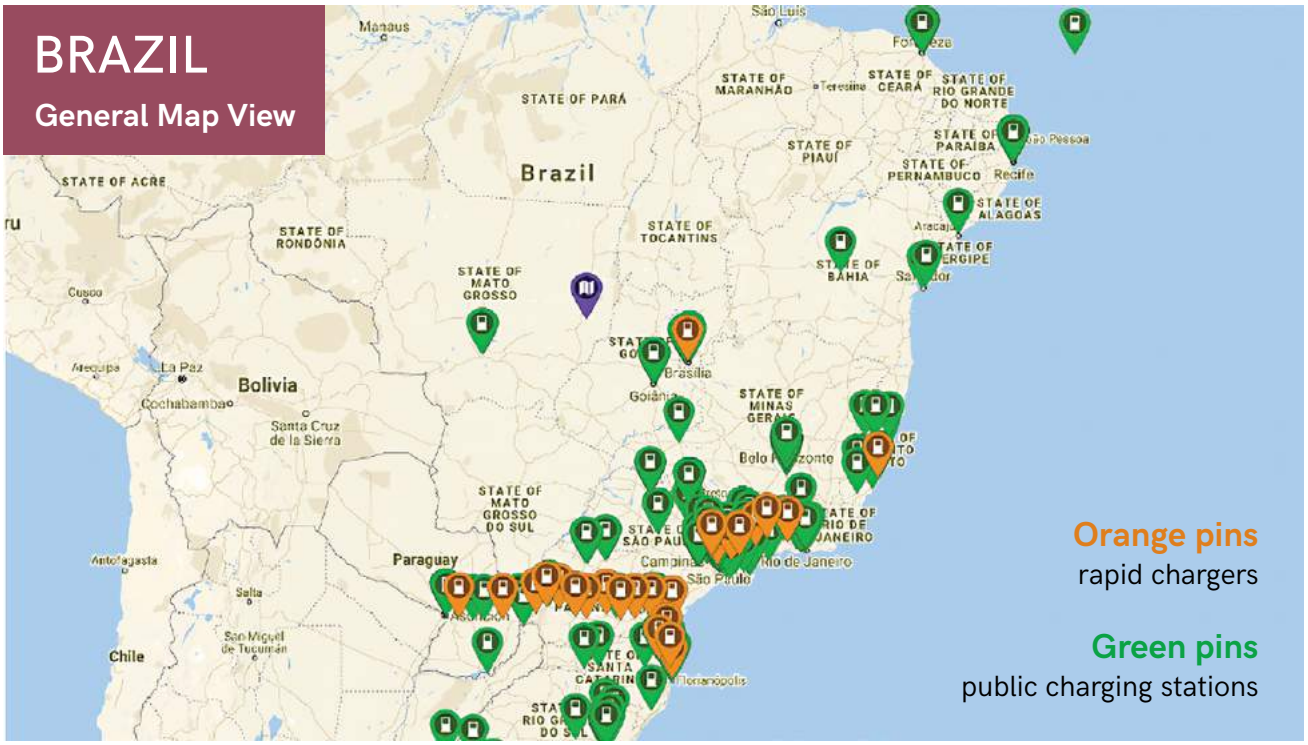
In regards to EVs recharging infrastructure, the PlugShare platform estimates that there are nearly 500 public or private charging stations constructed in Brazil, mainly in the South and Southeast regions of the country (see Figure 14).

Noteworthy in this analysis is the fact that the profile of the infrastructure that is being implemented in the country refers to its allocation in strategic transportation corridors traveled by heavy goods vehicles and passenger vehicles, as shown in Figure 15.

We noticed, for example, a corridor of charging stations that connects Curitiba to Asunción (Paraguay), another on the Anhanguera and Bandeirantes highways that connects the cities of Campinas and São Paulo and finally, a corridor on the Dutra highway, which connects the state of São Paulo to the state of Rio de Janeiro.

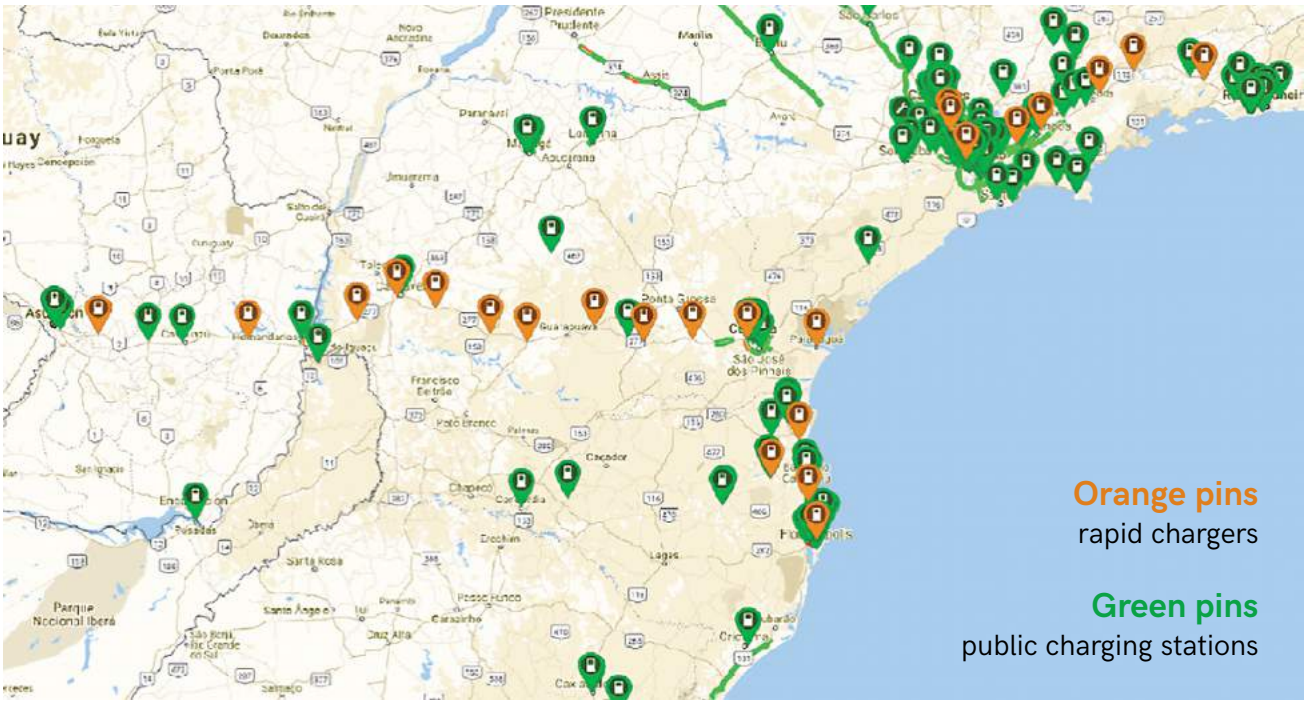
For now, rapid chargers can be found in strategic transportation corridors and highways traveled by Heavy Goods Vehicles and Passenger Vehicles

Figure 14. EVs recharging infrastructure in Brazil



Source: Amended from Plugshare, 2020.

Figure 15. recharging infrastructure in Brazil (notice the strategic transportation corridors in the map)



Source: Plugshare, 2020.

2.4 Conclusions

This chapter aimed to analyze the panorama of e-mobility in Brazil from the following perspectives: 1) reflect upon the motivations that support more assertive actions by the country towards e-mobility and their corresponding reasons and 2) paint a scenario of this market by states/cities and types of architecture and vehicles in circulation.

Regarding the motivations, at large, we find that:

- In Brazil, there is a potential **consumer market** to be explored by e-mobility. We saw that historically Brazil is among the biggest automakers in the world, with its consumer market among the top 10 on Earth. Furthermore, the recent free trade agreements previously explored offer national stakeholders possibilities of market gain (concerning vehicles and components) in international markets;

- As for energy security, the synergistic effect that can be produced by biofuels and what can come from such an approach integrates electrification demands with ethanol's strong and well-structured industrial base. This is a bet on national scientific and technological knowledge of biofuels;

- Considering Brazil's commitment to its environmental agenda and the Paris Agreement, the adoption of e-mobility can become an alternative to the reduction of air pollutants and the decarbonization of the Brazilian economy, honoring the commitment made by the country to fulfill the goals outlined in the Paris Agreement, as discussed before;

- As for public health, vehicle emissions are one of the major causes of deaths by air pollution in Brazil and e-mobility becomes especially relevant in this scenario;

- Regarding a new ecosystem that is being formed, we come across a window of opportunity to stimulate coordinated actions that foster technological competencies development in the e-mobility sector;

- Finally, the modernization of the Brazilian transportation sector is another relevant aspect to **boost e-mobility** in the national context, since it is involved in the development of pilot and demonstration projects in Brazilian cities.

In general, the debate on reasons and conditioning factors for e-mobility is still new in Brazil. However, a certain replication of the international motivations is remarkable as well as the country's unique demands. For instance, from the entrepreneurial perspective, there are windows of opportunities to all sorts of contexts, the same way that public health and its connection to public transportation is a demand common to Brazil and other countries. Contrarily, when it comes to its environmental agenda and emission targets, Brazil is not as sharp as others in the international panorama.

On the same comparative approach, we can say that the Brazilian e-mobility market is in its early stage of development and its numbers are still low when compared to those of the largest EV markets or even to its number of internal combustion vehicles. Yet, considering the pre-COVID-19 scenario, 2019 was a relevant year for the national e-mobility market, with

registrations of new electric passenger cars and LCVs three times bigger than 2018's.

It was also possible to confirm that the e-mobility market is mainly concentrated in the state of São Paulo, followed by Paraná, Rio de Janeiro and Minas Gerais. The state of São Paulo stands out among leading cities, especially represented by its capital São Paulo and the city Campinas.

Those findings highlight that e-mobility can be adopted through clustering, that is, at first being developed according to territorial mobility patterns. The deployment of recharging infrastructure corroborates that, since the first charging stations were allocated around the cities and regions previously mentioned, as well as in strategic transportation corridors that connect said states.

When analyzing these embryonic, high-leverage initiatives, some questions arise: **Who are the actors involved in these initiatives? How are their activities being structured? What kind of roles are these actors playing and what action plans are being prioritized?** Those and other questions are the theme of Chapter 3, which explores the ecosystem of e-mobility innovation in Brazil and analyzes each of its related profiles.

Developing a new ecosystem of e-mobility in Brazil: actors, policies, entrepreneurial initiatives and related businesses

WHO ARE THE ACTORS IN THE UNIVERSE OF E-MOBILITY IN BRAZIL?

WHAT ACTIONS ARE THESE ACTORS PERFORMING?

WHAT ROLES AND ATTITUDES HAVE THEY TAKEN IN THIS ENVIRONMENT OF THE STATUS QUO TRANSITION PERIOD?

3

3.1 Introduction

In order to better understand how the ecosystem of e-mobility works we may adopt the perspective of the innovation system, which is based on three components that cooperate and collaborate towards a common goal: actors, networks and institutions. From that perspective, the expansion of e-mobility in Brazil is a keyword. Some characteristics of that system were inherited from the long-established automotive sector, which concerns internal combustion engines, and where novelty and tradition coexist through this new path of e-mobility.

"In Brazil, electrification initiatives are still part of an emerging movement, but the first experiences have shown that electrification is certainly the path that will lead us to a low-emission mobility system."

Professor Flávia Consoni
University of Campinas (UNICAMP, 2019)

An **innovation system** is "the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies". In this regard, we suggest readers consult the works of founders Christopher Freeman (1987), Bengt-Ake Lundvall (1992) and Richard Nelson (1993) who constitute the basis in the interpretation of the National System of Innovation (NSI).

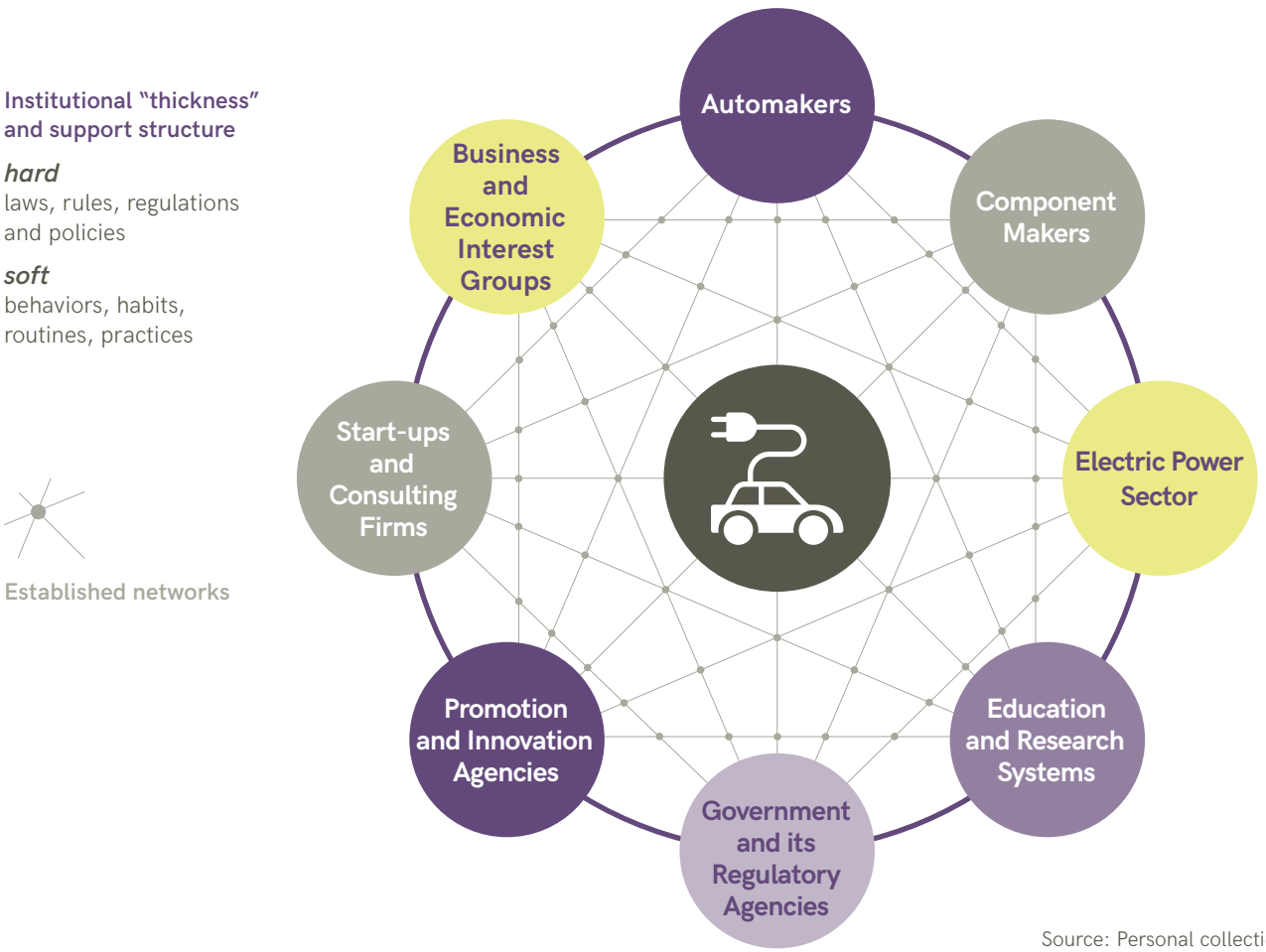
Said system is composed of some main spheres as shown in Figure 16 and Table 6, respectively, which will be further explored later.

Table 6. E-mobility ecosystem spheres in Brazil and their related roles

SPHERES	ROLES
Automakers	Automakers make up the auto industry along with auto parts manufacturers. Those companies lead the automotive supply chain in Brazil. All automakers that form the Brazilian auto scene are foreign capital companies and have started adopting measures in favor of EVs in the country.
Components	Components makers add up to automakers in the automotive supply chain. In the national context, foreign-owned companies and companies of domestic investment origin stand out in the sector when it comes to developing accumulators (batteries) as well as powertrain parts (electric motor parts).
Electric power sector	Companies in the electric power sector have been taking vigorous action in favor of e-mobility in Brazil, since their main role is to supply power – power that charges and moves EVs. Their projects stand out in the national scenario of e-mobility.
Education and research systems	Composed by initiatives of Universities, Research Institutes and other R&D centers that provide training and qualification of human resources and also generate scientific and technological knowledge on e-mobility.
Government and its regulatory agencies	It is a multi-scale system, organized in federal, state and local government levels, in which the State participation happens through fiscal policies, climate change policies, R&D policies, collaboration and cooperation of actors, industrial support policies and regulatory policies of this system.
An environment of promotion and innovation	The Innovation Environment is characterized by the performance of agencies such as the Brazilian Agency for Industrial Development (ABDI), the Brazilian Company of Research and Industrial Innovation (EMBRAPII) as well as the Research Support Foundations (FAPs). We highlight the capital contribution subsidized by FINEP (Funding Agency for Studies and Projects) and BNDES (Brazilian Development Bank), and also agencies of protection for inventions, like the National Institute of Industrial Property (INPI).
Start-ups	Technology-based companies that develop specific niche markets and that are taking advantage of available opportunities to launch new products and business models in the e-mobility sector.
Business and Economic Interest Groups	They are important when it comes to bringing together different actors, organizing debates and actions led by their members, especially aimed at promoting e-mobility. It is the role of organizations and civil society, which can engage with technological changes for e- mobility.

Source: Amended from Barassa, 2019.

Figure 16. Actors in the innovation ecosystem in Brazil



Source: Personal collection.

3.1.1. Automakers

According to Anfavea (2020), in 2018 there were 22 automakers, which provided 106,705 direct jobs, generated US$ 54 billion in revenue and made up nearly 18% of the national manufacturing sector GDP. All of these automakers that form the Brazilian auto scene are foreing capital companies and most of them have started adopting measures in favor of EVs in Brazil.

3.1.2. Components

In 2019, Sindipeças (National Association of Brazilian Auto Parts manufacturers, the biggest association in its sector) released a report that shows a total of 473 Sindipeças' member companies in 2018 and accounted for 174,537 employees. Its total revenue was estimated at US$ 26 million. Out of the total of its members, 57.2% are foreign direct investment (FDI) companies, 29.4% are domestic investment companies, 10.5% are majority-owned FDI companies, 1.6% are majority-owned domestic investment companies and 1.2% are mixed-economy companies. The auto parts trade balance ran a historical deficit of 5.6% in 2018, whose main

partners were Argentina, the United States, Mexico, China and Germany.

Despite the predominance of foreign-owned companies, it is noteworthy to mention that some companies of domestic investment origin stand out in the sector when it comes to developing accumulators (batteries), powertrain parts (electric motor parts), as well as EVs and PHEVs recharging infrastructure (charging stations) solutions.

3.1.3. The Electric Power Sector

Companies in the electric power sector have been taking vigorous action in favor of e-mobility in Brazil, since their main role is to supply power – power that charges and moves EVs. Said companies' main actions concern initiatives for the development of demonstration projects, whose goal is to further study and better understand EVs technology, as well as its applications and implications. Above all, they seek to identify possibilities for companies to act in electricity provision, the recharging infrastructure and the concerning new business models.

Within the sector, it is important to consider that these efforts allocated to the development of e-mobility are especially justified by the ANEEL R&D Program (Law n. 9991/00) and its the mandatory investment in research and development clauses. Although most projects are not exclusively linked to mobility, they have largely affected the actions from the electric sector in favor of EVs in Brazil, which promotes greater reflection on the topic in general.

3.1.4. Education and research systems

Barassa (2019) presents the competencies development in the e-mobility sector and indicates patents being issued and articles being published on the topic of e-mobility in Brazil, which illustrates an emerging scientific production movement. Those researches have been conducted mainly by universities and research institutes and, to a lesser extent, by companies in the private sector. We can also observe the following research focus areas: hybrid vehicle architectures, lithium batteries, electric motors and charging systems.

Local training activities are also an emerging and growing movement. A raise in the amount of scientific production and research groups inside universities and research institutes can be noticed. Said groups are open to partnerships with the industry, especially in developing studies on the electric powertrain.

3.1.5. The Government and its regulatory agencies (in the governmental environment)

Barassa (2019) points out that the State participation, at any of the federal, state and local government levels, happens through fiscal policies, climate change policies, R&D policies, collaboration and cooperation of actors, industrial support policies and regulatory policies of this system. The State participation takes place through its agencies, which regulate health and safety specifications and control vehicle emissions. At the same time, it is up to the State to provide, regulate and inspect the infrastructure for EVs to run.

In this context, some considerable steps were taken by the State, such as the Import Duty and Tax on Industrialized Products (IPI) – which taxes HEVs under specific rules – being extinguished by the

government, in addition to the Route 2030 program, or other local initiatives like the São Paulo Climate Change Policy.

On this matter, important state actors must be acknowledged: the Ministry of Science, Technology and Innovation, the Ministry of Economy, the Ministry of Regional Development, the Ministry of Mines and Energy, and others.

The challenge to the Brazilian governmental environment is to formulate policies in a coordinated and collaborative manner that dialog with all sectors, and more than that, with all states and municipalities that also govern their related entities.

Another relevant group within this context is that of regulatory agencies and programs such as ANEEL, INMETRO, ABNT, PROCONVE, among others, that work to set technological standards and define which paths technologies can take.

3.1.6. An environment of promotion and innovation

The Innovation Environment is characterized by the performance of agencies such as the Brazilian Agency for Industrial Development (ABDI), the Brazilian Company of Research and Industrial Innovation (EMBRAPII) as well as the Research Support Foundations (FAPs) that are agents of organization and promotion of innovation activities in the country, responsible for supporting research projects, carrying out projects in partnerships with both the private and the public sector, in addition to running demonstration projects on specific technologies. As for Intellectual Property, the National Institute of Industrial Property is responsible for managing applications, licenses, concessions and other procedures that involve the processing of patents in Brazil, including those of e-mobility.

In regard to promotion of e-mobility, we highlight the capital contribution subsidized by FINEP (Funding Agency for Studies and Projects) and BNDES (Brazilian Development Bank). Those institutions play the part of strategic sources of funding because of the technological uncertainties concerning e-mobility, which demand investments from companies.

3.1.7. *Start-ups*

Start-ups are essentially technology-based companies which are directly connected with the innovation environment, so they foster emerging technologies and new business models. They work particularly in the development of digital platforms for services and systems, such as BMS, power electronics and aspects of connectivity. In addition, start-ups provide new perspectives on business models supported by fresh proposals of how to offer and use urban mobility services, which results in coordinated efforts of other actors, such as the electricity sector itself and the automakers.

"Sharing is another inexorable trend that puts technology companies and start-ups in a position to collaborate or compete with traditional manufacturers/dealers of vehicles and auto parts."

Luiz Carlos Moraes
Chairman of Anfavea (ANFAVEA, 2020)

The development of car sharing models, for example, has been gaining more and more space within the mobility scenario.

We are dealing with a scenario full of challenges and opportunities that can boost e-mobility for society, by contributing to its popularization and market gain.

3.1.8. Business and Economic Interest Groups

Among Business and Economic Interest Groups that concern e-mobility, four of them stand out:

a) ABVE – *Brazilian Association of Electric Vehicle*: works with companies of the industrial sector and other actors, its objective is to promote the debate on e-mobility, explore the EVs theme so that society is familiarized with it, as well as support the decision-making process regarding regulatory measures and the collaboration and cooperation of actors, either from the public or the private sector.

b) ANFAVEA – *National Association of Vehicle Manufacturers*: brings together automakers and agricultural machinery manufacturers with production plants and facilities in Brazil. ANFAVEA has been in the spotlight since it carried out actions that require a more active participation in the scope of political decisions to promote e-mobility, such as its work with the Municipal Chamber of São Paulo for the city's bus fleet renewal and, in the federal sphere, in debates on the development of a policy for the automotive sector, the Route 2030 program.

c) ABRAVEI – *Association of Innovative Electric Vehicle Owners*: made up of EV owners, its goal is to advocate for the interests of its members in issues regarding their EVs and EV automakers and/or dealerships throughout the national territory.

d) SINDIPEÇAS – *National Association of Brazilian Auto Parts manufacturers*: brings together companies established in Brazil that supply components for automakers, it stands out in the discussions of e-mobility, aiming to better understand the role that these companies can play in the broader context of sustainable urban mobility.

Despite the embryonic stage of e-mobility in Brazil, it is important for actors in the private sector to understand public sector regulations and its organizational structure as well as their roles in this complex innovation system. That will lead said actors to reflection and forming opinions with strategic directions and synergistic, collaborative actions so that efforts are not spared in the promotion of e-mobility in Brazil.

3.2 Entrepreneurial initiatives of actors in this growing ecosystem of e-mobility

From the 2010's on, some pilot and demonstration projects were initiated aiming to address issues regarding e-mobility in Brazil. Said projects have been carried out by various actors and participants, such as traditional automakers established in Brazil, new companies, auto part manufacturers, technology-based companies and start-ups, electricity suppliers, recharging infrastructure and charging station companies and interest groups that support the activities mentioned above.

In a general sense, we are talking about initiatives for experimentation and knowledge generation of EV technologies, as well as initiatives for legitimization of e-mobility by society through a better understanding of how to operationalize this ecosystem, design new business models and overcome challenges to the adoption and development of e-mobility in the country.

Table 7 shows some examples of both pilot and demonstration projects carried out by automakers in Brazil (de Sant'Ana Fontes, 2018, Barassa, 2019, ABVE, 2020). Those are non-exhaustive examples, but they do illustrate how and to what extent the automakers' actions for EVs have been developed.

Finally, the importance of the participation of local governments, present in several of the aforementioned projects, stands out in this context. Political articulation as well as the study and understanding of the differences between Brazilian regions is something the promotion of e-mobility in the mainly urban areas of the great Brazilian municipalities can benefit from. In other words, it is about applying and broadening knowledge in a level closer to society, and that is up to local governments as well as other public and private institutions located in those municipalities which have a good understanding of opportunities and challenges thereof that can be decisive when carrying out a demonstration project in those areas.

"We have to seize this opportunity to make a speech on technological sovereignty in this area that we dominate. Renewable energy is within Brazilian competency, so that needs to be valued and transformed into production of wealth."

Paulo Alvim
Ministry of Science, Technology and Innovations' Secretary of Entrepreneurship and Innovation
(Senado Notícias, 2019)

Table 7. Examples of demonstration projects on e-mobility in Brazil (2010-2020)

Project and Project duration	General Objectives	Actors involved in the project
Pilot Project of Taxis in Rio de Janeiro (2013-2018)	Loan by lending contract of 50 EVs, whose ultimate goal was employing EVs as taxis, as well as the promotion of the Nissan brand and electric technology advances in the city of Rio de Janeiro.	Nissan and Rio de Janeiro City Hall
Emotive (2013 -2018)	To constitute a real e-mobility laboratory in the Metropolitan Region of Campinas (investment account for about R$ 40 million).	CPFL Energia, Unicamp, CPqD, Daimon Energy
Carro Leve (The Light Car) (2014-2015)	It works as an urban laboratory for testing innovative and sustainable technologies through an e-car sharing system and for introducing a new transportation model to be expanded on a commercial scale.	Porto Digital, MCTI, Government of Pernambuco, Recife City Hall, Serttel and Mobility
Mob-i Foz do Iguaçu (2014-2016)	The program embraced energy management systems for power supply, fleet management and EV sharing.	Itaipu Binacional. Itaipu Technological Park and CEiiA
Ecoelétrico Curitiba (The Ecoelectric City of Curitiba) (2014-2016)	To establish an intelligent, connected, integrated and sustainable mobility network focused on the management of EV charging stations and the implementation of a car-sharing system (by a lending contract).	Itaipu Binacional, Curitiba City Hall, Renault-Nissan-Mitsubishi Alliance, and CEiiA
Brasília Ecomóvel (The Ecomobile City of Brasília) (2014-2016)	To implement a sustainable management model for EV corporate fleets (by lending contract) and charging infrastructure that was managed by CEB (Brasília's electric power company) and Correios (the Brazilian Post). This project aims to test concepts and propose solutions during the 2014 FIFA World Cup.	Itaipu Binacional, CEB, Government of the Federal District, Correios, Renault-Nissan-Mitsubishi Alliance, and CEiiA
Mob-i UN (2015-2016)	To contribute to the reduction of air pollutant emissions and to demonstrate UNDP's commitment to the development of innovative technologies that employ renewable resources and reduce GHG emissions.	Itaipu Binacional, Renault-Nissan-Mitsubishi Alliance, and CEiiA, United Nations Development Program and United Nations Entity for Gender Equality and the Empowerment of Women.
Nissan fuel cells program (2015-current)	development of the world's first SOFC-powered vehicle system that runs on bio-ethanol electric power.	Nissan Japan, Nissan Brazil and ISTs

Table 7. (continuation)

Project and project duration	General objectives	Actors involved in the project
Business model experimentation to individuals and companies (2015-current)	Direct sale of vehicles to individuals and companies and the monitoring of usage and recharge patterns from selected customers	BMW
Construction of recharging infrastructure in strategic transportation corridors and highways (2015-current)	Partnerships for the construction of charging stations in car dealerships and commercial establishments, aiming to promote brands of associated companies	BMW and Electromobility Brazil
The Campinas fleet electrification (2015-current)	To test the electrification of the fleet of the city of Campinas (in the state of São Paulo) and assess costs and improvement in the quality of service and in the environment	Campinas City Hall, BYD Brazil, CPFL Energia, taxi drives and public transportation operators
Sales of EVs for business model analysis (2016-current)	Projects in partnership with private companies for testing business models	Renault
Alternative Vehicles for Mobility (VAMO) (2016-current)	To encourage and consolidate the concept of sharing in Fortaleza (in the state of Ceará), in addition to promoting sustainable urban mobility through a network of sharing of EVs in the city	Fortaleza City Hall, Serttel, Mobilicidade and Hapvida (sponsor)
E-buses in Brasília's public transportation (2018-current)	To renew the fleet and reduce of air pollutant emissions in Brasília (in the Federal District)	Piracicabana, BYD Brazil and Marcopolo
E-buses Operating in São Paulo (2019-current)	Compliance with new pollution reduction targets by municipal buses in São Paulo, 15 e-buses are operating.	Transwolff, BYD Brazil and São Paulo City Hall
VEM-DF (2019-current)	EV sharing in public fleets of the Government of the Federal District, composed of 16 Renault-Twizy which serves pre-registered public employees.	Renault, WEG Industries, Government of the Federal District, Itaipu Technological Park, Brazilian Agency for Industrial Development (ABDI)

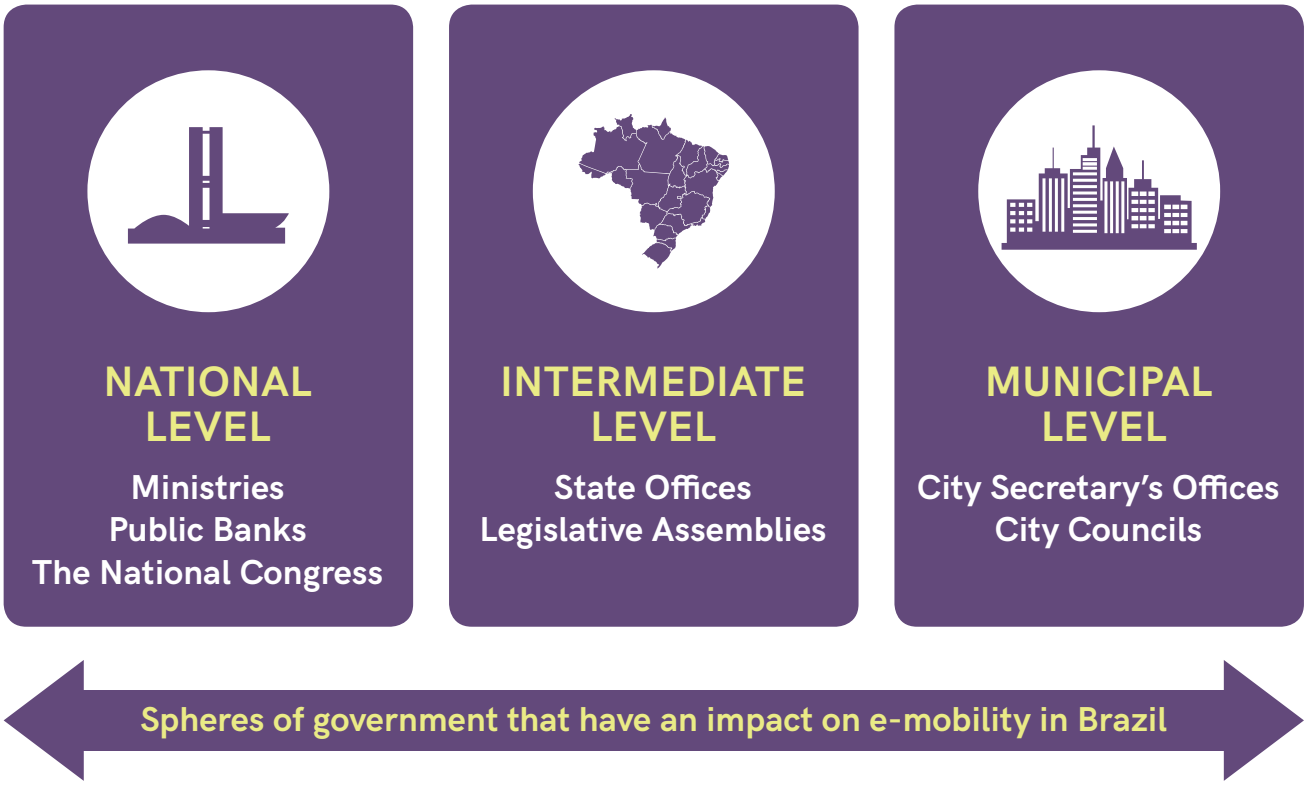
Source: Personal collection amended from De Sant'ana Fontes, 2018; Barassa, 2019; and ABVE, 2020.

3.3 Public policies and government instruments of promotion

This section aims to present and study the main initiatives on public policies, programs and debates promoted by the governments on e-mobility in the three Brazilian spheres of government (federal, state and municipal), their related government agencies, autarchies or entities (see Figure 17).

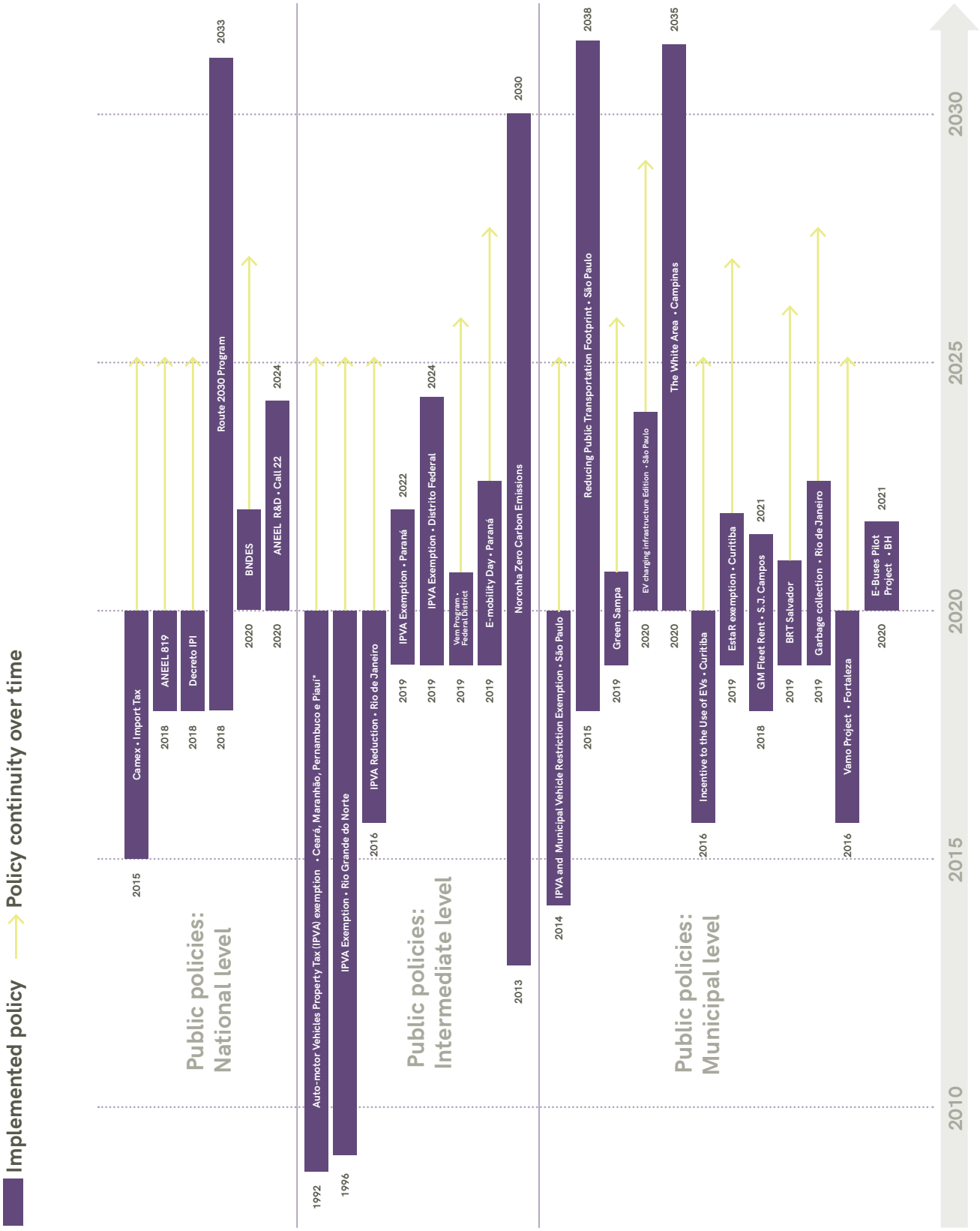
As for ongoing policies and programs, Figure 18 shows how those are mapped from a temporal perspective presented in a timeline from 2010 to 2030, though in some cases, policies go beyond the original observation range as they show promising continuity. When considering the progress made in recent years, we may observe a more intense practice from 2018 on. Some specific actions in the various layers suggest a scene of more daring planning and targets in the long run. A more detailed approach on those policies and programs can be found in the following section.

Figure 17. Public policies by government levels in Brazil



Source: Personal collection.

Figure 18. Timeline of policies that impact (either directly or indirectly) e-mobility in Brazil



3.3.1. Public policies at the national level: the federal government

I. Brazil Foreign Trade Chamber (CAMEX) Resolution n. 97, dated 26 October 2015

This resolution by CAMEX extinguishes the 35% Import Duty on BEVs and FCEVs. HEVs also benefit from that incentive, which ranges from 2% to 7% tax reduction depending on their engine capacity and energy efficiency.

"Considering EV market penetration scenarios until 2050, we can see the great importance of EVs in the future of urban mobility – EVs may even be first place in the global vehicle fleet by 2050, an estimate that also impacts many different sectors, such as the energy sector, which, in such case, strategic planning by governments is necessary so that society can benefit from this mass insertion of technology. Brazil will certainly be part of this trend."

Report of the Brazilian Panel on Climate Change (RIBEIRO & SOUZA, 2017)

II. Brazilian National Electric Energy Agency (ANEEL) Resolution n. 819, dated 19 June 2018

This resolution is the first one to establish rules for EVs, it presents the concept of free competition between different recharging service providers and it also establishes that said service and energy supply, commercialization and distribution are two distinct and disconnected phenomena. From that, we conclude that those who aim to sell an energy-supply-based service for EVs are allowed to choose a business model that best fits their business ideas.

III. Decree of the President of the Republic of Brazil n. 9,442, dated 5 July 2018

This Presidential Decree alters the tax rate on Industrialized Products (IPI) for vehicles powered by hybrid or electric engines. According to this measure, the cut in tax rates was from 25% to 7% for BEVs and from 25% to 20% for HEVs.

IV. The Brazilian Development Bank (BNDES) E-mobility Program

This is a strategy adopted by BNDES that aims to promote the development of e-mobility according to two main purposes: 1. Finance the ecosystem of e-mobility, automakers and auto parts manufacturers willing to boost the production of EVs in the country and 2. Finance companies that are willing to buy EVs to include them in new business models based on corporate fleets or urban mobility. Beginning in 2020, this opportunity is a watershed in the development of e-mobility in Brazil, offering more attractive credit rates for those willing to invest in this sector.

The approach of said strategy has three pillars:

i. **accreditation**, which refers to a gradual rate of minimum local content requirements, to be incorporated in the long run, and which follows special criteria to specify local content for the main technologies and component;

ii. **financing the production** of electric and hybrid vehicles, as well as their recharging equipment and components, especially the set up of assembly lines and production of traction batteries and fuel cells;

iii. **financing the purchase** of vehicles and equipment for business models for EVs and the construction of charging stations. This type of financing is also directed to the deployment of a hydrogen supply infrastructure, which is attained by ethanol reforming reactions, and the infrastructure of electric power distribution.

V. ANEEL R&D – Call 22

Chamada estratégica da ANEEL com o intuito de ANEEL launched this strategic class aiming to generate business and foster solutions to the e-mobility market regarding a 4-year period (2020-2024). The program covers business models, equipements, technologies, services, systems or infrastructures that support the development or management of EVs (see Figure 19). For that, approximately R$ 620 million were allocated for the project, which is the

Figure 19. ANEEL R&D CALL 22

Basis	Public policy	Target	Project resources
Law n. 9,991 as of 24/07/2000	Public policy to stimulate research and development and energy efficiency	Companies of the electric power sector	Through the compulsory application of resources from Net Operating Income (NOI)
General objectives			
1. Generate business and show the technical and economic feasibility of e-mobility 2. Generate knowledge and develop competencies for the creation of efficient e-mobility national products and services 3. Propose public policies and normative/regulatory instruments 4. Build networks and new production processes			
Specific objectives			
1. Create an innovation network 2. Analyze the technical, economic and financial feasibility of the project 3. Asses technological improvements and advances 4. Study technology adequacy and/or adaptation 5. Estudo de adequação e/ou adaptação das tecnologias 6. Asses components service life and EV performance 7. Propose a regulatory and commercial framework 8. Propose nationalization or local production of the developed technology 9. Business model			

Source: Personal collection.

Figure 20. Route 2030 Program

Basis	Public policy	Target	Project resources
Law n. 13,755 as of 10/12/2018	Policy for the automobile industry with long-term goals implemented in Brazil, that will be effective for a 15-year period (2018-2033)	Automotive sector (automobiles, trucks, buses, chassis with engine) and auto parts	Tax exemption
General objectives			
1. Support the technological development 2. Promote competitiveness and innovation 3. Establish vehicle safety standards 4. Act to protect the environment through energy-efficient propulsion systems 5. Maintain high quality standards 6. Expand the global insertion of the Brazilian automotive industry through the export of vehicles and auto parts			

Source: Personal collection.

greatest amount of money ever invested in the e-mobility initiative in Brazil.

It is expected that the projects developed come to the latest stages of the innovation value chain with products and solutions to be presented; the results of the Program, likewise, may contribute to the assessment of the economic and technological impacts of projects in order to promote the insertion of those in the market

VI. Route 2030 Program

The Route 2030 Program is the first policy for the automobile industry with long-term goals implemented in Brazil, that will be effective for a 15-year period (2018-2033). Right in its launch, a series of regulations and incentives by the Program were defined, which are aimed to improve the transport sector competitiveness and logistics in the country. The Program also includes the promotion of activities and innovations regarding biofuels and new propulsion technologies, which also embraces those concerning e-mobility (see Figure 20).

As a prerequisite for participants, automakers shall improve their energy efficiency in 11% by 2022. That concerns phase I and its more restrictive targets for the 5-year period of 2027-2032. In order to reach their targets, projects can be developed with local R&D support contained in this law (Law 13,755/2018).

The policy also comprises incentives for projects developed between companies and universities, with R&D expenditures covered by tax exemption granted by the federal government.

The calls for proposals in point V, especially, stand out (they regard Biofuels, Automotive Safety and Alternative Propulsion Systems). Those calls for proposals will grant R$ 21 million to support projects in Institutes of Science and Technology (ISTs) that form partnerships with start-ups and automotive supply chain companies so as to foster the development of the national industry and research.

3.3.2. Public policies at the intermediate level: state governments

At a state government level, many states adopted the Auto-motor Vehicles Property Tax (IPVA) exemption policy for EVs.

According to ABVE, besides the Federal District, 8 other states grant this exemption, as follows: Ceará, Maranhão, Mato Grosso do Sul, Paraná, Pernambuco, Piauí, Rio de Janeiro and Rio Grande do Norte.

Sometimes federal policies or local policies for the governance of e-mobility stand out more. However, it is convenient to acknowledge possibilities of contributions state governments can make through policies aiming to work towards regional level solutions, or even through partnerships between municipalities that want to tackle common issues.

For instance, it is viable to have infrastructure equipment, like charging stations, shared according to legal-administrative contracts through well-established agreements and the rights and duties defined between the parties, which goes beyond a local planning level.

3.3.3. Public policies at the municipal level: local governments

I. São Paulo

São Paulo is the biggest metropolis in South America and has adopted some actions in favor of e-mobility, since its urban context is densely populated and industrialized.

The first action taken was the City Law 16.802/2018, which requires vehicles used in public transportation to commit to a 50% cut in emissions in 10 years and a 100% cut in 20 years. Particulate Matter ($PM_{2.5}$) emissions shall drop around 90% and 95% nitrogen oxides (NO_x) around 80% and 95%. Such a measure stimulates the adoption of e-buses by the municipality, whose current fleet consists of more than 14,000 diesel buses. On December 6th, 2019, the São Paulo City Hall started issuing bids for 32 contracts of the new public transportation system in the capital.

In addition, City Law 15,997/2014 stipulates the Auto-motor Vehicles Property Tax (IPVA) exemption concerning its municipal share for BEVs, HEVs and FCEVs for the first 5-year period of taxation of vehicles below R$ 150,000. As an incentive for EV owners, said law also exempts those from the municipal vehicle restriction.

Three other municipalities in the state of São Paulo offer the same benefit of exemption: Indaiatuba, São Bernardo do Campo e Sorocaba.

It is also worth mentioning the Green Sampa Program of the municipality of São Paulo, led by its Local Secretariat for Economic Development and Labor and carried out by the São Paulo Development Agency. This initiative aims to bring together strategic actors of the sustainable technologies sector in order to create a platform for innovative solutions that foster the development of the sector with green technologies. Although not being its main focus, there are lines of action in the program that dialogue with e-mobility.

More recently, on March 30th, 2020, City Law 17,336 was enacted and it determines that residential and commercial buildings in São Paulo offer EV charging

solutions. These solutions must follow Brazilian technical standards, and both energy use and fees shall be individualized. The determination is valid for projects filed as of March 2021, when the law officially comes into force.

II. Campinas

Campinas is the biggest countryside city in the state of São Paulo and has started issuing bids for the improvement of its public transportation system. Among other proposals of its new system, we highlight the creation of the so-called "Área Branca" (the White Area) a non-polluting-bus-only lane. For said target to be hit, a demand of 339 e-buses is expected, which will make up a total of 34 urban lines that will run through the central region as a common area. It is in said central area that of the public transportation trips occur. The municipality expects to reduce GHG emissions by 32%.

III. Curitiba

In Curitiba, in addition to demonstration projects, the City Hall enacted the exemption of Regulated Parking Areas (EstaR) fees for BEVs. The measure applies both to private vehicles and to car-sharing systems vehicles. In the case of private individuals, the exemption is up to two hours in the city's parking areas; for shared cars there is no time limit.

3.4 An environment of business, funding and promotion with private equity and Venture capital

The environment of business and investment via private equity and Venture capital funds are essential to the development of e-mobility in Brazil. Such a process cannot be restricted to actions by the federal government, instead it demands initiatives by actors in the private sector for the development of processes, products, demonstration projects, construction of facilities and other options that can help the country reach convergent efforts that will promote actions for the development of a sustainable urban mobility model.

Recharging infrastructure-related businesses stand out in this context, being those which supply, construct charging stations or develop new energy supply models. Noteworthy in this scenario is the offer of EVs as products (business as usual), as well as services (new business development), such as sharing and rental services.

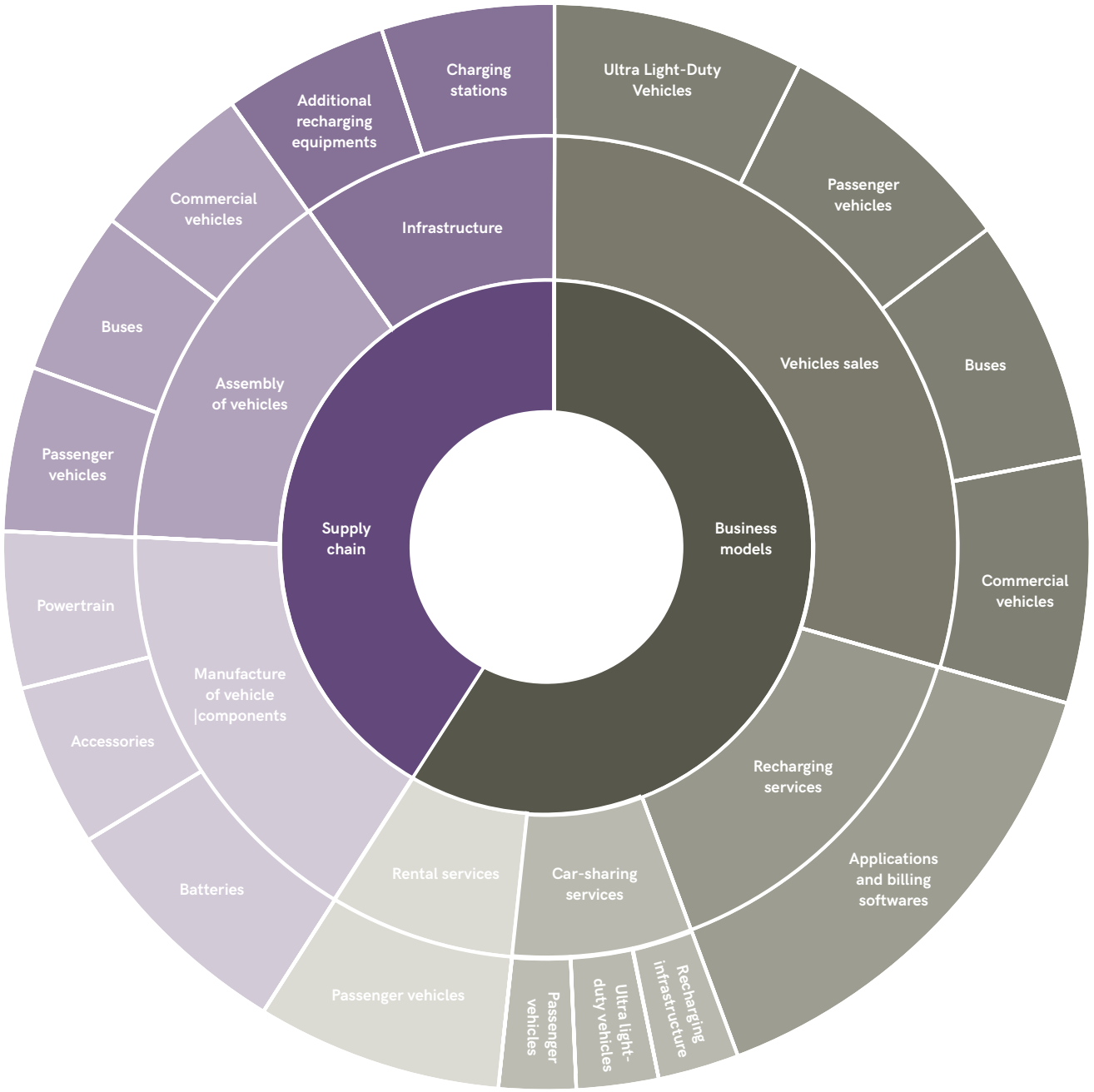
Investments in e-mobility can be noticed in the form of the transformation of the auto supply chain by components needed, creation of services (car-sharing) and the deployment of recharging infrastructures.

When it comes to mapped private equity and Venture capital actions in Brazil (mapped non-exhaustively), there is in its first layer the investments in the supply chain and, in another layer, those that represent new business models.

As for the supply chain, its activities involve infrastructure, production of vehicles and their components. As for new business models, activities regarding sales of EVs, recharging services, as well as sharing and rental services.

The categories previously mentioned are presented in more detail with a third layer, as in Figure 21, in which specific niche markets connect to each of said categories, resulting in a scenario of various action plans.

Figure 21. The environment of business with private equity and Venture capital



Source: Personal collection.

Table 8 presents investment profiles in the supply chain in more detail, it shows the main examples of identified projects and related companies.

In the same way, Table 9 shows companies that stand out from the perspective of new "Business Models" development.

Table 8. Examples of investments which participate in the transformation of the auto supply and product implementation.

Operation	Category	Companies	Target	Year
Manufacturing of vehicle components	Accessories	WEG and Randon Companies	Development of electric semi-trailer with e-Sys system	2019
	Powertrain	WEG Industries and FuelTech	Development of technologies for converting conventional vehicles into an electric vehicles (EV)	2019
	Batteries	Moura Group, XALT Energy and Eletra	Imported battery tropicalization	2019
		BYD	Build a lithium iron phosphate (LiFePO) battery plant in Manaus	2020
		Oxis Brazil and Codemge	Build the world's first lithium-sulfur (Li-S) battery manufacturing operation in Minas Gerais	2023
		Moura Group, CATL, Eletra and VWCO e-Consortium	Partnership for battery module life cycle management	2019
Infraestructure	Charging Stations	Electric Mobility Brazil and Bradesco	Construction of 12 charging stations in commercial buildings	2018
		EDP Brazil, Federation of Industry of the State of Espírito Santo (FINDES) and SENAI	Construction of 7 charging stations in Espírito Santo	2019
		Moura Group and Neosolar	Construction of a network of charging stations in the Northeast	2019
		Audi and Engie	Construction of 200 charging stations	2020
		NeoCharge and Leroy Merlin	Construction of charging stations for customers	2020
		ABB e Aldo Electronic Components	Import and distribution of energy inverters and chargers for EVs	2020
Assembly of vehicles	Commercial Vehicles	Volkswagen, Bosch, CATL, Moura Group, Semcon, Siemens, WEG Industries, Meritor and Eletra	Development and manufacturing of an electric truck	2019
Vehicle sales	Buses	Volkswagen, WEG and Marcopolo	Development of plug-in hybrid flex buses	2018

Source: Personal collection.

Table 9. Examples of the development of new business models

Operation	Category	Companies	Target	Year
Rental services	Ultra Light-Duty Vehicles	Riba Brazil and iFood	E-moped rental for delivery drivers	2019
Sharing	Passenger Vehicles	Beepbeep and Renault	EV sharing	2019
		Renault and MRV Engenharia	Vehicle sharing in private enterprises	2019
		Renault, Itaú, Joycar and Efacec	Vehicle sharing in private enterprises	2019
	Recharging infrastructure	Vela Bike	Construction of 100 e-bike charging stations	2019
	Ultra Light-Duty Vehicles	Riba Brazil and CEiiA	E-moped sharing	2019
Venda de Veículos	Commercial Vehicles	BYD and Unilever	EV purchase for delivery service	2020
	Commercial Vehicles	Volkswagen and Ambev	E-truck test in urban environment	2018

Source: Personal collection.

From the examples shown previously, we highlight the following:

I. Project in which the partnership between Oxis Brazil and Minas Gerais Economic Development Company (Codemge) is formed. The purpose of this cooperation is to build the world's first lithium-sulfur (Li-S) battery manufacturing operation. The initial focus is Heavy-Duty Vehicles, either passenger or goods vehicles, as well as the Aerospace/Defense Industry (A&E). The annual production is expected to be 300,000 cells, which can go as far as 5 million Li-S cells per year. Among the companies interested in those Li-S cells, there is the Brazilian company Embraer, the North Americans Boeing and Lockheed Martin, the European aircraft-manufacturing consortium Airbus and the German Mercedes-Benz and Porsche. The target is to invest around R$ 245 million and have the plant operating by 2023.

II. The partnership between EDP Brazil, the Federation of Industry of the State of Espírito Santo (FINDES) and the National Service of Industrial Apprenticeship (SENAI) resulted in the largest EV charging networks in the Espírito Santo state. This project covers the construction of 7 charging stations in the municipalities of São Mateus, Nova Venécia and Guarapari. Those units located in public areas allow two cars to simultaneously recharge in the fast mode. Despite the initial investment of R$ 350,000, at first, the user will not be charged for the service, the only requirement is for users to register and have a card provided by EDP Brazil.

III. The partnership between Audi and Engie will invest R$ 10 million in the construction of 200 charging stations by 2022. Engie will handle the construction, maintenance and operation of the stations and its app to access the service.

IV. In 2019 Volkswagen Truck & Bus (VWCO) led the initiative of the e-Consortium, which aims to develop and manufacture the first Brazilian e-trucks in its facilities in Resende (RJ). An initial investment of around R$110 million was announced. Many companies are part of this partnership, such as: Siemens, which will handle infrastructure (charging stations and energy supply); CATL and Moura, which will supply battery modules; Bosch and WEG Industries, which will supply components; Semcon, which will provide engineering services; Meritor, which will supply electric axles for EVs; and Eletra, as an strategic partner.

V. The BeepBeep start-up operates a fleet of Renault Zoe EVs via a car-sharing system available in the municipalities of São Paulo and São José dos Campos and that will soon start operating in Porto Alegre. Vehicles can be enabled for use through an app, and are supported by several charging stations built by the start-up in private areas, such as shopping malls, supermarkets, corporate housing buildings, parking lots and hotels. The initiative's initial investment was around R$ 3 million.

VI. The Brazilian e-bike manufacturer Velabike has announced the construction of 100 charging stations in cafes in the municipality of São Paulo by the end of 2019. Each station costs an average of R$ 8,000, totaling an investment of approximately R$ 800,000. Despite the investment, the service is free for those who own a Velabike. The expectation is that other bike brands can also use the charging structure.

3.5 The role of accumulators in Brazil's commodity chain: a look into possibilities for the lithium battery supply chain

In general, we can affirm that batteries in Brazil – when considering auto parts – are in its majority produced by domestic investment companies, which represent 75% of the market.

This industry is mainly of lead-acid battery, its production is directed to OEM (Original Equipment Manufacturer) markets and replacement products, with an average participation rate of 24% and 76% respectively, operating as a large industrial park especially in the states of São Paulo, Paraná and Pernambuco.

Although there is a strong presence of lead-acid batteries in manufacturing, the country supports R&D initiatives as well as demonstration projects regarding the development of the lithium battery value chain.

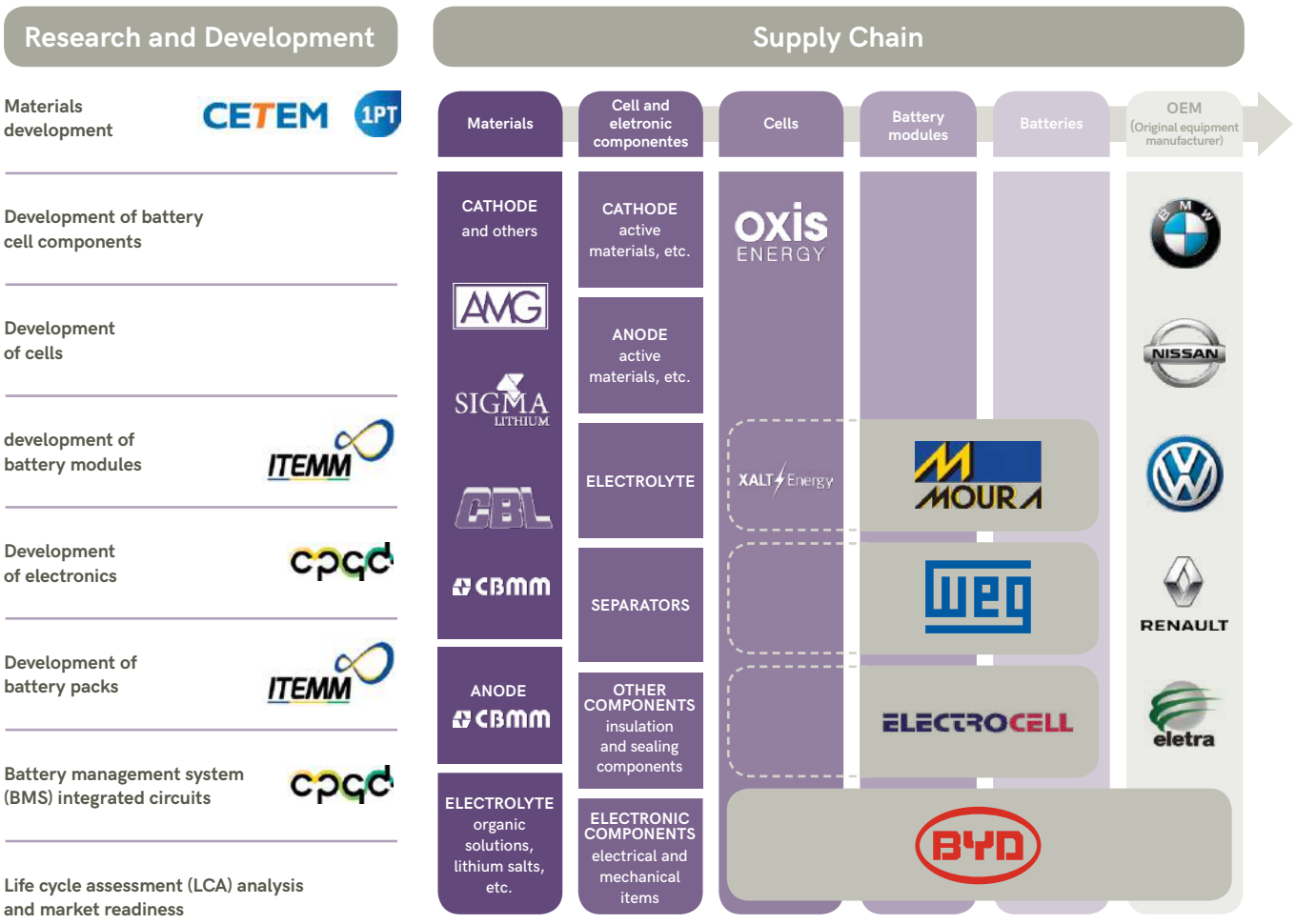
When we talk about R&D initiatives, CETEM (Mineral Center for Technology) and IPT (Institute for Technological Research) have historically worked on issues concerning the development of materials (see Figure 22), especially on the processing of lithium for use and industrial applications.

Likewise, the Institute Edson Mororo Moura (ITEEM) has been playing an important role in research, development and innovation in energy accumulators by contributing with their competencies in the application of cells in modules and in the design of battery packs. Additionally, the Telecommunications Research and Development Center (CPqD) has carried out a number of projects of varied applications, having then gained wide experience that was shared with the electronic systems project (BMS), the battery pack production, and vast knowledge of batteries testing and approval.

In fact, there is still room for the development of competencies in advancing cells and their components, and, at the same time, it is necessary to define actors that will contribute to market and Life Cycle Assessment (LCA) analysis. All in all, the set of essential competencies is already a reality and that boosts the development of an ecosystem of research, development and innovation.

Next, we present and analyze some different perspectives of performances in the supply chain.

Figure 22. R&D actors and the lithium battery supply chain in Brazil



Source: Cruz, 2020.

3.5.1 Suppliers of battery materials – Lithium

When it comes to suppliers of battery materials, more specifically lithium (a cathode precursor), we can say that Brazil's production has always been small-scale, the country produced only 0.6 thousand tons of lithium in 2018, accounting for about 0.5% of the global market.

Brazilian Lithium Company (CBL), located in Araçuaí (Minas Gerais state) produced the aforementioned lithium. CBL has made partnership investments in the Minas Gerais Economic Development Company (CODEMGE) – and is specially focused on the goods for domestic consumption , such as lubricants and ceramics.

In the last years, the activities of the sector were more intense, as in the case of AMG Mining in Nazareno (Minas Gerais) which invested R$ 450 million in an operation that started in 60% of its capacity, producing 90,000 tons of spodumene (a source of lithium) per year. With such volume, the potential for lithium extraction, which is a necessary input for the chain, is about 5.4 thousand tons.

Furthermore, Sigma Mining, located in the valley of the Jequitinhonha – between the cities Araçuaí and Itinga – started a big operation for lithium production in 2018, its planned production target was 220,000 tons of spodumene per year from 2020 on, with a potential for lithium extraction of 14,000 tons.

In face of this, new actors were mobilized and took their role in the chain and, when considering the demand for new exploration and extraction of lithium in the country, future growth is expected.

As for anode, the Brazilian Metallurgy and Mining Company (CBMM) – located in Araxá (Minas Gerais) – is the largest niobium producer in the world. In 2018, it partnered with Toshiba Corporation aiming to replace the carbon anode with a titanium-niobium composite oxide (NTO – Niobium Titanium Oxide), while maintaining the traditional cathode configuration. Thus, it is expected that the volumetric change and the related mechanical stresses during the recharge process will be reduced, which would otherwise lead to cracking and anode disintegration. The partnership between CBMM and Toshiba establishes that each side will invest US$7.2 million in a pilot plant being built in Yokohama, Japan, where the first units are expected to be produced by 2021.

Another project, still in its early stages of development, aims to apply niobium in making cathodes. In this project CBMM partnered with the North American Wildcat Discovery Technologies in San Diego, California.

3.5.2. Cell suppliers

Oxis Brazil, born from the partnership formed between the Brazilian Codemge and the English Oxis Energy, has become the world's first lithium-sulfur (Li-S) battery manufacturing operation. Its primary focus is Heavy-Duty Vehicles, either passenger or goods vehicles, as well as the Aerospace/Defense Industry (A&E), such as drones, satellites and eVTOL – Electric Vertical Take-off and Landing aircrafts.

Planned to be constructed in Juiz de Fora (Minas Gerais), the factory's initial investment was R$ 245 million and the plant is expected to start operating by 2023 with an annual production of 300,000 cells, which can go as far as 5 million Li-S cells per year. Among the companies interested in those Li-S cells, there is the Brazilian company Embraer, the North Americans Boeing and Lockheed Martin, the European aircraft-manufacturing consortium Airbus and the German Mercedes-Benz and Porsche.

The English company Oxis Energy owns the cell technology and received the amount of R$ 18.6 million from Codemge through the Aerotec fund (a Private Equity fund anchored by Codemge). By doing so, Codemge invested a 12% stake in Oxis Energy and brought to Brazil the project of a production facility aiming for a more intense lithium commodity chain in Minas Gerais. The Li-S cells technology has been on the radar of Sony, for smart-phone applications and Sion Power Corporation, for automotive applications.

Build Your Dreams (BYD), one of the main EVs and batteries manufacturers, opened its factory in Caminas (São Paulo) in 2014. In 2016, its e-bus chassis assembly line started operating with an annual production of 720 chassi (which can go as far as 1,440 per year) and in 2017 it inaugurated its solar panel plant. In August 2020 its third factory was opened in the Manaus Industrial Pole (in the state of Amazonas) and is focused on the assembly of lithium iron phosphate (LiFePO) batteries to be mainly applied in the buses manufactured in the Campinas plant. Depending on the demand, BYD plans to build a plant for cell production, which will be also located in Manaus.

3.5.3. Battery modules and packs suppliers

Moura Group, a traditional Brazilian lead-acid battery manufacturer, partnered with the Chinese company CATL to supply and manage the Chinese batteries life cycle that are imported to be used in the hybrid bus DualBus by Eletra bus manufacturer from São Paulo as well as in the models to be produced by the Volkswagen Truck & Bus (VWCO) e-Consortium, which will start producing the light-duty truck e-Delivery by the end of 2020. There are plans concerning a potential construction of a battery module assembly line facility with 1 GW annual installed capacity, which is enough energy supply to move about 2.5 thousand e-buses per year. On another note, the partnership between Eletra and the American company Xalt Energy was celebrated. Eletra intends to adapt Xalt's battery technology for operating conditions in Brazil.

In 2019, the Brazilian multinational WEG Industries acquired the Energy Storage System (ESS) business of Vermont-US-based Northern Power Systems Corp. (NPS). In this transaction, WEG became the owner of NPS's assests, patents and know-how. Such a transaction was part of WEG's strategies that expects a global growth in the battery energy storage market that will combine lithium batteries with wind and solar energy generation.

It is known that in the US WEG is focused on the installation of energy storage units in substations, while in Brazil the company intends to foster solutions in energy security based on hybrid battery models and renewable energy generation. Hereupon, WEG has incorporated competencies in battery modules and packs, and it has now a favorable position to operate in the auto market, since the company already owns electric propulsion system components and technologies, such as power electronics and motor drive systems.

Electrocell, located in the Center for Innovation, Entrepreneurship and Technology (CIETEC) of the University of São Paulo (USP), has been working on the development of lithium-ion batteries since 2007. It stands out in partnerships for battery supply that follow the model of importing cells and integrating them into lithium batteries locally (which involves designing and manufacturing battery modules and cells).

The prospects point to more intense activities in the development of the battery supply chain in Brazil and show relevant R&D and innovation competencies.

Professional training and skilled human resources in e-mobility in Brazil

3.6

For its diffusion in the country, e-mobility demands training of human resources for technical capacity to deal with issues brought by EV new technologies. In the auto industry environment, where professionals are used to dealing with internal combustion engine conventional technologies, it is important that opportunities be granted so that said professionals at all levels can acquire and broaden knowledge in favor of e-mobility.

The ideal profile of a professional who deals with e-mobility technologies is of a person who can adopt an integrated approach of building different blocks of competency, which means that the worker will not only have a good understanding of EV parts and its functions, but will also be aware of how EVs integrate with the power grid, and how all that works in new business environments.

In this regard, offering workers training courses is as important as companies and personnel showing interest in building up a more technical profile for themselves aligned with these new technological trends. Another clear challenge concerns educational institutions, in the sense of working towards the creation of courses and subjects that embrace the training of professionals in the auto industry.

In this scenario, it is worthy to mention the Brazilian-German Cooperation for Sustainable Development, initiated by the German Agency for International Cooperation (GIZ), which fosters the Energy Systems of the Future initiative and the National Platform for Electric Mobility (PNME). Those projects brought together actors of Higher-educational Institutions (HEI) and the productive sector in a partnership with ABVE to debate and propose 4 course subjects to be adopted by HEIs in the training of qualified human resources that wish to meet the needs of the national market.

From 2021 on, 4 subjects designed by the Cooperation projects are part of the HEIs curricula: (1) Low-emission mobility: energy efficiency and vehicle electrification technologies; (2) Strategic Management of E-mobility; (3) E-mobility general outlook: vehicles, infrastructures and grid integration; (4) Energy storage units for e-mobility: vehicle/infrastructure technologies and interfaces.

In Brazil, some courses and subjects for the qualification of professionals in the auto industry are offered. Table 10 presents some training initiatives in that field.

Table 10. Initiatives of courses and subjects on e-mobility

Course / Subject title	Title of program	Institution	Campus
Hybrid and Electric Vehicle Engineering	Postgraduate (Lato sensu)	National Service of Industrial Apprenticeship (SENAI PR)	Curitiba – PR
Hybrid and Electric Vehicle Engineering	Postgraduate (Lato sensu)	Claretiano – Educational Network	Rio Claro – SP
Automotive Energy Efficiency	Specialization	Federal University of Paraíba (UFPB)	João Pessoa – PB
Hybrid and Electric Vehicles	Update Course	MAUÁ Institute of Technology	São Caetano do Sul – SP
Hybrid and Electric Vehicles	Undergraduate	Federal University of Minas Gerais (UFMG)	Belo Horizonte – MG
Electric Traction Systems	Undergraduate	University Center of FEI	São Bernardo do Campo – SP
Alternative Propulsion Systems – Hybrid and Electric	Specialization	University Center of FEI	São Bernardo do Campo – SP
Flow batteries and fuel cells	Postgraduate (Stricto sensu)	UNICAMP -Faculty of Electrical and Computer Engineering (FEEC)	Campinas-SP

Source: Personal collection.

Conclusions 3.7

This chapter aimed to detail the ecosystem of e-mobility in Brazil from a perspective of actors thereof. On this topic, in general, actors are still in the process of building their networks, forming partnerships for a better performance in the domestic market and interpreting their roles and space to be taken in such an environment. These conclusions show that the actors are still in the process of understanding their own positions in the value chain, as well as the possibilities of action in their fields in view of the possibility of insertion of EVs in Brazil.

In fact, those elements converge to the place occupied by the Brazilian market in the world, which was the topic of Chapter 2, and strengthen the embryonic stage of e-mobility in Brazil.

Still, it is noteworthy in this inter-sectoral composition, where the interaction between the transportation sector and the electrical and electronic industries is essential, that opportunities for new players to enter the sector are being created, given that the connection with the new sectors is still narrow. In other words, new players, sectors and business models are now welcomed in this scenario that they did not participate in before.

Let's say, for instance, the electric power sector, fundamental to the recharging infrastructure; or even the supply chain of electronic components such as electric motors, and more specifically, EV accumulators and batteries, which are key to e-mobility.

And based on the entrepreneurial initiatives reported and observed in this chapter, we can see the structuring of new collaborations and arrangements between the actors that make up this ecosystem.

The interaction and the establishment of new partnerships between those actors support the emergence, expansion and consolidation of new networks, which emerge to overcome barriers and which leverage the development of new businesses.

In section 3.2, we saw the existing public policies that impact or, in some way, deal with e-mobility. The list of policies mentioned in this publication may boost entrepreneurial activities already underway in the country, but it would be opportune to design more robust public policy instruments for the promotion of EVs, so that an institutional framework that allows and facilitates market expansion is built.

We also learned about the multiplicity of instruments that make up the interface of the e-mobility spheres and the efforts, albeit timid, made through municipal, state and federal policies. It is worth mentioning the important strategic announcement of ANEEL's R&D program which, in 2020, started to direct, through its companies in the electric power sector, approximately half a billion reais to EV-related projects in Brazil.

Finally, we analyzed business environments. We presented some cases that show how investments via private equity and Venture capital funds are an essential part in the development of e-mobility in the country. In fact, we learned that the window of opportunity associated with new businesses is presented by investments in services that have e-mobility as a conducting wire – see EV recharging infrastructure-related businesses – being those which supply, construct charging stations or develop new energy supply models.

Noteworthy in this scenario is the offer of EVs as products (business as usual), as well as services (new business development), such as sharing and rental services. We can also point out activities related to the batteries and accumulators commodity chain, which leads us to a discussion focused on technologies pro e-mobility and to conclude that in Brazil some local production initiatives are beginning to emerge.

In conclusion, with regard to professional training, the mapping of courses being offered in the country shows that the training on e-mobility of professionals in the auto industry is an ongoing reality that grows at the same speed at which this market is expanding.

The impact of COVID-19 on e-mobility in Brazil: an analysis of barriers and opportunities identified in this scenario


WHAT ARE THE IMPACTS COVID-19 BROUGHT TO E-MOBILITY AND TO ITS VARIOUS MODES OF TRANSPORTATION?
WHAT ARE THE REAL BARRIERS?
ARE THERE ANY OPPORTUNITIES?
4

4.1 Introduction

COVID-19 can be characterized as a unique event on a global scale for the year 2020. By considering its alarming levels of spread and severity, COVID-19 impacted national societies and economies directly, since social distancing was recommended as a mechanism to slow down and prevent the spread of the virus. As a result, commercial establishments of most economic sectors were closed and face-to-face activities in various contexts (schools, churches, gyms and others) were suspended.

In fact, Brazil followed those guidelines at large and so it suffered income loss and bilateral trade relations reduction in the first semester of 2020. Taking this wide set of sectors and segments impacted by the COVID-19, e-mobility was not an exception as it suffered in various ways, which then shaped new paths to this segment in Brazil.

It will be from the context presented above that this chapter will develop its objective of presenting and debating the impacts of COVID-19 on the evolution of e-mobility in Brazil. Said impacts will be interpreted from the analysis of barriers and opportunities for e-mobility in Brazil brought by the pandemic. Hence, it is important to understand the types of elements that affect investments presented previously in Chapter 3 and how they may impede or limit the expansion of e-mobility technologies. As importantly, it is essential that we recognize if there are opportunities in this context and the kind of factors and mechanisms of induction could strengthen EV-related activities.

In regards to sources of the information hereby presented, the results obtained were based on answers from a semi-structured questionnaire carried out with more than a dozen specialists in the mobility sector and from different institutional layers (academia, government, automakers and system administrators of the electric power sector, for example). In a complementary way, secondary sources were used and cited throughout the text. On this methodological aspect, see appendices for details on the procedures adopted in the development of this chapter.

Despite being discovered at the end of 2019 in China, it was in the beginning of 2020 that COVID-19 spread widely over countries and reached the status of pandemic after a community level outbreak.

As a conceptual starting point, we will present opportunities, actions, factors and circumstances created by COVID-19 that can help in the development and acceleration of e-mobility. This way, we will show what the pandemic may have provided as levers for opportunities that have not yet been explored and how they may be interpreted. We also present, when relevant, technological alternatives, some ideas on new business models and necessary elements for the sector from a public policy and governance perspective.

Barries, on the other hand, involve impacts and aspects brought by COVID-19 that impede or limit the expansion of e-mobility in Brazil.

It is imperative that we study such elements and present them in this Annual Report, since it will be from said investigation that impacts regarding debates on market forecasts and governance for e-mobility in Brazil will be assessed, topics to be discussed in following chapters. In order to present the results obtained, this chapter is organized in sections, as follows: public transportation, commercial vehicles, private passenger vehicles, micro-mobility.

4.2 Public transportation

Within the scope of this Annual Report, public transportation includes battery-powered e-buses connected to the grid and fed by an overhead line.

Table 11 shows the main barriers and opportunities for electric public transportation growth in Brazil mapped in the COVID-19 scenario.

4.2.1. Barriers

Based on interviews we conducted, the public transportation sector, in general, was hit hard by the pandemic. That was caused due to a decline in the number of daily passengers, and consequently, daily fare losses and reduction in pay of employees.

Table 11. Barriers and opportunities for electric public transportation growth brought by COVID-19

BARRIERS	OPPORTUNITIES
• Decline in the number of daily passengers, of public transportation due to the COVID-19 pandemic • Postponement of investments in e-buses • Financial fragility of private operators which went through processes of operational restructuring and cost reduction • Price fluctuation due to exchange rate imbalance • Economic and financial imbalances of city halls • Public transportation users switching to individual cars • Process of stigmatizing public transportation as a locus for contamination of COVID-19 • Outdated business model when compared to current technologies and models	• An appropriate time for discussing new business models and new fare systems • Operational restructuring of public transportation companies • Changes in visible air pollution and air quality in large urban centers during the pandemic • The pandemic reinforced public awareness of the importance and the need to prioritize public transportation • COVID-19 imposed the use of management tools that will bring a positive legacy on indicators and quality assessment of the service provided

Source: Personal collection.

According to those interviews, ridership was down 70%, resulting in a 30% to 40% retraction in revenues obtained by daily fare, on average, in Brazilian cities.

In fact, during the studied period, some people changed their habits, including those regarding the way they commute. For instance, in Brazil, approximately 77% of employees of small and medium-sized companies started to work remotely, from home. Another change was that people had to abide by social distancing guidelines, which means that people could no longer come into close contact with each other, a measure intended to prevent the spread of the virus COVID-19. Those are antagonistic elements to public transportation use, which, in its operational essence, involves groups of people travelling inside a shared mode of transportation and whose purpose is to take people to their respective workplaces, predominantly.

There is another element to aggravate the scenario: an increase of operating expenses for public transportation operators, who had to follow cleaning and disinfecting procedures of buses because of the pandemic.

This set of aspects clearly also affected investments and actions that were expected to happen, in this case, to e- mobility. According to the interviews carried out, companies and investors saved their resources and investments – some of which were destined to the acquisition of new propulsion technologies for public transportation – since the drive in such a scenario is to work towards better circumstances in view of the financial difficulties imposed by COVID-19. Still based on the interviews, actions by the public transportation sector were, in fact, directed to the maintenance of its operational survival.

In this sense, we can see clear actions of companies in this sector on their own internal reorganization by reducing their operating expenses; when it comes to making investments, it is a component not yet to be explored or developed hereby.

In view of the severe effect on the public transportation system, in these interviews we found that acquisition processes of e-buses for the year 2020 were suspended by some operators, without any concrete prospect for their resumption.

In addition to the losses suffered by operators themselves, cities where these technologies were used have also shown interest in postponing agreements and resolutions for EV fleet transition and use of new propulsion systems, especially cities that had signed commitments to this scope. São Paulo is an example in this regard. The city declared a temporary postponement of the obligations imposed by the Municipal Policy on Climate

Change of São Paulo (Law n. 14,933/2009), which has a direct effect on the transition to low-emission buses, including electric ones.

In addition, e-buses became more expensive in this period, which resulted in a barrier with higher acquisition costs. Considering that most EV components are not manufactured locally, for example, batteries (being the most critical component, in this sense), so it is necessary to import said components and even entire vehicles all together. In this sense, in the pandemic, according to Infomoney, the depreciation of the Brazilian real against the US dollar was 35.6% as compared to the cumulative revenues of June 2020.

In summary, said depreciation directly affected the prices of imported goods. Such new values put investments in e-buses even more in check.

Similarly, this scenario of COVID-19 also had an impact on the plans of new market entrants, companies that supply vehicles and components, which will reevaluate their business expansion plans in the Brazilian market.

Another barrier identified as a consequence of COVID-19 is the broad understanding of public transportation as one of the main transmission routes of the virus. This process of stigmatizing public transportation as a locus for contamination has influenced users to seek other forms of mobility, such as individual cars or micro-mobility vehicles.

In short, the set of elements presented previously – drop in demand due to COVID-19, financial fragility of private operators, public policies being paralyzed, postponed or suspended, systems based on daily fare collection suffering losses and currency volatility challenges to acquisition of imported goods – create, as a whole, a great pressure for the introduction of e-buses to be stopped, rethought and invariably postponed.

However, this scenario of extreme uncertainty and challenges have a certain duality, as opportunities revealed are precisely resultant of the pandemic. The next section will present how to explore this other side to electric public transportation.

4.2.2. Opportunities

When we think of all the difficulties previously studied, still, we spot some positive factors within this perspective of COVID-19, which can be seen as opportunities for electric public transportation.

According to experts' viewpoints, this moment of crisis in public transportation also revealed a crisis in the current business model in which this segment is shaped. In this case, it refers to the current model in which operation is linked to ownership.

The dramatic drop in public transit usage during COVID-19 can be interpreted as an appropriate time for this system and its operation to be rethought and alternatives discussed. An example given by the experts interviewed during the development of this publication refers to a new procurement approach that separates bus ownership from operation and maintenance.

In the current model, the transport operator holds all ownership of assets, including their associated operating expenses; therefore, one option is to share those responsibilities with other actors. For example, the Chilean model allows the entry of players from the electric power sector as participants in this model, whereas new players in the former are owners of assets (e-buses). In short, this ecosystem can be more sophisticated if we consider contemporary business models.

To learn more, we suggest the publication "Electromobility in Public Transportation: the case of the city of São Paulo", carried out by WRI Brazil in partnership with Unicamp.

"Transportation is a social right to Brazilians provided by the constitution, so it is up to governments, during social isolation, to guarantee its functioning for both those who work to overcome the health crisis and those who work in essential services for the population."

(WRI, 2020, p.1)

By taking into account a possible reformulation of the procurement approach, we can see greater investment attractiveness for this segment in the national scenario. And this greater attractiveness has the power to leverage other companies and get new players into this ecosystem, which will then result in new products and services to be offered.

Another extremely notorious aspect that was mentioned in the interviews was the role of vehicles in air pollutant emissions in cities. During the pandemic, air pollution averages were well below those observed routinely and it was possible to notice changes in visible air pollution and air quality in large urban centers. COVID-19 made the problem of air pollution explicit and EVs came as a real alternative to pollution mitigation measures. In a way, this contrast exposes the possibility of mobilizing public managers towards the e-mobility cause.

Finally, the pandemic reinforced public awareness of the importance and the need to prioritize public transportation, being considered an essential service in this context. This statement has been supported by several specialist institutions in the urban mobility sector.

4.3 Commercial vehicles

Commercial vehicles include trucks, and corporate fleets represent vehicles used for such a purpose, including utility vehicles for transporting goods (vans, panel vans, Urban Freight Transportation Vehicles – UFTVs) and passenger vehicles.

Table 12, below, shows the main COVID-19-related barriers and opportunities for the growth of this segment. Next, these aspects will be discussed in more detail.

Table 12. Barriers and opportunities for electric commercial vehicles and for cargo transportation EVs created by COVID-19

TYPES OF VEHICLES	BARRIERS	OPPORTUNITIES
Trucks	• Trucks became more expensive in this period due to the depreciation of the Brazilian real against the US dollar • The lack of enough trucks was reinforced during the pandemic • No lines of credit for EVs for cargo transportation nor for its related infrastructure	• An appropriate time for redesigning their existing strategies and business models • Possibility of gaining leverage due to pollution and interest of companies in reducing their carbon footprint
Corporate fleets	• Employees of small and medium-sized companies of various sectors and segments started to work remotely, from home • Less people commuting • Companies and investors saved their resources and investments in view of the financial difficulties imposed by COVID-19	• New business models may start operating • It is a way to complement routes where buses do not serve or have had their commuting rearranged due to COVID-19 • Ongoing pilot projects revealed related opportunities and continued to be carried out during the pandemic • Data generation in this period is an opportunity for mapping and assessing scenarios

Source: Personal collection.

4.3.1. Barriers

Considerando as barreiras para os veículos comer-When we consider barriers for commercial vehicles, there are some difficulties analogous to those of e-buses. The sector that employs this type of vehicle was also affected by high dollar rates, which impacted prospects of e-trucks acquisition. Likewise, the economic crisis has slowed down investments in new propulsion technologies.

The pre-COVID-19 barriers were reinforced during the pandemic, such as no lines of credit for EVs for cargo transportation nor for its related infrastructure. In the same way, the lack of enough routes served and diversity of vehicles and their components are still an issue, which reinforces the challenges for the diffusion of commercial vehicles.

From the perspective of acquisitions, companies that were considering making investments in the purchase of electric trucks postponed their investments during COVID-19.

Changing the focus to passenger vehicles for commercial use, which includes the categories of sharing, rental and urban mobility services in general, more specific barriers can be spotted, such as the broad implementation of home office by companies. Parallel to that, this sector also had to follow cleaning and disinfecting procedures as well as redesign strategies concerning vehicle use. In this sense, we noticed the demand on car rentals and sharing platforms has dipped during the pandemic.

Divulgação/FNM

The Brazilian manufacturer FeNeMe will return to the market of e-trucks. Its strategies had been drawn before COVID-19 and are being carried out despite the pandemic.

4.3.2. Opportunities

As for opportunities, the electrification of commercial vehicles can count on prospects or ongoing projects as a means to continuing the process. The case of air quality in urban centers made by COVID-19 can boost the growth of electric commercial vehicles in urban areas, since it was concluded that e-mobility has a positive effect on GHG emission and noise pollution.

As for corporate electric fleets, EV sharing and rental service, the opportunity now is to seize the moment to redesign their existing strategies and business models. The pandemic has created a new way of mobility which shall be adopted so that agglomerations are avoided, at least till the population is vaccinated. And it is in that sense that, for instance, we can see users migrating from public transportation modes to those new options of vehicle sharing.

Users' profiles and new business models have a more advantageous total cost of operation when compared to internal combustion options. Opportunities open up for corporate electric taxi fleets, for example.

At last, in this period of change in consumer spending habits and consumer demand, there is an unprecedented considerable volume of information and sector-specific intelligence produced by the pandemic. Such a volume can be very helpful to the mapping of new opportunities and evaluation of ongoing projects in the COVID-19 scenario.

Private passenger vehicles 4.4

In this section we will study passenger vehicles for private use and road use. Table 13 shows the main barriers and opportunities for electric passenger vehicles growth in Brazil mapped in the COVID-19 scenario and the impacts thereof.

Table 13. Barriers and opportunities for electric passenger vehicles created by COVID-19

TYPES OF VEHICLES	BARRIERS	OPPORTUNITIES
EVs	• Cars became more expensive in this period due to the depreciation of the Brazilian real against the US dollar • The launch of new EV models was postponed • Sensitivity to investments that were automatically postponed in this scenario • Consumers reevaluating their acquisition plans	Experts did not spot any opportunities for private EVs
Premium-EVs (including hybrids and plug-ins)	Experts did not spot any barriers for premium-EVs	• Most EV sales will be from this category • The value of this product is placed in a competitive way according to the Market Consensus Indicator (MCI) and has influenced consumers to purchase premium-EVs
Flex-fuel hybrid	• Sales were impacted by COVID-19, a drop in car sales was noticed	• May be appropriate marketing strategies for automakers • Great opportunity for the economic recovery of this segment

Source: Personal collection.

4.4.1. Barriers

Based on results obtained in the interviews, the biggest limitation to electric passenger vehicles is their high cost. As imports, their price was changed in face of the depreciation of the Brazilian real against the US dollar, which also impacted other categories of EVs, such as Heavy-Duty Vehicles and Heavy-duty Commercial Vehicles.

The launch of new EV models was postponed. For instance, automakers whose strategies were designed to sell electrics and plug-in hybrids (PHEVs) in Brazil ended up reevaluating their plans and delaying their launches. That was the case of the hybrids FCA Jeep Renegade and Jeep Compass, whose launches were postponed to 2021.

4.4.2. Opportunities

In the interviews, experts did not spot any opportunities for private EVs. However, in the premium-EV segment, whose prices are above R$250,000 on average, the impacts of COVID-19 are minimal. In fact, there were some cases of queues forming for launches of PHEVs in the premium segment.

As for Hybrid Electric Vehicles (HEVs), based on the interviews, there is an opportunity for expanding the production and supply of flex-fuel hybrid models in Brazil, and even flex-fuel plug-in hybrids as in the pandemic their sales were not affected. On the contrary, the only flex-fuel hybrid model available in the market showed consistent growth levels throughout 2019 in a pre-pandemic scenario, as discussed in Chapter 2 of this publication.

Moreover, combining biofuel engine technologies – which run on ethanol – and electric powertrain technologies is within Brazilian competency. This integration of technologies is a distinct, unique competency of Brazil in relation to other countries that have been experimenting with EV manufacturing. It is worth saying that some plants in Brazil can already meet the demand for EVs in the coming years.

Micro-mobility: ultra light-duty vehicles

4.5

Within the scope of this publication, Ultra Light-Duty Vehicles (ULDVs) are e-bikes and e-mopeds, although there are other categories, such as electric standing scooters, for example.

Table 14 presents the main barriers and opportunities for ULDVs growth in Brazil in the COVID-19 scenario. Next, these aspects will be discussed in more detail.

4.5.1. Barriers

Based on the interviews carried out, the prospect is that ULDVs' prices will rise as an impact of COVID-19. As explained previously, during the pandemic there was a depreciation of the Brazilian real against the US dollar. That resulted in higher prices of ULDVs, since they are mostly imports or so are their components (such as batteries) to be used in local assembly operations.

Higher prices reinforce another barrier that already existed in the pre-COVID-19 scenario: EVs are more expensive when compared to their non-electrified peers. In addition, the losses on investments in new businesses affect the category, and also affect the

Table 14. Barriers and opportunities for micro-mobility created by COVID-19

BARRIERS	OPPORTUNITIES
• EVs are more expensive when compared to their non-electrified peers • ULDVs' prices will rise as an impact of the depreciation of the Brazilian real against the US dollar during the pandemic • Losses on investments in new businesses affect the category • Not many models (of mopeds) are offered by traditional and well-established automakers	• ULDVs, which are usually one-seater vehicles, help avoid agglomeration of people • Consistent actions towards upgrading and reinventing roads for ULDVs • Delivery services in cities increased during COVID-19 • Several incentives for ULDVs use and more infrastructure due to the pandemic • Mix of opportunities, as ULDVs are considered cheaper solutions

Source: Personal collection.

expansion of supply of those models in Brazil or even the prospecting for new business models. Such a scenario of insecurity and freezing of economic resources will only aggravate the situation.

4.5.2. Opportunities

When it comes to opportunities, ULDVs, which are usually one-seater vehicles, do not help avoid agglomeration of people as long as users comply with minimum distance guidelines; hence, ULDVs came as part of the so-called new normal in 2020.

In fact, people who needed to commute started realizing that they could do so by bike, for example. That brought about an increase in conventional bicycle sales and there is enough room in the market for e-bikes, especially in cities with hills.

Therefore, we noticed those opportunities are linked to new spending habits which can attract new users from other categories, such as public transportation users. E-bikes are an alternative for short trips as opposed to public transportation – and that is motivated by fear of Coronavirus contamination. E-bikes can even bite off a portion of the small-motorcycles sales market.

This way, consistent actions towards upgrading and reinventing roads for those alternatives have been happening both nationally and internationally. Foreign examples are Belgium, the Netherlands and Germany expanded cycle lanes and areas for micro-mobility; in Brazil, the examples are from the cities of Porto Alegre, São Paulo and Curitiba.

Still, as for the logistics of the last mile delivery, delivery services in cities increased during COVID-19. E-micromobility has become a timely strategy, as it meets delivery parameters established, and whose e-bikes are the most common choice.

Conclusions 4.6

Chapter 4 aimed to present the impacts of COVID-19 on the evolution of e-mobility in Brazil in 2020. The information was collected and analyzed, then studied according to its corresponding modes – Heavy-Duty Vehicles and Heavy-duty Commercial Vehicles, passenger vehicles and micro-mobility. This is a non-exhaustive study, since it was based on interviews from a limited set of specialists in the sector.

This Annual Report showed us some developments disguised as barriers and opportunities for e-mobility technologies in Brazil. We can take those barriers and opportunities as points that actors of the transportation sector, which is facing countless uncertainties during and after COVID-19, should pay attention to when planning their strategies and actions.

As for electric public transportation, according to the interviews with the specialists, a negative effect of COVID-19 was a decline in the number of daily passengers, and consequently, daily fare losses and reduction in pay of employees. There was also an increase of operating expenses for public transportation operators, who had to follow cleaning and disinfecting procedures of buses because of the pandemic.

The set of elements presented previously – drop in demand due to COVID-19, financial fragility of private operators, public policies being paralyzed, postponed or suspended, systems based on daily fare collection suffering losses and currency volatility challenges to acquisition of imported goods – create, as a whole, a great pressure for the introduction of e-buses to be stopped, rethought and invariably postponed.

However, in this scenario of challenges, opportunities were revealed. The dramatic drop in public transit usage during COVID-19 can be interpreted as an appropriate time for this system and its operation to be rethought and alternatives discussed. In short, this ecosystem can be more sophisticated if we consider contemporary business models.

When it comes to commercial vehicles and cargo transportation vehicles, the sector that employs this type of vehicle was also affected by high dollar rates, which impacted prospects of e-trucks acquisition. Likewise, the economic crisis has slowed down investments in new propulsion technologies. As for opportunities, the electrification of commercial vehicles can count on prospects or ongoing projects as a means to continuing the process. As for corporate electric fleets, EV sharing and rental service, the opportunity now is to seize the moment to redesign their existing strategies and business models.

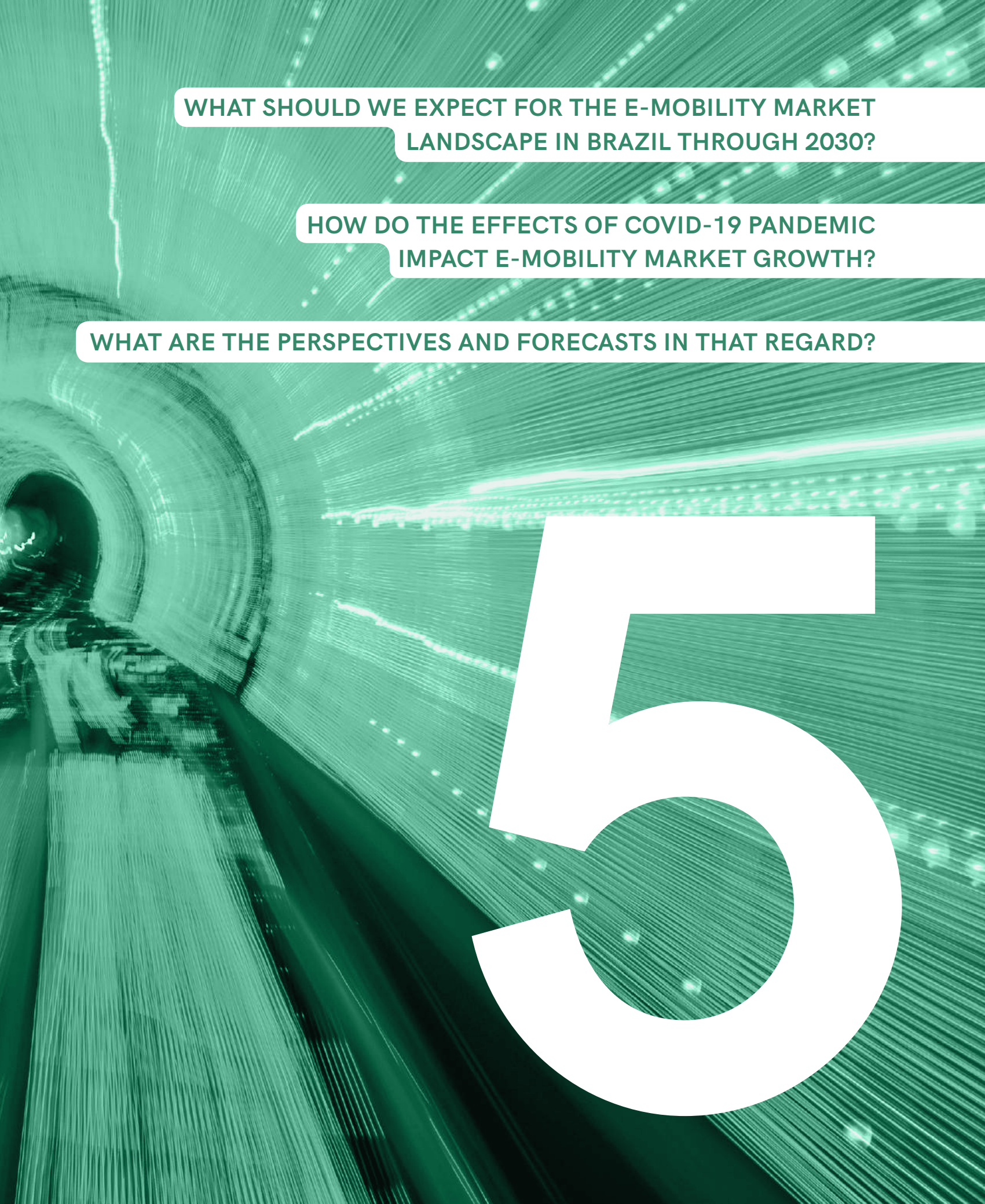
The biggest limitation to electric passenger vehicles is their high cost. Their price was changed in face of the depreciation of the Brazilian real against the US dollar. As for Hybrid Electric Vehicles (HEVs), there is an opportunity for expanding the production and supply of flex-fuel hybrid models in Brazil, and even flex-fuel plug-in hybrids as in the pandemic their sales were not affected, contrary to similar models of internal combustion.

Finally, on micro-mobility, the prospect is that ULDVs' prices will rise as an impact of COVID-19. In addition, the losses on investments in new businesses affect the category, and also affect the expansion of supply of those models in Brazil or even the prospecting for new business models. When it comes to

opportunities, ULDVs, which are usually one-seater vehicles, help avoid agglomeration of people. In fact, people who needed to commute started realizing that they could do so by bike, for example. Therefore, we noticed those opportunities are linked to new spending habits which can, for instance, attract new users from other categories, such as public transportation users migrating to micro-mobility.

And beyond COVID-19? **What types of market trends can be spotted for the coming years? How can we estimate numbers that electrification may reach within the 2030 time horizon?** We will address this topic in Chapter 5, which provides insights into a vision of the future for e-mobility in Brazil.

A vision of the future for e-mobility in Brazil: perspectives on market growth and infrastructure for Horizon 2030



WHAT SHOULD WE EXPECT FOR THE E-MOBILITY MARKET LANDSCAPE IN BRAZIL THROUGH 2030?

HOW DO THE EFFECTS OF COVID-19 PANDEMIC IMPACT E-MOBILITY MARKET GROWTH?

WHAT ARE THE PERSPECTIVES AND FORECASTS IN THAT REGARD?

5

5.1 Introduction

What should we expect for the e-mobility market landscape in Brazil through 2030? How do the effects of COVID-19 pandemic impact e-mobility market growth? What are the perspectives and forecasts in that regard?

One of the biggest challenges to e-mobility in Brazil is the gap between its vision of the future and the current reality. Such vision concerns the e-mobility market behavior for the coming years and its evolution in face of business volumes and the development of related technologies.

To a great extent, that challenge is posed by the intrinsic difficulty of having converging expectations and visions of various experts, stakeholders and decision-makers that influence and work on e-mobility in Brazil.

Without the vision of the future, choosing a route/strategies necessary for the planning of the sector becomes such an arduous task and, when it comes to local supply chains, we must anticipate how those will be impacted and what types of investments and actions will be required given the future transformations.

It is in this blurred context that Chapter 5 aims to fill those gaps to some extent by drawing up essays and generating debate on possible market scenarios for e-mobility in Brazil in the 2030 time horizon from a multimodal choice model perspective.

The reason for constructing such scenarios lies in the need to establish a more clear horizon for the adoption and expansion of e-mobility in Brazil in the coming years. In addition, the idea of outlining said vision of the future for the Brazilian context has already been engendered in other occasions, as in meetings of GT7, a group formed to design the actions for the Route 2030 program, and, in parallel, in other studies. By addressing said topic in this publication we aim to interpret and better understand how Brazil will take part in this new automotive journey that has been going on in other countries, as discussed in Chapter 1.

In order to better organize our content, we present proposals of scenarios arranged into categories of technological applications for e-mobility, in which the electric propulsion system (EPS) is their common element. Said categories were divided as follows: (1) Public transportation (e-buses); (2) Commercial vehicles; (3) Passenger Light-Duty Vehicles: electric vehicles and hybrids; (4) Recharging infrastructure, and finally, (5) Micro-mobility.

On a methodological approach, for each of the categories previously mentioned three types of curve patterns were defined, each having their own prerogatives and conditioning factors that shape and impact their flows. Thus, all the scenarios presented will have the following elements as their backdrop and panorama:

a) Conservative scenario

The economic situation in this scenario is of unfavorable conditions, such as those brought by the impacts of COVID-19 for the 2020 time horizon as well as the 2030. In this case, we understand that neither incentive policies nor targeted regulatory instruments will be implemented for EVs, much less any type of new devices to promote/finance the acquisition and manufacturing of those technologies.

b) Moderate scenario

In this scenario, public policies and incentive instruments for e-mobility are stagnant, just like in the conservative scenario. However, economic recovery is expected to gain greater traction, which reveals strategies similar to those adopted in 2010-2020. As a direct result, in this scenario there is leverage of income as well as growth of internal demand for the coming years, new investment cycles from private actors are also expected. Regarding this last point, exploring new business models for e-mobility means making investments which concern the perspective of sustainable businesses and are linked to the post-COVID-19 economic recovery and the green transition approach, for example.

c) Aggressive scenario

In this scenario, the economic conditions are favorable in view of the growth of national income and the country's economic growth in general. In addition to this positive economics, public policies and incentive instruments for e-mobility are expected to be formulated and will be aimed at promoting EV technology in the market as well as promoting its purchase with more competitive prices; in regards to its supply, by strengthening entrepreneurial activities and also activities of the supply chain in Brazil.

In order to support those scenarios, our sources of information were interviews carried out with more than twenty specialists from different e-mobility spheres of operation and segments. This data collection went through a posteriori non-individualized control process of information on an analysis and processing of the sets of samples upon grouping data.

Therefore, it is worth stressing that the scenarios presented in this publication do not represent the opinion of any particular institution or individual actor, nor even does it represent the view of any state actor or interest groups. This is an uncharacterized compilation and selection that presents reflections and essays about potential development pathways that e-mobility may follow in Brazil.

5.2 Public transportation: e-buses

Firstly, the category of e-buses was studied and the forecast of its fleet growth is shown in Figure 23.

For public transportation, three scenarios were considered (conservative, moderate and aggressive scenario).

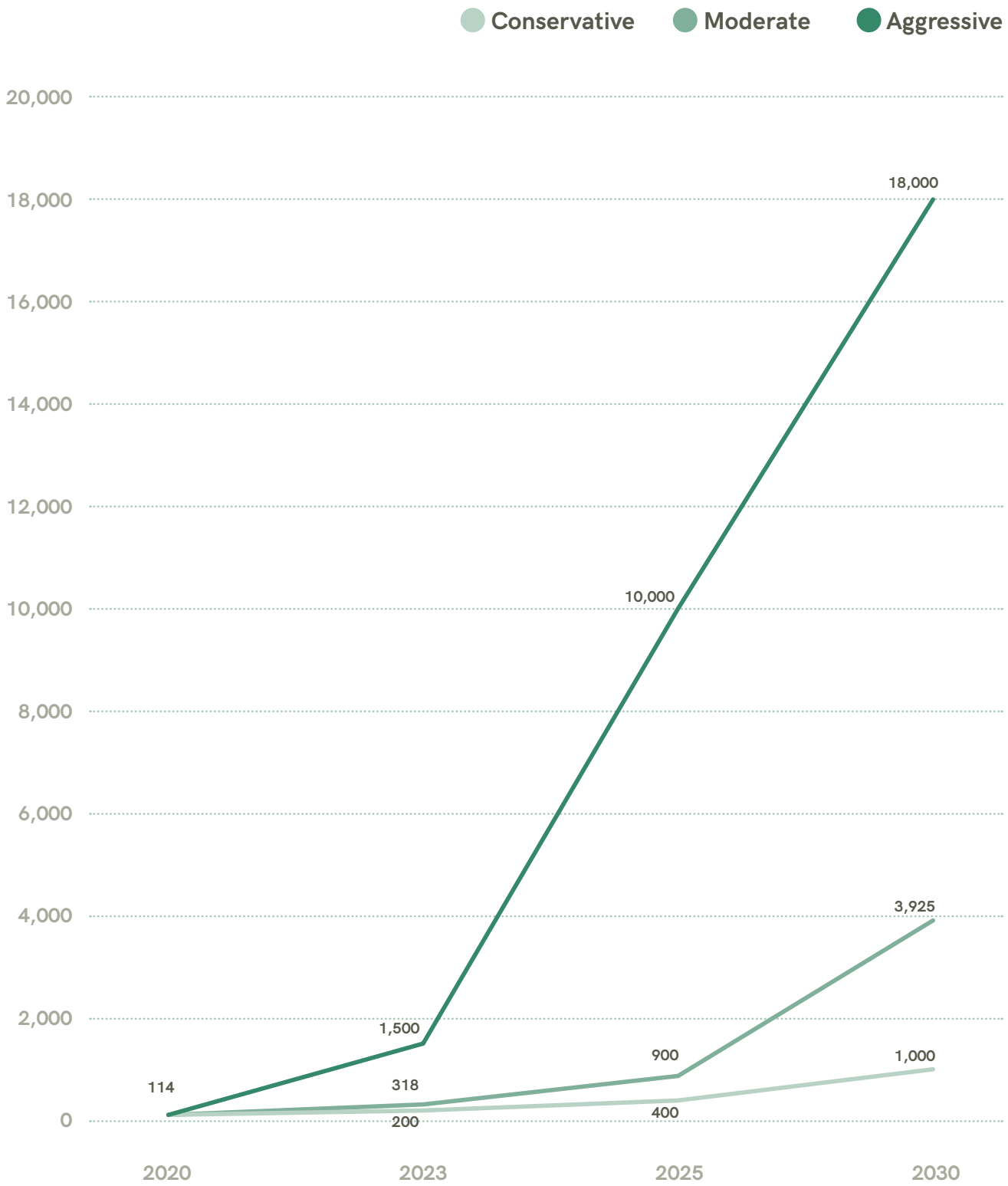
In the conservative scenario, the e-bus fleet is poised for a modest increase, which is projected to be from 114 battery e-buses to nearly 200 units by 2023 and its double by 2025, which means a forecast of 400 e-buses. In said scenario, we expect to have 1,000 e-buses running by 2030.

The moderate scenario goes in the same direction, but with a more positive slope regarding its curve behavior. Again, we notice the e-bus fleet will experience a small increase by 2025, which will account for 200 e-buses by 2023 and 900 units by 2025. In 2030 the increase is more substantial, it is 4 times bigger than in 2025 and accounts for 3,925 e-buses.

At last, the aggressive scenario takes a different direction, since a bigger increase starts in 2023 (not only in 2025, as in the moderate and conservative curves), its absolute percentage growth is expected to be bigger likewise. In this scenario, we forecast 1,500 e-buses running by 2023, which will rise to 10,000 by 2025 and, finally, 18,000 by 2030.

In general, according to specialists, the e-bus fleet will grow during the 2020-30 time horizon. However, for the more conservative and moderate curves, a correlation with the impacts of COVID-19 can be seen, as previously discussed and analyzed in Chapter 4. Due to COVID-19, we noticed the postponing of agreements and resolutions for EV fleet transition as well as investments in new alternative propulsion systems. And in this case, the curves reflect that data, they start to grow only from 2025. Such a difference impacts the aggressive scenario more hardly, since it bets on e-bus fleet growth from 2023 and over the following years.

Figure 23. forecast of e-buses fleet growth by scenario (2020-2030)



Source: Personal collection.

5.3 Commercial vehicles

Figure 24 shows commercial vehicles (light, medium and heavy-duty) through numbers that show fleet within the 2030 time horizon.

With a different behavior from the panorama presented by the e-buses, in the case of commercial vehicles, three clearly different scenarios were built.

From the conservative point of view, e-commercial vehicles are practically absent in the national urban logistics system and road transportation system. Approximately 500 trucks are estimated by 2030, revealing a modest and punctual increase, restricted to a few cases, only.

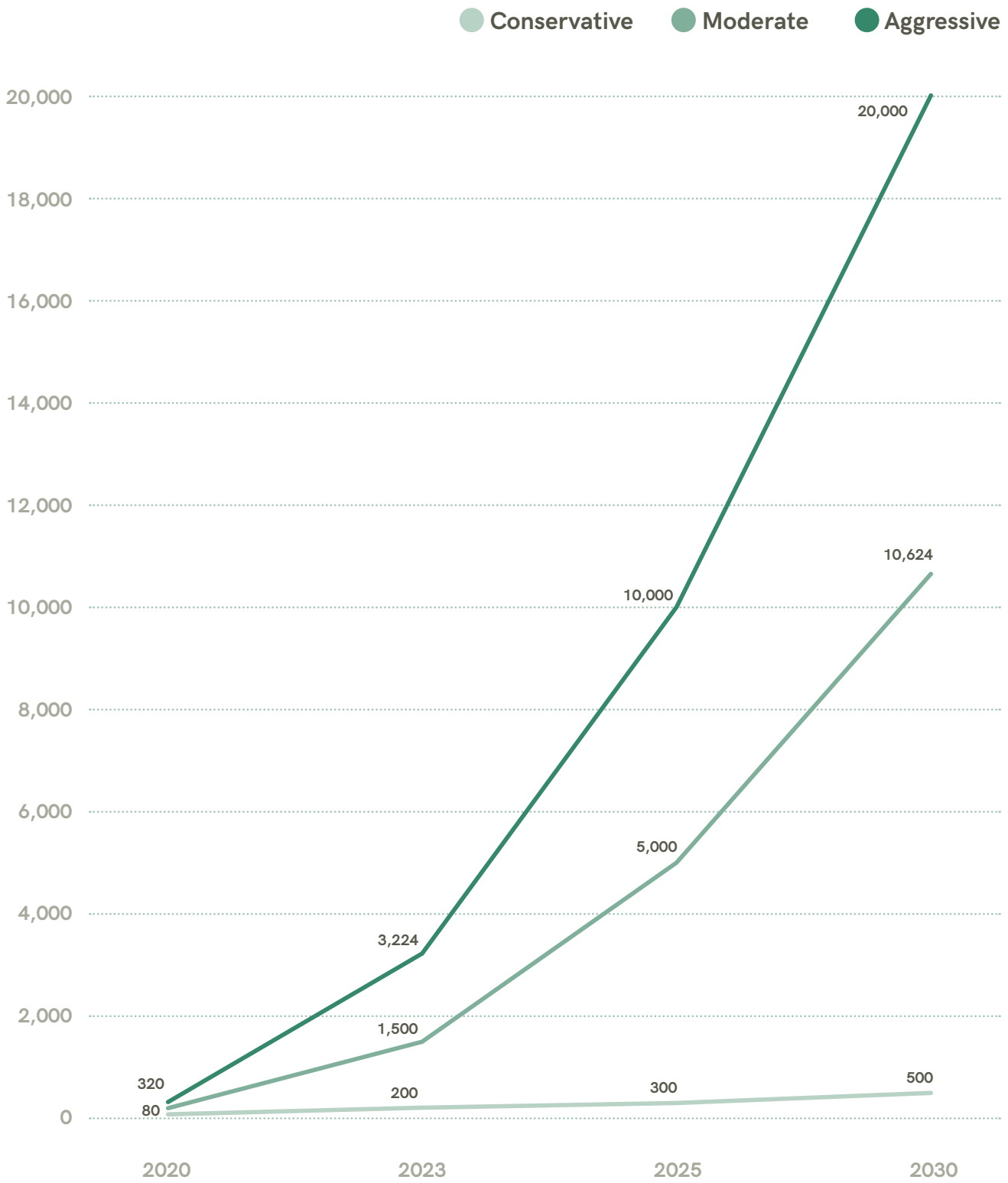
As for the moderate scenario, we aim for a more consistent trajectory. In this case, considering that there are approximately 120 units in 2020, 1,500 units are expected by 2023, and 5,000 by 2025. The target is 10,624 vehicles by 2030.

The belief in the technological diffusion of this category is in forecast for the aggressive scenario. In this scenario, our forecast is optimistic: 3,000 units are expected by 2023, which will increase to 10,000 by 2025 and 20,000 by 2030, which accounts for twice the number of units expected for the moderate scenario.

Based on the data collected, two perspectives for the case of e-commercial vehicles are thus apparent. The first, represented by the conservative scenario, that there will be no significant penetration of e-commercial vehicles in the market. Factors such as high acquisition costs, or TCO (Total Cost of Ownership) and the constraints of battery autonomy, as well as the requirement of Total Gross Weight (which reveals scarcity of options and models of EV technologies in the country) interfere with e-commercial vehicles fleet growth in this skeptical diagnosis presented hereby. In addition, we must mention a background of economic difficulties and lack of incentives for the conservative scenario.

On the other hand, when it comes to the moderate and aggressive scenarios, we believe in an optimistic forecast of growth for this segment. In this scenario, challenges such as TCO, battery autonomy and gross weight will be faced and e-commercial vehicles will have their space in logistics and in other cargo contexts, with greater market penetration in the aggressive scenario.

Figure 24. Forecast of commercial vehicle fleet growth by scenario (2020-2030)



Source: Personal collection.

5.4 Passenger Light-Duty Vehicles: electric vehicles and hybrids

As for passenger vehicles, they are categorized according to their different possibilities of recharging: Battery Electric Vehicles (BEVs) and Plug-In Hybrid Electric Vehicles (PHEVs) whose supply model regards getting electricity from the grid and Hybrid Electric Vehicle (HEVs) which cannot plug into the grid to recharge and run on liquid fuels mostly.

It should be noted that the fleet growth was referenced by participation rates (%) in new vehicles sales per year. Figure 25 shows its forecast.

In general, when it comes to passenger vehicles, we can see convergences and discrepancies among the different scenarios studied and among the types of electric propulsion system considered.

In the conservative scenario, there will be no significant penetration of BEVs and HEVs in the national market within the 2030 time horizon. We predict a modest penetration of 0.50% by HEVs and 0.10% by BEVs by 2030. In fact, for both cases, electric and hybrid vehicles would be considered part of a niche market of consumers who are technology enthusiasts of electrification, for example.

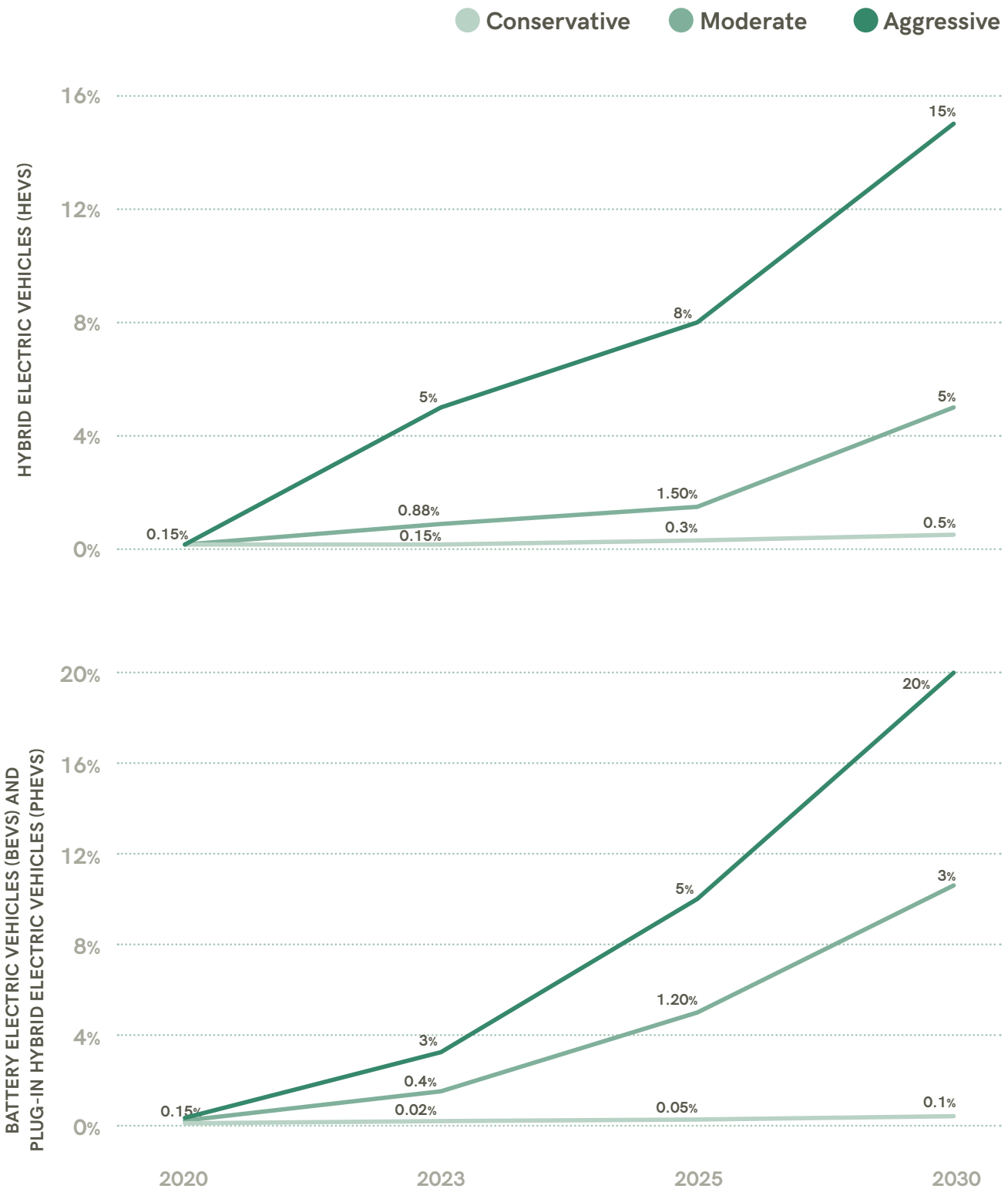
As for the moderate scenario, a greater diffusion of HEVs followed by BEVs is noticeable, accounting for 5% and 3% of sales in 2030, respectively. This slight positive difference of 2% in HEVs sales refers to the greater attractiveness of such a technological solution for the Brazilian context in view of its close connection with hybrid propulsion systems that include biofuels, as described and analyzed throughout this Annual Report.

However, when observing the aggressive scenario, we see a contrasting behavior between the BEVs and HEVs curves, different from the conservative and moderate cases previously analyzed.

As for HEVs, there is a more significant growth between 2020 and 2023, which accounts for 5% of the vehicle fleet. This growth continues at a similar rate between 2023 and 2025, reaching 8% of the vehicle fleet. By 2030, the leverage expected is 15% of the market.

On the other hand, when it comes to BEVs and PHEVs, the aggressive scenario shows low growth rates between 2020 and 2025, representing 5% of new vehicle sales. It will be between 2025 and 2030 that this segment will experience greater expansion, rising from 5% in 2025, to 20% in 2030. The hypothesis for such growth is based on the technological advancement of batteries and their large-scale production, which will result in better autonomy for EVs and also more competitive options as for acquisition cost, respectively.

Figure 25. Forecast of BEVs and HEVs share (%) in new passenger vehicles sales by scenario (2020-2030)



Source: Personal collection.

5.5 Recharging infrastructure

We hereby address the recharging infrastructure for electric passenger vehicles only (charging infrastructure for buses and trucks are beyond the scope of this report, as their technical standards and norms for allocation are different from passenger vehicles', which prevents us from doing sample agglutination in this analysis).

Recharging infrastructure refers to any external equipment aimed at supplying energy to charge EV batteries. Charging stations include EV charging cords, charge stands (residential or public), attachment plugs, vehicle connectors and protection hardware to ensure a safe and secure operation. Further definitions of terms and concepts can be found at the end of this publication (see Glossary).

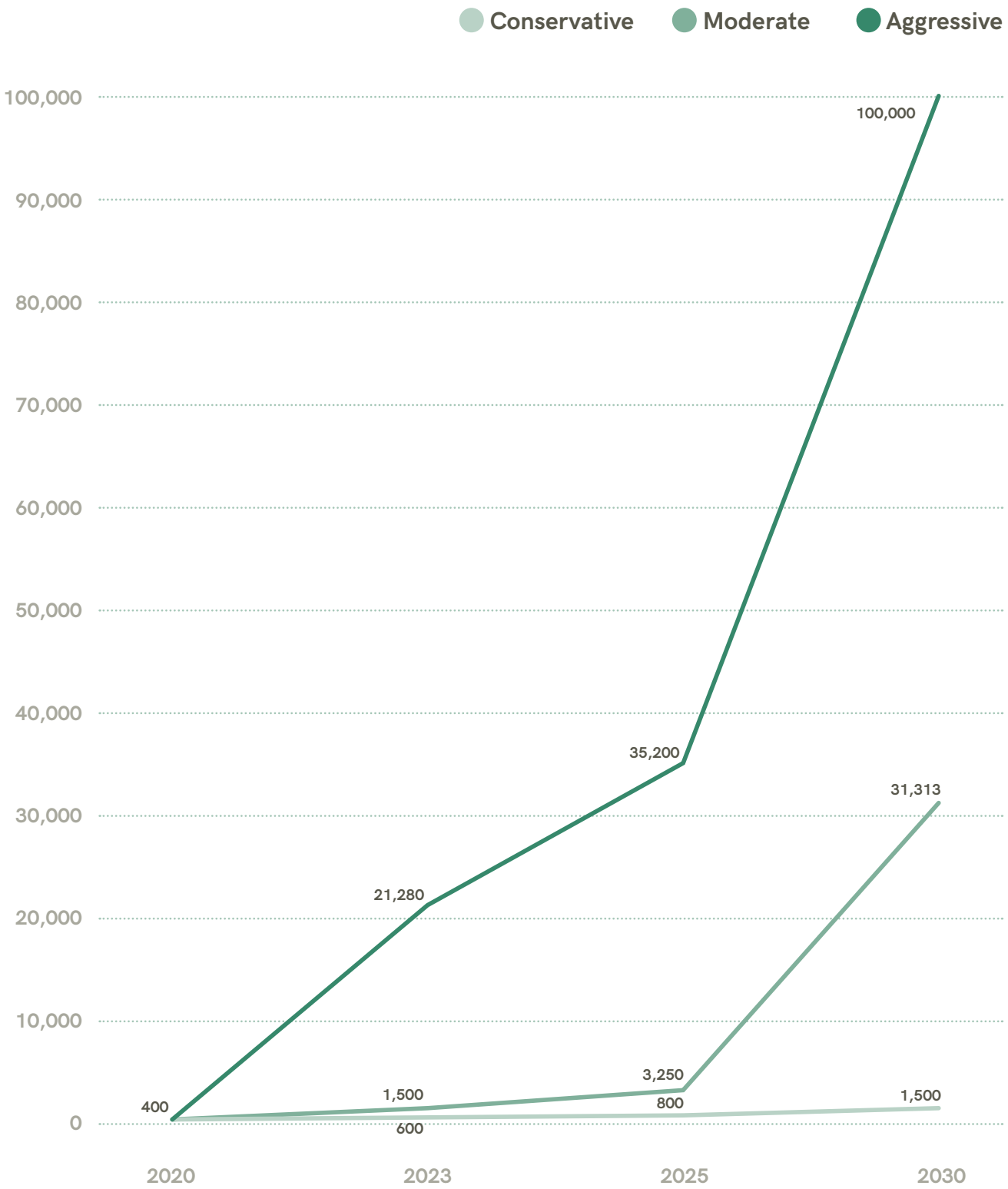
As a methodological decision, no distinctions will be made regarding charging speeds (slow chargers, fast chargers and rapid chargers). In addition, private chargers for residential use are disregarded from these forecasts (given that practically every EV has its own charger for home charging). The focus of this analysis is on recharging infrastructure in cities (in public and private areas), as well as in highways and strategic transportation corridors.

As for infrastructure, the conservative scenario shows poor penetration of this equipment in the national system, since approximately 1,500 charging stations will be built in 2030, which is approximately three times more than in the year 2020.

The moderate scenario also shows the same poor penetration of charging stations until 2025, from that on the number of stations will increase till 2030, reaching nearly 31,000 units around the country, a rise 10 times bigger than 2025.

At last, the aggressive scenario reveals significant growth rates until 2025, the number of charging stations is expected to approach 35,000. Such growth is projected to be stronger between 2025 and 2030, assuming a steep to nearly 100,000 stations by 2030.

Figure 26. Forecast of recharging infrastructure deployment by scenario (2020-2030)



Source: Personal collection.

5.6 Micro-mobility

Lastly, we will address micro-mobility, also known as ultra light-duty vehicles. Our study will encompass e-mopeds and e-bikes. In a complementary manner, fat tire electric scooters, more specifically, CityCoco models will also be addressed (see Figure 27), since its sales saw a steady increase in the 2017-2019 triennium. As mentioned earlier, electric standing scooters will not be analyzed in this Annual Report.

Figure 28 shows projections for the above-mentioned categories regarding fleet growth over the 2020-2030 period.

The outlook of micro-mobility will, in general, experience growth of all its categories in the coming years.

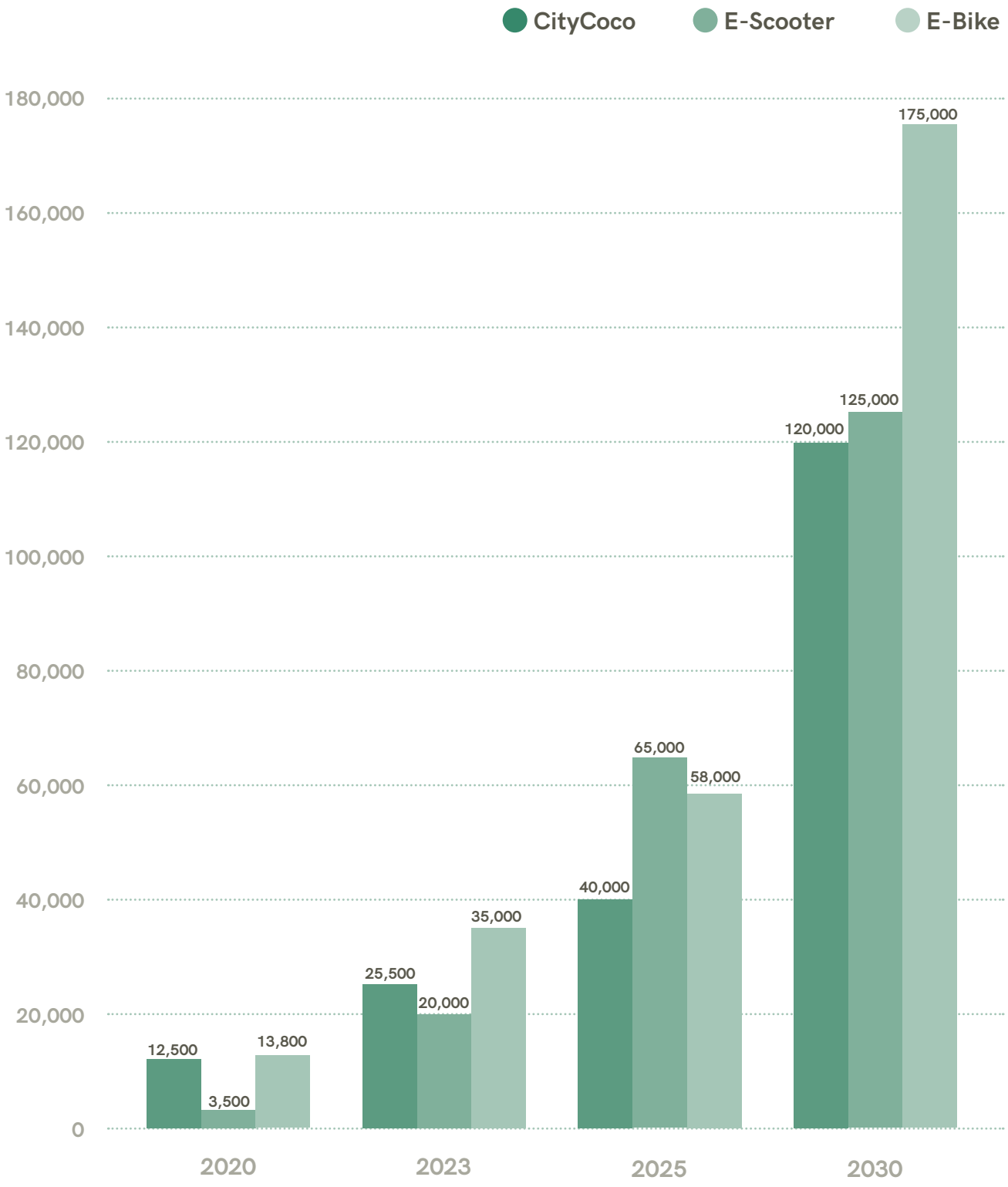
Figure 27. CityCoco electric scooter

With regard to CityCoco, this category has been growing, as presented in Chapter 2, and will continue to expand and reach approximately 120,000 units sold by 2030.

As for e-mopeds, a more significant increase can be observed from 2025 on, with 65,000 units and increasing to 125,000 by 2030. The forecast on this category is that its acquisition costs will decline and become more competitive in mid-2025 as batteries will be produced in large-scale and will be more efficient, resulting in better autonomy for EVs. It is worth mentioning that improvements in the exchange rate imbalance between the Brazilian real and the US dollar are essential to leverage the acquisition of e-mopeds and their components.

Finally, e-bikes are also poised for growth in the years analyzed (2023, 2025 and 2030). When it comes to acquisition costs, the scenario is more optimistic for this segment, as their prices are lower than other micro-mobility devices'. In addition, e-bikes have the advantages of being within the usage parameters for urban mobility, as in the urban context e-bikes can ride on cycle lanes, for instance. Besides, e-bikes favor the flow of people and support individual mobility, and that goes beyond leisure activities and is also a solution for the daily commute, for example.

Figure 28. Forecast of micro-mobility fleet growth by categories (2020-2030).



Source: Personal collection.

5.7 Conclusions

In short, creating projections and forecasts for the post-COVID-19 scenario in the 2020-30 time horizon is surely a challenging task.

In view of various uncertainties, we must take many factors into account, such as the stabilization of the health care scenario, changes in the political agenda and expectations concerning the exchange rate to name a few.

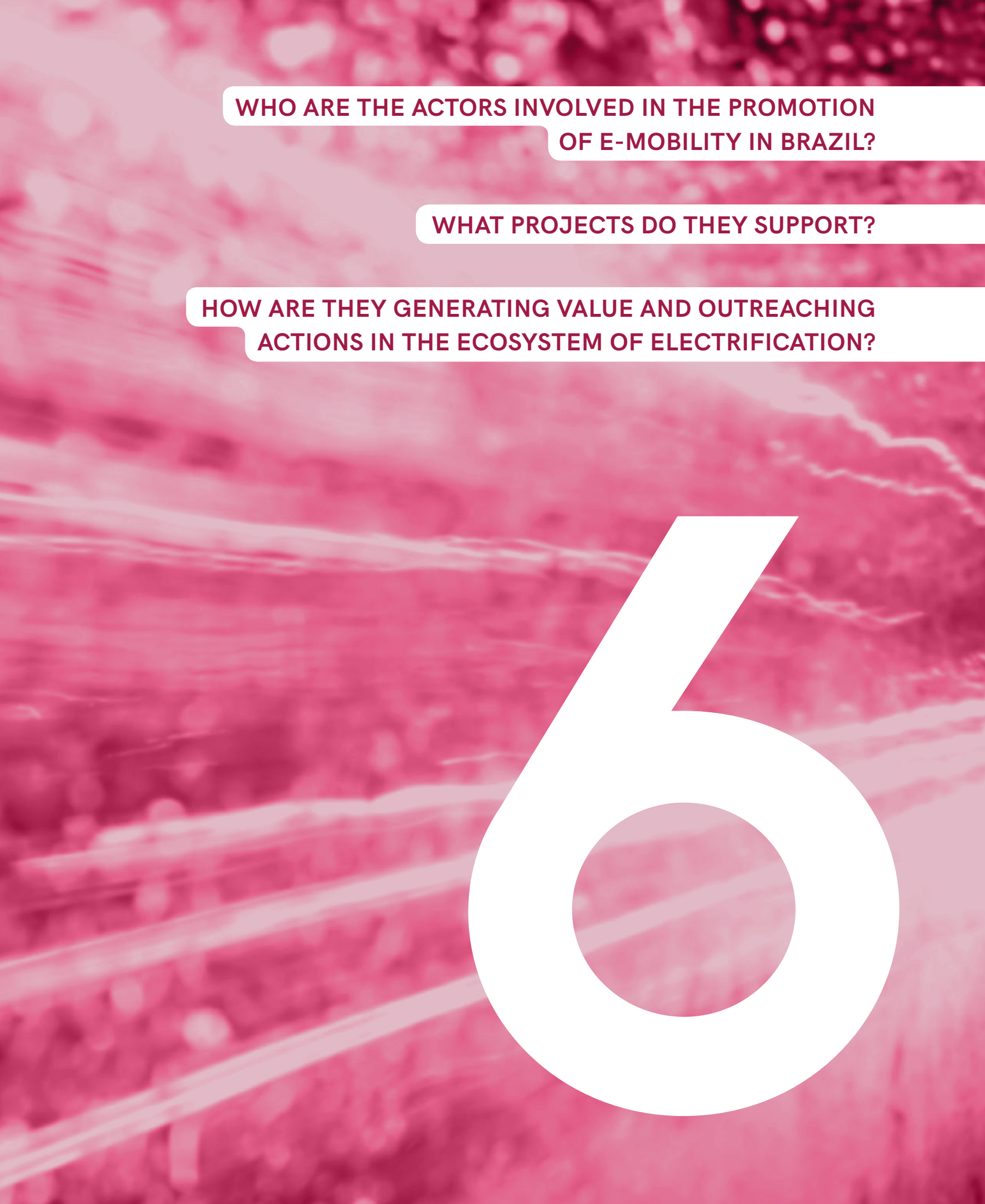
It can be assumed that for all the modes of transportation studied in this chapter, the market evolution will potentially happen in the lines of both the conservative and the moderate scenarios, whose center of gravity will be mainly focused on the conservative scenario.

However, it is evident that the recovery scenario up until 2023 brings with it the large set of uncertainties that we are now experiencing, since treatment and/or vaccine-related solutions are expected to be achieved by 2023 or earlier, indicating that from that point on the global context and, in particular, Brazil, will have new perspectives – probably positive ones – about the economic situation.

By the same logic, we expect that as of 2025, the modes of transportation addressed will largely be represented by the moderate scenario, with the exception of e-buses, whose market growth will be in the lines of the moderate and the aggressive scenarios depending on cities' climate policies and mitigation strategies for reducing air pollution.

It is expected that during the 2025-2030 period, even with the market growth adhering to the moderate scenario, there will be no demand to sustain local production of some modes of transportation, such as passenger Light-Duty Vehicles and Light Commercial Vehicles. Therefore, that indicates that exchange rate stabilization is imperative in order to mitigate disadvantages of fluctuating acquisition costs of EVs. As a positive effect, technological advancement of batteries and their large-scale production are expected, which is an important attribute in the adoption of EVs and its consequent market growth. In addition to that, new business models that treat e-mobility as an enabling technology and that believe in digitalization and connectivity in cities are emerging.

Perspectives and next steps for e-mobility in Brazil: elements of governance and collaboration among actors


WHO ARE THE ACTORS INVOLVED IN THE PROMOTION OF E-MOBILITY IN BRAZIL?
WHAT PROJECTS DO THEY SUPPORT?
HOW ARE THEY GENERATING VALUE AND OUTREACHING ACTIONS IN THE ECOSYSTEM OF ELECTRIFICATION?
6

6.1 Introduction

Chapter 6 aims to describe and analyze initiatives involved in governance and in the orchestration of some actors presented in this Annual Report who work in the promotion of e-mobility in Brazil. This chapter is mainly based on acknowledging the importance of building catalytic linkages between actors so as to design strategies which, for instance, have positively impacted experiences such as those of the United States, the European Union and China.

From studying those examples, we concluded that networking makes information exchange more dynamic and tends to contribute greatly to learning activities and training courses of competencies in e-mobility. In such cases, we can see the orchestration in the e-mobility sector for technology development, its adoption and manufacturing, which will guide actors through paths to be taken in this new journey.

Hence, we will describe and analyze the type of emerging instances of orchestration at the national level so as to formulate some future perspectives for the country. The arguments used to support the data hereby presented are anchored in the interviews carried out with the main collectives involved in the subject of e-mobility.

The collectives are as follows:

- The National Platform for Electric Mobility (PNME)
- The Brazilian Association of Electric Vehicle (ABVE)
- Zero Emission Bus Rapid-deployment Accelerator (ZEBRA)
- SAE EVs and Hybrids Technical Committee
- Research Development Foundation (FUNDEP)
- Electromobility Program by the Brazilian Development Bank (BNDES)
- The National Energy Agency (ANEEL)

Each of those collectives have been playing a major role in regard to initiatives that promote cooperation and collaboration of actors in Brazil and devote efforts to the governance in favor of better coordinated actions.

Additionally, we collected information from secondary sources and references available on websites and documents provided by those institutions.

Hence, we will present these governance initiatives, which, even under construction, have already shown concrete results and significant advances in the e-mobility field.

The National Platform for Electric Mobility: A necessary orchestrator

6.2

Launched in February 2020, the National Platform for Electric Mobility (PNME) aims to work as an instrument of collaboration and interaction between actors of the government, market, institutes of science and technology (ISTs) and civil society organizations by coordinating their actions in favor of directing and shaping the roadmap for the realization of the objectives and action agendas for the e-mobility in Brazil.

With specific objectives, the action plan proposed that the national strategy for e-mobility takes into account:

a) The promotion and induction of its market;

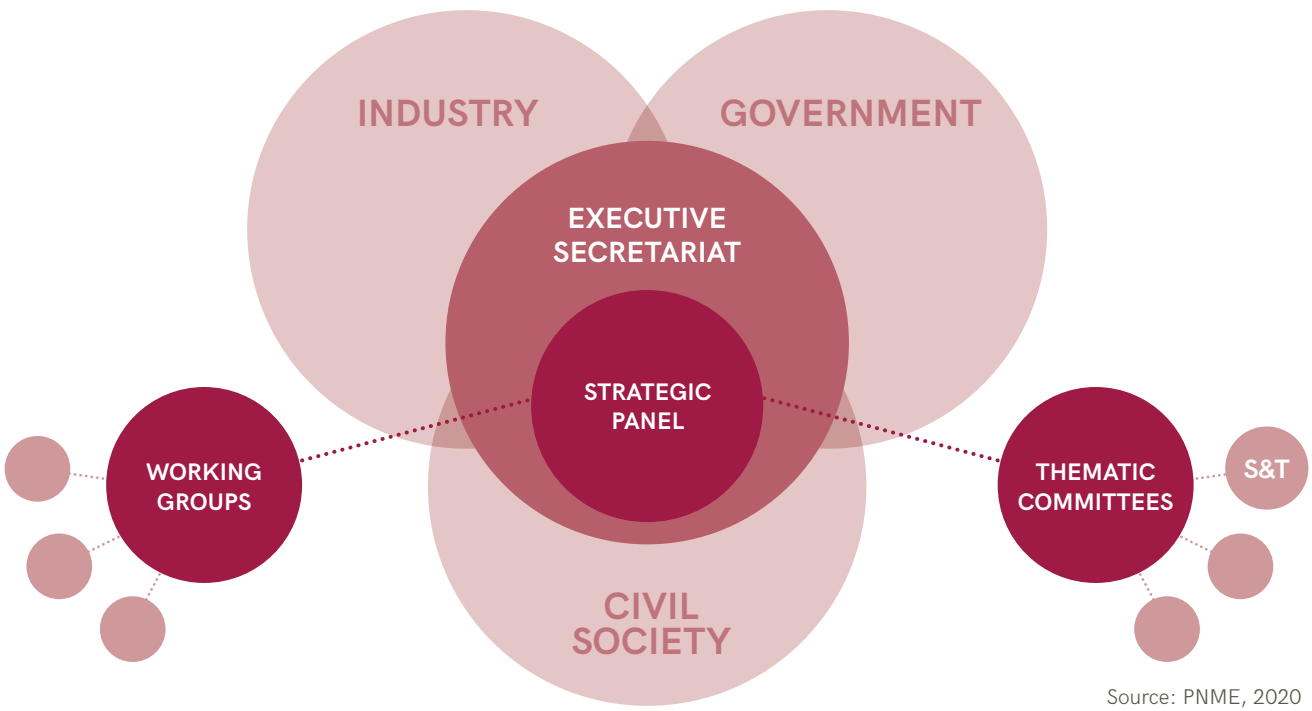
b) The densification of the insertion of local producers in the market;

c) the proposition of instruments of public policy and regulation;

d) the creation of competences in research and development (R&D) in Brazil by building a space of generation, dissemination of knowledge and sharing of learning to all participating fronts and to society in general.

Both general and specific objectives of the Platform were defined by organizing dynamics to be directed

Figure 29. PNME's governance framework structure



Source: PNME, 2020

Since the beginning, more than a dozen well-structured, well-planned meetings with the Platform's members were conducted, which stimulated wide-ranging multi-stakeholder discussions. In fact, PNME's meetings are currently one of the main events for discussing e-mobility in Brazil.

during the collaborative planning process of the Platform, which resulted in concrete objectives.

For more information about the Platform's methodological process of creation, see Appendix 1.

Next, we will address some elements in more details, such as the outcomes and actors involved in the Platform.

6.2.1. Actors and their competencies

The Steering Committee is responsible for the leadership and strategic planning of the platform, for discussing members' demands and topics to be prioritized and directed towards reaching concrete solutions.

The Committee is composed of 14 institutions, each representing a collective of actors. Currently, the Committee is formed by: the Ministry of the Economy (ME), the Ministry of Science, Technology, Innovation and Communications (MCTIC), the Ministry of Regional Development (MRD), the Brazilian Development Bank (BNDES), the Energy Research Office (EPE), the National Energy Agency (ANEEL), the Brazilian Agency for Industrial Development (ABDI), the National Forum of Secretaries and Directors of Urban Mobility, the International Council on Clean Transportation (ICCT), the World Resources Institute (WRI), the National Association of Brazilian Auto Parts manufacturers (Sindipeças), the Association of Innovative Electric Vehicle Owners (ABRAVEi), the Federation of Industries of the State of São Paulo (FIESP) and the Brazilian Association of Electric Vehicle (ABVE).

The Secretariat, in turn, is responsible for the management of the platform and organization of its activities. The secretariat is composed of institutions that are not subordinate agencies to the government, industry or academia, so that neutral operations and transparency are guaranteed: currently, the Brazil-Germany joint action on sustainable development in cooperation with the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH and the Institute for Climate and Society (ICS) is a partnership which brings capacities and competencies together so as to guarantee the operation of the Platform (PNME, 2020).

The PNME can also count on commissions for specific topics. Currently, the Science and Technology Commission (CST) is composed of important names in e-mobility research in Brazil and it advises the Steering Committee technically, so as to ensure the alignment of PNME's Research and Development efforts.

The Platform also has Working Groups (WGs). By mobilizing relevant actors, members of the WGs focus on more specific topics, and work on delivering products that contribute to the advancement of the sector in Brazil.

Figure 30. PNME's Steering Committee

Source: PNME, 2020.

The first WG works on issues concerning the electrification of urban transportation and seeks, among other things, to propose a common agenda to the main municipalities which are carrying out pilot projects in the country. The second WG – the Professional Training WG – is dedicated to the creation of courses and subjects that embrace the training of professionals for e-mobility in both undergraduate and graduate levels.

One of the Platform's great strengths is the diversity of its stakeholders. Various sectors and actors are thereby represented. Another great strength is its Secretariat, with its unique skills and know-how on structuring and monitoring of actions and projects, and its own set of instruments and methodologies.

6.2.2. Next steps: the upcoming launch of the The National Action Plan for Electric Mobility

The members of the Platform are actively interested in carrying on with the development of the National Action Plan for Electric Mobility, which has been preliminarily discussed and outlined in meetings of the GT7 – Route 2030 program. It is certain that Brazil cannot leave its National Action Plan out and so the PNME is ready to stage those discussions for the development of the Plan.

The Brazilian Association of Electric Vehicle 6.3

ABVE joined the movement as a catalyzer of demands and of cooperation and collaboration processes within and between different branches of economic EV-related activities, and so its role involves taking those demands forward to decision-makers of different functions of the State – Executive and Legislative, in order to advocate for the development and use of electric vehicles (EVs) in the country.

It is a priority in ABVE's mission to work for the creation and consolidation of a Federal Policy for E-mobility by partnering with the National Platform for E-mobility and improving its relations with the Federal Government. Internally, ABVE aims to strengthen and expand its representativeness by enlarging its associate base and field of work. For instance, due to COVID-19, ABVE has recently created a specific department for Urban Mobility whose purpose is to promote debates and formulate policies on the integration of different electric modes of transportation to be implemented in post-pandemic metropolises around the country.

ABVE's objectives also include (1) the creation of a specific department to support and provide a welcoming environment for start-ups and (2) the creation of a department that brings together prospecting clients and rare earths companies as well as metal and mining EV-related businesses.

The end point of ABVE's work is to promote the development of the **National Action Plan for Electric Mobility**, supported by a long-term program that fosters collaboration with different decision-makers (in local, state and federal governments) as well as with branches of economic EV-related activities in Brazil.

ABVE stands out because it is the only association of its kind in Brazil that represents the EV supply chain as a whole. Small and large companies, domestic and transnational corporations, local business and importers are all among ABVE's associates; which comprises e-bike small-businesses as well as large electric power generation and electricity distribution companies, it also embraces the main car companies and heavy-duty vehicles manufacturers in the market.

ABVE's mission is "to foster the wide use of EVs in Brazil so that people and goods transportation become more efficient, benefitting the population well-being, the environment, and its associates as a whole."

Moreover, as previously mentioned, ABVE aims to expand its representative participation by incorporating Urban Mobility consultancy and research firms, start-ups and prospecting clients and metal and mining EV-related businesses to its associate base.

ABVE is composed by a rich diversity of associates who work collaboratively towards a common goal: creating a robust business ecosystem for e-mobility in Brazil for their own benefit of developing their companies and industries as well as for generating new jobs, improving health and the quality of life of the population in Brazilian cities.

Table 15. ABVE's strategic actions by categories.

Category	Scope	Summary of the strategic actions
Heavy-Duty Vehicles	New environmental legislation for public transport in the city of São Paulo	Direct and systematic action by ABVE in partnership with the São Paulo City Hall, the São Paulo City Council, the Public Prosecutor's Office, environmental organizations, companies, consultancy firms, etc. The result was the enactment of Law 16,802/2018, the most advanced environmental legislation on public transportation in Brazil which is a reference for other large Brazilian cities, as well as a new bidding process based on the environmental goals of the new law.
Light-Duty Vehicles	Working group for Route 2030 Program and GT-7	For a year and a half this group worked intensively, composed of different representatives of companies associated with ABVE it shaped the new Brazilian automotive industry regime. Such work helped to establish important concepts for the Route 2030 program, such as energy efficiency and reduction of air pollutants emissions, in addition to tax benefits on EVs. In parallel, ABVE's participation in debates of Route 2030 also contributed to the creation of the GT7, a specific working group on e-mobility created within the Ministry of Development, Industry and Foreign Trade (MDIC) to discuss strategies for Brazil which engaged qualified technicians from the Federal Government, companies and business associations.
Ultra Light-Duty Vehicles	ABNT, GT7 and Denatran	ABVE directly acted through GT7 in the creation of a subgroup of ultra light-duty vehicles, highlighting its importance in the debate agenda for the development of the national strategy This action involved the creation of a specific working group to formulate regulations on ultra light-duty vehicles by the Brazilian Association of Technical Standards (ABNT-CB 005 Brazilian Automotive Committee – Bikes, Mopeds and Scooters), under the coordination of an ABVE director. Cooperation between the National Traffic Department of Brazil (DENATRAN) and the National Congress, in which the concrete proposals of regulatory standards for ultra light-duty vehicles (Categories L1 to L7) were presented. There are also actions to remedy the current regulatory gap on ULDVs in federal legislation, the aim is to modernize and align the Brazilian legal framework to that in force in the European Union and the US.

Source: Personal collection based on interviews conducted by Fabiana Dias.

6.3.1. ABVE in action

From 2006 to 2017, ABVE focused on promoting e-mobility events and developed pioneering actions, such as the "Electric Vehicle Technology Expo" and the "EV Convoy Trips: Making Way for E-mobility". Those initiatives helped to spread the word and promote e-mobility in society. As for businesses, it was a period for them to introduce their products and assess economic capillarity and market readiness for the manufacturing and distribution of different EV modes.

In 2017, ABVE gradually shifted the focus of its actions onto advocating for the cause, aiming to create a regulatory support base for the e-mobility business environment in Brazil. Many strategic actions were adopted, as presented in Table 15.

6.3.2. E-mobility in Brazil: value creation and outcomes

Creating value involves establishing a stable relationship between e-mobility, comfort and safety for users of public and private transportation modes, quality of life in cities, attention to environmental degradation and respect of the environment. Creation of value derives from activities carried out in three big areas, as follows:

- **The average citizen, transportation user and individual consumer,** by participating in fairs, events, debates, expos and EV convoy trips;
- **The government and decision-makers**, by performing actions that foster the creation of a legal and regulatory environment of e-mobility in the three levels of government;
- **The press and medial**, by showing ABVE and its associates' actions on the traditional media, TV, radio, blogs and social media, aiming to strengthen the e-mobility agenda and its importance with the general public.

Some of the outcomes achieved

The main outcome produced by the set of actions described above was a stronger agenda for e-mobility in Brazil. We can affirm that over the last years the clean and sustainable urban mobility agenda has had a role in business segments that are involved in the fossil fuel paradigm nevertheless; the agenda has also been breaking down the skepticism of authorities and politicians as well as reducing consumers and users uncertainties over new low-emission transportation modes.

To the associates, the following achieved outcomes are as follows:

1. Creation of and access to information quality
2. Practice of legitimate advocacy
3. More visibility to "best practices"
4. Networking and business matchmaking

6.3.3. ABVE's Framework

ABVE is currently composed of six working groups that represent the e-mobility supply chain in Brazil, as follows:

- Heavy-Duty Vehicles;
- Light- Duty Vehicles;
- Ultra Light-Duty Vehicles;
- Components;
- Infrastructure;
- Urban Mobility.

Each of those groups is formed by representatives of the associated companies, which make major strategic

decisions and, occasionally, spare part of their operational structure where some of the Association's projects can be carried out.

Those six working groups are composed of 53 associates from varied segments, as follows: the automakers and auto parts manufacturers/system administrators', the recharging infrastructure, the mobility service providers', the technology companies', the highway concessionaires/developers and operators of private toll roads', the metro-railway companies', and start-ups.

As for business operations, a financial adviser administrator and an institutional relations and communications advisor are also part of the team.

6.3.4. Collaboration and cooperation of actors and network building

Since 2017 ABVE has been working with political leaders of São Paulo, Campinas, Sorocaba, Indaiatuba and others. Said work is focused on public transportation issues and tax benefits on EVs, integration of transportation modes and the creation of the Green Urban Mobility Zones (GUM Zones).

In 2018 and 2019 ABVE partnered with state governments of the following states: São Paulo (the Governor's Office, the Metropolitan Company of Urban Transport in São Paulo – EMTU/SP and the State of São Paulo Environmental Company), Bahia (Secretariat of Economic Development – SDE) and Paraná (the Staff Office). During said period, ABVE focused on working on tax benefits on EVs (the Auto-motor Vehicles Property Tax – IPVA and the Value-added Tax on the Circulation of Goods and Services – ICMS), electric public transportation and projects on the construction of charging infrastructure in state roads.

In 2019, and specially from 2020 on, the focus shifted to partnering with strategic authorities in the Federal Government, particularly with the Ministry of Mines and Energy (MME), the Ministry of Economy (ME), the Ministry of Science, Technology and Innovation (MCTI), the Office of the Chief of Staff of the Presidency, the Ministry of Economy's Secretary of Development, the Ministry of Economy's Special Secretariat for Productivity and Employment, the Brazilian Agency for Industrial Development (ABDI) and the Brazilian Development Bank (BNDES).

ABVE also works jointly with universities, such as the University of São Paulo (USP), the University of Campinas (UNICAMP), the Federal University of Santa Catarina (UFSC) and Investment Promotion Agencies (IPAs), for example, Investe São Paulo.

Internationally, ABVE works collaboratively with the World Resources Institute (WRI), the International Council on Clean Transportation (ICCT) and the Institute for Transportation and Development Policy (ITDP) and also with multilateral development banks, such as the Inter-American Development Bank IDB), the World Bank and the United Nations Environment Programme.

Moreover, ABVE maintains relations with the British Consulate-General in São Paulo as well as the Embassy of Germany and the Embassy of Portugal in Brasília. Ongoing collaborative works may result in future projects with countries such as Denmark, Sweden, Norway and Austria.

6.4 EVs and Hybrids Technical Committee (EV&H-TC) and the Society of Automotive Engineers (SAE) in Brazil

The EVs and Hybrids Technical Committee promotes actions on the spread and sharing of scientific and technological knowledge and information about e-mobility by working towards solutions and systems concerning the cause. Hence, EV&H-TC focuses on technical projects and actions that are business bias-free or works preferably with specific technologies. Likewise, the EV&H-TC stimulates active support and commitment to e-mobility from government agencies so that ongoing projects are strengthened and the EV supply chain broadened.

The EV&H-TC's objectives are as follows:

- Market diagnosis of the national and international auto scenario – projections and forecasts of 1-5 year periods;
- Development of strategies for the e-mobility sector;
- Implementation of said actions;
- Assessment of outcomes produced by the strategies and related adjustments;
- Identification of local initiatives and opportunities in the market;
- Engineering training and courses and the creation of a knowledge base on electric transportation technology;
- Promotion of e-mobility symposia, virtual conferences and technical events on sustainable mobility;
- Evaluation of collaborative projects and actions for low-emissions and efficient transportation, together with the industry, academia, RD&I centers and government, focused on sustainable mobility.

For EV&H-TC, transforming the energy matrix of the different types of passenger and commercial vehicles is a proof of the global trend towards the use of electric traction systems. In this sense, Brazil needs to be able to carry out and achieve this technological transformation, under the risk of being considered outdated in relation to most countries in the world.

Arquivo PNME

Technologies within the scope of EV&H-TC

- Electric motors, converters and inverters of various types (AC/DC, DC/DC, DC/AC)
- Lithium-ion batteries of different electrochemical properties
- Controls, connectivity and automation systems, charging systems, etc. that follows standardization, certification and homologation of the automotive sector
- Electric traction systems
- Safety and security
- Infrastructure for EVs

EV&H-TC believes that the Brazilian automotive engineering sector should seek competitiveness for the production of vehicles with propulsion systems that reduce, or even eliminate, gas emissions and particulate matter emissions, motivated by environmental, public health or even energy efficiency issues.

To this end, it is necessary to promote exchange between the various actors in the sector – automakers, tiers of the industry's supply chain, academia, government and institutions focused on the development of global electrification actions and their impact in Brazil.

According to EV&H-TC, e-mobility in Brazil will go through a transition phase via hybrid vehicles – which can last for different periods depending on their categories: light and heavy vehicles (5 to 10 years) – until a total fleet electrification, with the exception of those that, for various reasons, cannot be fully electrified

6.4.1. E-mobility in Brazil: value creation and outcomes

The actions undertaken by EV&H-TC have attracted growing interest from the Brazilian tech community in its events and technical and scientific work sessions, promoting professional training, spread and exchange of knowledge among different actors of e-mobility.

Through its events, training and publishing of technical and scientific material by the press and other types of publicity, EV&H-TC has strengthened ties with the industry and academia, creating a stronger e-mobility chain so as to adopt a lifestyle that embraces alternative energies and an eco-transport in the country

In addition, EV&H-TC spreads new information about technological trends and supports the establishment of EV technical standards and norms in Brazil as well as its access to international standardization materials.

Examples of events and knowledge dissemination in the community

- The Annual Hybrid and Electric Vehicle Technologies Symposium – SAE Brazil
- The Hybrid and Electric Vehicles Panel – SAE BRAZIL Annual Congress
- Creation and support of academic competition programs, such as the Annual Formula SAE® Electric – FSAE-E, the new international **H2 Challenge**
- Continuing education courses offered by SAE BRAZIL (E-Mobility Training and Courses)
- Publication of articles in the quarterly Magazine SAE AAE – Aerospace and Automotive Engineering
- Participation in forums, workshops e webinars
- Face-to-face and distance learning professional training courses of competencies in e-mobility for professionals and professionals-to-be of the auto industry
- Grant interviews to communication channels participants of not of the ecosystem of e-mobility
- Maintain relations with the industry, academia, representatives (ANFAVEA, ABNT and Sindipeças) and research and development centers (CPqD), AHK (German-Brazilian Chamber of Commerce and Industry)

saebrasil.org.br

Such collaborative work aims at the dissemination of knowledge and information, new technologies and roadmaps, cooperation in the development of standards and in the implementation of initiatives, such as student programs and the promotion of events.

Therefore, the set of actions and training courses carried out by EV&H-TC translates the outcomes produced by the Committee's performance in a tangible way, which provides mobility professionals with a broad view of the e-mobility ecosystem and the technological challenges thereof, in addition to solutions to overcome those challenges.

6.4.2. EV&H-TC's Framework

The Committee is formed by a plural spectrum of participants, dedicated to the promotion of meetings and events targeted at the electrification of the vehicle propulsion system. It has approximately 40 volunteers, including professionals of the industry, research and skills development centers, the academy and those who work in transportation companies or other sectors that are somehow connected to e-mobility.

As for its facilities, EV&H-TC works in two rooms at the SAE BRAZIL headquarters on Avenida Paulista, in São Paulo. In addition, SAE provides the Committee with administrative support.

6 4.3. Collaboration and cooperation of actors and network building

The Commission works jointly with agencies, entities, associations, researchers and professionals of e-mobility-related industries, non-exhaustive examples are as follows:

- USP, UNICAMP, MAUÁ Institute of Technology, Telecommunications Research and Development Center (CPqD) and Engineering Institute (IE);
- The Brazilian Association of Technical Standards (ABNT), the Brazilian Automotive Engineering Association (AEA), the National Association of Vehicle Manufacturers (Anfavea), the National Association of Brazilian Auto Parts manufacturers (Sindipeças), the Ministry of Science, Technology and Innovation (MCTI), Petrobras, the International Association of Public Transport (UITP), the Union of Engineers of the State of São Paulo (SEESP), Brazilian Association of Electric Vehicle (ABVE;
- Mercedes-Benz, General Motors, Scania, VWCO, Toyota, BMW, Caoa Cherry, Bosch, Magneti Marelli, Schaffler, Siemens, WEG Industries, and others.

Internationally, EV&H-TC works collaboratively with international actors via SAE International and its associates through their respective companies.

The ZEBRA Partnership 6.5

The Zero Emission Bus Rapid-deployment Accelerator (ZEBRA) aims to deploy more new electric buses in São Paulo (Brazil), Santiago (Chile), Medellín (Colombia) and Mexico City (Mexico). Those are cities that are already determined to innovate and make their public transportation fleets zero emissions. The Chilean experience is considered as the inspiration and example to guide actions planned for Mexico City, São Paulo and Medellín, as well as other Latin American cities.

With the C40 Cities Climate Leadership Group and the International Council on Clean Transportation (ICCT) as co-leaders, this program seeks to partner with local financial institutions that are willing to invest $1 billion for the deployment of EV zero-emission technology and electric propulsion technologies by 2021 and that also believe in the design and proposition of new means of financing and business models for the operation of public transportation.

Parallel to demand, the program also aims to act on supply by securing commitments from the main bus and engine manufacturers to support the growth of the e-bus fleet in Latin America. For that, said manufacturers collaborate by providing technical specifications of vehicles, loading plans, execution of pilot projects, and other aspects of technological nature.

In addition to accelerating the e-bus transition in Latin America, the project aims to stimulate competition between manufacturers, in order to make advances, allow operators to experiment with different brands and allow the financial sector actors to invest in zero-carbon technologies.

In its first phase (2019), the ZEBRA Partnership established working groups in each of the cities previously mentioned, in order to build an action plan for the acquisition of e-buses. Those groups included representatives of the public and private sectors.

For the leaders of this initiative, what makes the ZEBRA Partnership stand out is the collaboration and coordination of its actors: public managers, vehicle manufacturers, operators and business financiers. In fact, this initiative plays a fundamental role in guiding and supporting public and private actors in designing strategies for low-emission mobility.

6.6 ANEEL R&D – Call 22

In the ecosystem of e-mobility, the relevant role of the National Energy Agency (ANEEL) stands out. Since 2010, ANEEL has been participating in a series of e-mobility-related projects and investments through its R&D strategic project carried out by actors regulated by the Agency. Said investments were part of the traditional R&D program, transversal to the themes of the electric power sector, and were used in the construction of the first charging infrastructures in the country, as well as in e-mobility demonstration projects.

Launched in 2018, the R&D Call 22 provided a spur for e-mobility, which included 30 approved projects that account for more than R$ 463 million in investments in e-mobility from various proponents and administrators. The total of approximately R$ 73 million in collaterals (that shall be of at least 10% of the total project value in financial resources and the like) may be added to the figures mentioned above.

In fact, if 2020 was a complex year for investments in mobility due to COVID-19, revealing a certain general stagnation in the ventures and related actions, we can affirm that R&D Call 22 is largely responsible for the continuity of new e-mobility projects.

These projects have also made it possible to leverage the ecosystem of e-mobility as R&D Call 22 advocates for inter-sphere cooperation, with the participation of companies, Institutes of Science and Technology (ISTs), start-ups, consultancy firms and other market actors. That resulted in the creation and development (in progress) of a network structure for R&D projects, the Network of Innovation in the Electric Sector (Rise).

We emphasize that R&D Call 22 aimed to focus on go-to-market strategy projects, that is, projects directed to solutions that come to the latest stages of the innovation value chain, such as: material selection processes, development of prototypes, and spread and insertion of products in the market.

BNDES 6.7

The Brazilian Development Bank (BNDES) has a structured range of financial products to foster the deployment of low-emission mobility and clean technologies. In order to do so, BNDES has financed projects and plans that were in line with the concepts of renewable energy and energy efficiency through the "Renewable Energy'' special credit line and the "Efficient Capital Goods/National Technology'' credit line, respectively, both accredited by BNDES's FINAME Product. The Bank has played an important role in offering financing for the purchase of low or zero-emission machinery and equipment.

From this perspective, a line for low-emission mobility has become a financial product. This type of product is suitable for both suppliers, that is, for companies that wish to invest in the manufacture and assembly of vehicles and their components, and for demanders, i.e., for companies and consumers that wish to purchase products. Examples of beneficiaries are: the public administration, companies, small-businesses, actors of road freight transportation, foundations, associations and cooperatives with headquarters located in Brazil and, finally, domiciled residents in the country.

As motivations to commit to the e-mobility agenda, the BNDES highlights some demands from several actors, such as:

- External demand (financial agents and multilateral development banks);
- Third sector demand (WRI, C40, PNME);
- Market demand (product suppliers and potential customers).

6.7.1. BNDES' Framework

The Bank's technical staff deserves attention as it masters the state-of-the-art (and how to employ it in products and services) and takes the various Brazilian realities into account when seeking to develop the best models or arrangements of services to be successfully implemented, with a focus on efficient and decarbonized transportation in cities.

We also highlight the BNDES' performance and collaboration with other institutions, such as the C40. The motivations for those interfaces clearly indicate that greater future cooperation is to be promoted in this technological field. Hence, BNDES has developed and promoted products and services to match marketplace needs and has crystallized the concept of low-emission mobility in the institution, which is interpreted as a strategic, priority issue.

BNDES financing compiles a wide list of products and technological

The agreements signed with other institutions reinforce commitments to be fulfilled by BNDES regarding low-emission mobility

6.7.2. E-mobility in Brazil: value creation

We can affirm that the creation of value by BNDES goes beyond the sphere of financing instruments. In fact, the Bank is also present on other fronts, such as its participation in discussion forums, as a member of the National Platform for Electric Mobility (PNME) and in low-emission mobility projects in cities, such as the ZEBRA Partnership.

FUNDEP – The Research Development Foundation

6.8

FUNDEP considers that the diffusion of e-mobility in Brazil, in its various modes, is still incipient when compared to other markets (the Chinese market, for example). However, since its mission embraces fostering the development of society through education, research and innovation and also providing support to the government in decision-making processes, FUNDEP believes that e-mobility is a key driver of change, which transcends the issues of health and environment: for FUNDEP it is also a matter of energy.

In fact, FUNDEP assesses that the e-mobility agenda in Brazil is fragmented and a few steps back in relation to Europe, the United States and China, which requires coordinated efforts and the mobilization of actors – a role now played by the PNME.

In this context, FUNDEP is a moderator as well as a link between actors which maps demands, on the one hand, and opportunities for technological development, on the other, in order to draw up a plan and the necessary actions for their implementation on a multi-stakeholder approach.

FUNDEP is a catalyst for change that has played a leading role in working on key drivers of change.

6.8.1. FUNDEP in action

FUNDEP argues that e-mobility does not exclusively concern engineering, it is defined in a broader context: (1) zero-emission modes of transportation, (2) connectivity with smart cities and (3) integration between different modes, in which mobility is provided as a service (MaaS – Mobility as a Service).

Therefore, this broad scope results in permanent collaboration and coordination between FUNDEP and the government (at the national, intermediate and municipal levels), private institutions and ISTs. Also noteworthy is the Route 2030 point V, which regards projects on alternative propulsion systems.

Additionally, FUNDEP plays the role of co-secretary of PNME and is also part of the Platform's Science and Technology Commission.

It also participates in the project on the 1st lithium-ion battery cell plant, employing the lithium-sulfur (Li-S) technology, together with Minas Gerais Economic Development Company (CODEMGE) and Oxis Brazil. FUNDEP collaborates on a pilot project of e-vehicles in car-sharing services, in partnership with the Energy Power Company of Minas Gerais (CEMIG) and the Minas Gerais State Economic Development Secretariat (SEDE).

6.8.2. Motivations for FUNDEP's participation, value creation and outcomes

FUNDEP believes that e-mobility will have a major impact and will produce results that cannot yet be determined and the fact that there are new researches, developments and innovations to take place is of the foundation's interest, those are the key motivations that led the FUNDEP towards the e-mobility cause.

In the various actions undertaken by FUNDEP, value was created by (1) assessing the number of financed projects and the resources thereof, (2) the number of actors involved, (3) the international relations established within the scope of the projects carried out and (4) active participation in events that encourage the formulation of public policies, which resulted in R$ 85 million to support projects of the Route 2030 point V.

6.8.3. FUNDEP's Framework

FUNDEP is currently made up of 250 professionals who work in different programs and projects in various areas of knowledge, of which 20 to 30 people are directly engaged in the Route 2030 point V – which regards projects on alternative propulsion systems- and in PNME activities.

FUNDEP also works with international organizations that also promote initiatives on e-mobility, such as Calstart, MIT, Harvard Institute (USA), Technion (Israel), Fraunhofer Gesellschaft (Germany). In addition, the Foundation maintains relations with both the British and the Portuguese Consulate-General

6 8.4. Collaboration and cooperation of actors and network building

FUNDEP works closely with ISTs, having in its portfolio approximately 40 actions directly supported by the Foundation in the most varied areas of knowledge and whose subjects are transversal to e-mobility. As for example the areas of advanced materials, power electronics and electrochemical accumulators. In addition to ISTs, FUNDEP maintains relations with the Ministry of Economy (ME), the Ministry of Science, Technology and Innovation (MCTI), the Ministry of Regional Development (MDR) – said Ministries are members of PNME – as well as with the National Energy Agency (ANEEL), the Funding Agency for Studies and Projects (FINEP), the Brazilian Development Bank (BNDES), and others.

FUNDEP works jointly with associations, such as the National Association of Vehicle Manufacturers (ANFAVEA), the Brazilian Automotive Engineering Association (AEA), the National Association of Brazilian Auto Parts manufacturers (SINDIPEÇAS), the Society of Automotive Engineers (SAE Brasil), and so forth.

6.8.5. Brief analysis of the e-mobility ecosystem in Brazil

Finally, the FUNDEP recognizes several actors in the e-mobility ecosystem, but there is still a gap in national collaboration among them and instruments and public policies that encourage the widespread diffusion of e-mobility in the country are still to be developed. In this regard, the Foundation believes that the PNME works as the integrator that provides the right space for collaborative and coordinated work of actors.

FUNDEP considers that for the promotion of new businesses, integration and collaboration are decisive factors, since it facilitates the process for Brazil to keep up with other countries.

6.9 Conclusions

In this chapter, we addressed initiatives and their features as a place of collaboration and cooperation of actors and the governance structure adopted in partnerships between leaders of those collectives. This study provided us with a comprehensive overview of the institutions' objectives, how they are formed, their frameworks, their approach to e-mobility and also their roles in the e-mobility ecosystem.

As for PNME, it is a multi-stakeholder platform whose greatest asset is its ability to coordinate actors with diversity of experiences, knowledge and points of view directed towards a common goal. The Platform is composed of members from (1) government (2) industry, (3) ISTs and (4) civil society. In fact, PNME acts on a national scale and aims to orchestrate projects and large programs for e-mobility. The proposal for the National Action Plan for Electric Mobilit is being discussed in the Platform, whose first meeting and activities were carried out in 2018.

In fact, PNME fills the gap of governance structure at a strategic level that embraces the perspectives of the market, government and academia.

In a supply chain, market-oriented approach, ABVE plays an important role as it is the only association of its kind in Brazil that represents the EV supply chain as a whole. ABVE has among its associates small and large companies, national and transnational companies, local producers and importers. ABVE has among its associates small and large companies, national and transnational companies, local producers and importers.

We learned that ABVE joined the movement as a catalyzer of demands and of cooperation and collaboration processes within and between different branches of economic EV-related activities, and so its role involves taking those demands forward to decision-makers of different functions of the State – Executive and Legislative, in order to advocate for the development and use of EVs in the country. ABVE also partners with the PNME so as to work in the promotion of e-mobility in Brazil.

Moreover, SAE EVs and Hybrids Technical Committee (EV&H-TC) promotes actions on the spread and sharing of scientific and technological knowledge and information about e-mobility by working towards solutions and systems concerning the cause.

Hence, EV&H-TC contributes greatly to collaboration, tech support and training courses of competencies in e-mobility from an engineering approach, which is also the Committee's identity. It is also worth mentioning the connections between the EV&H-TC and SAE International, which is a channel for the exchange of knowledge and information as a means of learning.

After studying the activities undertaken by the ZEBRA project, we observed that it is one of the main collaborators and supporters of the electrification of public transportation in cities. Its operations are intrinsically linked to the governance of good practices in cities that aim to transition to low or zero-emission public transportation.

Hence, the ZEBRA project took the role of bringing interested parties together, both demanders, which are the cities, as well as suppliers, such as automakers and components makers. Also, to incorporate supply and demand by considering the challenges regarding acquisition of EVs and business models of

public transportation, the project provides the actors involved with technical, economic and financial support for their decision-making process.

Furthermore, the relevant role of the National Energy Agency (ANEEL) stands out. ANEEL has been participating in a series of e-mobility-related projects and investments through its R&D strategic project. We can affirm that R&D Call 22 projects are largely responsible for the continuity of the e-mobility agenda as said projects are carried out and receives half a billion reais in investments.

As for the Brazilian Development Bank (BNDES), it has a structured range of financial products to foster the deployment of low-emission mobility and clean technologies and offers financial instruments to actors of the supply chain as well as to companies and consumers that wish to use adopt solutions in favor of public transportation, for instance.

At last, FUNDEP's mission embraces fostering the development of society through education, research and innovation – via ISTs – and also by providing support to the government in decision-making processes. FUNDEP believes that e-mobility is a key driver of change, it is a moderator as well as a link between actors which maps demands, on the one hand, and opportunities for technological development, on the other, in order to draw up a plan and the necessary actions for their implementation on a multi-stakeholder approach.

In conclusion, we have hereby approached the main organizations working towards the adoption of a governance for e-mobility in Brazil. Above all, these collectives are understood and treated as open channels so that there is interaction with those who wish to have a deeper knowledge of their actions or identify opportunities for partnerships on e-mobility. Unlike the scenario painted by BARASSA, 2015; CONSONI et al., 2018b, where there is no e-mobility governance in action in the country, the spectrum of actors presented in this chapter brings elements that allow us to argue that the governance for e-mobility is an ongoing reality in Brazil.

Conclusions

This Annual Report aimed to describe and study the e-mobility panorama in Brazil according to the following elements:

- drivers for motivation
- technologies
- businesses and markets
- governance and policies

This study was driven by the question:

How are the actions and activities regarding e-mobily being developed and prioritized in Brazil?

Such a question arises, especially, as we noticed a gap to be filled by a publication that addresses the many ongoing initiatives on e-mobility by a well-structured, systemic vision approach; such a publication may also adopt different perspectives when assessing innovations, such as the technology, political and marketing perspectives. Moreover, we can affirm that a well-presented report on the sector has not yet been published, that is, there are no publications on the growing e-mobility sector and its advances and activities available in Brazil. Hence, with the absence of a publication in Portuguese, neither is it expected a publication written in English.

And in this scenario in which Brazil does not publish nor share relevant information on e-mobility, the country abstains from participating in other markets, countries and regions. We can even infer that it is due to those circumstances that there are a few international actors interested in the Brazilian e-mobility market.

Thus, we find it imperative that we organize, collect, process and publish a study about the current status of the development of e-mobility in Brazil. Consequently, it is for the above-stated exact reasons that we presented this Annual Report and, motivated by it being the first publication of its kind on the subject and also being published in English, this Report plays an important role of disseminating information regarding e-mobility in this scenario of uncertainties and barriers in which we are inserted now.

Chapter 1, presented a general outlook of e-mobility, addressing e-mobility from a broad perspective that embraced not only electric vehicles and their related technologies, but also the way in which those are applied and used in new interfaces and businesses. The modes of transportation presented were Heavy-Duty Vehicles Passenger Vehicles and Heavy-duty Commercial Vehicles, Light-Duty Vehicles Passenger Vehicles, as well as those labelled as micro-mobily, especially e-mopeds and e-bikes. As for technology, we defined the Electric Propulsion System (EPS) as the component that is central and common to all those categories, which is com-

posed of a set of components and technologies to create EV traction. It involves electric motors, accumulators (e.g. batteries), inverters, chargers, hybrid systems and other subsystems.

In addition, in Chapter 1 we provided reflections about how different variables stimulate and shape vehicle electrification, like the relation between PM emissions and public health, the calls to reduce emissions under increasingly aggressive metrics, the advantages of not using fossil fuels and, finally, the new windows of opportunities in solutions and business. When it comes to emissions, we noticed that automakers have been put in check when offering only internal combustion engine vehicles and there is a clear reconfiguration of their product portfolios which now have hybrid and pure electric vehicles.

We also learned that e-mobility poses a dilemma for the industry, since it put questions to investing in a well-established, mature technology that, still, has limited application. In this process of technological transition, the focus of investments is on those critical elements which depend on technological improvements in order to become fully economically and financially viable, such as batteries.

Chapter 2, in which we addressed the national context and its common drivers for the adoption of e-mobility, showed us that the Brazilian market has active players, being those interested in the supply chain or in new businesses, who are, in whichever case, interested in boosting e-mobility in the country. It is noteworthy to mention the embryonic stage of e-mobility in Brazil that is still being introduced and spread in the market. Hence, the sector is being structured in the country, especially in the state of São Paulo, but also in the states of Minas Gerais, Rio de Janeiro, Paraná, Santa Catarina and in the Brazilian capital Brasília. That highlights that e-mobility is being adopted through clustering, mainly present in the axis formed by the cities of Rio de Janeiro – São Paulo and São Paulo – Paraná.

In fact, we consider that actors are still identifying their roles, the ways in which they can act and develop their business in the market, which was present in various interviews and talks carried out as preparatory work for this publication. We also noticed the introduction of new companies in the market who came from other sectors, such as the electrical and electronic sector, which brings new elements to e-mobility and its supply chain.

Chapter 3 presents public policies that are transversal to e-mobility, such as the Route 2030 program (automotive sector) and the ANEEL R&D (electric power sector). Those institutions are considered relevant drivers that promote demonstration projects and the experimentation of EV technologies.

The set of mapped public policies can contribute to more intense entrepreneurial activities ongoing in the country, especially in regards to the industrial policy implemented at the end of 2018 – the Route 2030 program. That is a key public policy for the auto industry which comprises incentives for R&D projects, which may affect EVs, as the companies qualified in these activities must comply with the increase of energy efficiency of vehicles sold in the country, possibly resulting in the electrification of their fleets. In addition, ANEEL R&D Program (Law n. 9991/00) started to direct approximately half a billion reais to EV-related projects in Brazil.

This program will definitely bring companies of the electric power sector close to e-mobility by leveraging the development of new technologies and business models.

We can affirm that there are ongoing efforts to foster scientific and technological competencies development

in the e-mobility sector in Brazil, in view of professional training courses being offered and the participation of ISTs in several R&D projects in progress.

Chapter 4, which addressed impacts of the COVID-19 in the e-mobility sector, we learned that mapped projects and ongoing projects can be negatively affected by the pandemia, as it impacted all the other industry sectors, including the e-mobility sector. We saw that practically all modes of transportation were badly affected as investments and actions that were expected to happen were postponed. In addition, the depreciation of the Brazilian real against the US dollar directly affected prices of imported goods, posing more barriers to the adoption of e-mobility. However, in this scenario of challenges, opportunities were revealed. Opportunities to redesign public transportation existing strategies and business models, and also to adopt micro-mobility in Brazil.

And beyond COVID-19? What types of market trends can be spotted for the coming years? What shall we expect within the 2030 time horizon?

Chapter 5, provides insights into a vision of the future for e-mobility in Brazil. It built exploratory scenarios as well as prospective scenarios of market behavior of EVs and their modes. Curve patterns were defined and based on a great number of interviews and talks carried out with market actors and specialists who shared their views and perspectives on e-mobility for 2023, 2025 and 2030.

On a methodological approach, those views were categorized in conservative scenario, moderate scenario and aggressive scenario, which addressed EV fleet growth by year and the market share (%) of light passenger vehicles. We concluded that, from the data collected, in the short term (2023) all modes of transportation and recharging infrastructure will be affected by of COVID-19, with a profile framed between the conservative and moderate scenarios.

However, it will be between 2025 and 2030 that the EV market behavior will be inserted in the moderate scenario, whose growth will be similar to the pre-COVID scenario.

Finally, Chapter 6, which addressed elements of governance and collaboration among actors, presented a comprehensive overview of the many actors who work for the development of e-mobility in Brazil: how they prioritize their actions, their frameworks, their approach to e-mobility and also their roles in the em-mobility ecosystem. Hence, we approached the main organizations working towards the adoption of a governance for e-mobility in Brazil. Above all, these collectives are key to spread the word and promote e-mobility in society and to offer training courses of competencies in e-mobility, as well as to orchestrate agendas, collaborate and cooperate and perform strategic actions that promote impact.

All in all, we hereby described and studied the e-mobility panorama in Brazil. We did try to present the vast majority of activities of the sector undertaken today. However, we believe that this is an inexhaustible exercise, since other ventures, new regulations and other initiatives may be engendered and were not covered prior to the conclusion of this publication.

However, this Annual Report does not end in itself. In fact, we consider it to be an evergreen document, which must be revisited and updated year by year. We advise the constant monitoring of the various dimensions that affect e-mobility, which include (new) technologies, institutional evolution (new types of

policies and international collaborative efforts), market advancement and other elements that affect the diagnosis presented by this Annual Report.

This follow-up is necessary for the updating on the new features of e-mobility. In fact, that is one of the roles of this type of publication and the next editions must present the reader with an up-to-date outlook of e-mobility. Until then, the expectation is for the expansion of this ecosystem and for new elements to be brought to stage.

APPENDIX I

Workshops to design the structure of PNME and their development methodologies

Table 16. methodological process of creation and consolidation of PNME by research fronts

WORKSHOP	ADDRESSED TOPICS	METHODOLOGICAL PROCESS
1st Workshop August.23rd.2019 *FIESP-SP*	1. MOTIVATIONAL DRIVERS 2. OBJECTIVES (and risks) 3. ACTORS AND PARTIES	Facilitated activities performed by 3 groups of stakeholders aiming to: • Establish three main motivations • Establish three main objectives and risks • Identify actors and parties by the Innovation Radar method
2nd Workshop October.24th.2019 *Brasília*	4. GOVERNANCE FRAMEWORK STRUCTURE (part 1) • Strategic Planning • The Secretariat	facilitated activities performed by 3 groups of stakeholders aiming at: • Questions and answers pertaining to the strategic planning, secretariat, members and others *** In addition to the workshop, bibliographic review regarding other network and platform structures was undertaken
3rd Workshop December.5th.2019 *Brasília*	5. GOVERNANCE FRAMEWORK STRUCTURE (part 2) • Members • Science and Technology Comission (CST) • Finance Commission 6. INSTRUMENTS OF PUBLIC POLICY AND REGULATION	Facilitated activities performed by 3 groups of stakeholders aiming to: • Answer previously selected topics referring to the CST, Finance Commission and other organizational Structure parts

Source: Personal collection.

APPENDIX II

Electric Mobility as a means to advance in the promotion of citizenship and human rights

Flávia L. Consoni

Tatiana Bermúdez Rodríguez

1. Introduction

This article aims to reflect upon the complex challenge of Brazilian cities in promoting the sustainability transition [1]of urban mobility, by strengthening the relation between urban space usage and less polluting land vehicles in a good quality, safe, inclusive and accessible manner. This study is guided by the belief shared with the United Nations on the place urban public transportation takes in debates about mobility, which is considered *"not as an end in itself, but as a means that allows people to access needs of any sort: employment, markets and goods, social interaction, education and a series of other services that contribute to healthy and fulfilling living."* (CNM, 2018; UN, 2016). In other words, urban transportation, which includes its various modes, shall be treated as part of a system of urban mobility that fosters advances towards sustainable urban development and as an instrument to build more just, sustainable and inclusive societies (GUZMÁN; OVIEDO; ARDILA, 2019).

Such approach is in accordance with the principles established by the National Urban Mobility Policy (NUMP) passed as Law n. 12,587/2012, which is based on the belief that adequate mobility is a preponderant factor to achieve sustainable development of cities, in both the socioeconomic and the environmental dimension; its end point is that cities work towards improving quality of life and enforce the right of citizens to access diverse opportunities for employment, education, leisure, services, and others (PEREIRA et al, 2020). And it is a fact that unhealthy and precarious conditions of transit limit people's options to live healthy and productive lives (VENTER; MAHENDRA; HIDALGO, 2019).

Cities, and especially local governments, are fundamental to (re)directing and stimulating such transition processes towards sustainable mobility (BANISTER, 2007). As for the Brazilian scenario, local governments are responsible for planning, executing and evaluating the urban mobility policy and for organizing and providing public and private transportation services, adopting standards for the control of environmental and noise pollution. For those reasons, local governments have all the power to implement policies and actions to promote the transition to sustainable mobility[2], which in many cases are not aligned with the national context.

In this context, local governments should reflect on the impact of implementing low-emission transportation systems to reduce greenhouse gas (GHG) and local pollutant emissions, noise, public health and, in general, improving citizens' quality of life and reducing inequalities. E-mobility is one of the alternatives that can contribute to the transition to sustainable mobility in cities, given the greater energy efficiency of different electric modes of transportation and less dependent fossil fuel alternatives.

We can affirm that cities have become a kind of living laboratory for the promotion of low and zero-emission technologies, where it is necessary to take into account specific characteristics of each technology, the possibilities of integrating vehicles with renewable energy sources (solar power, wind energy, biofuels) and the benefits associated with their implementation, especially those concerning the environment, health and mobility. Cities are no longer static elements, they have become dynamic places that encourage transitions to sustainability (BERMÚDEZ, 2018).

From this perspective, the question that arises is: how do cities manage to adequately meet the needs of citizens regarding transit and commuting by guaranteeing their basic rights, access to diverse opportunities

1 *Sustainability Transitions* are long-term, multi-dimensional, and fundamental transformation processes through which established socio-technical systems shift to more sustainable modes of production and consumption. (MARKARD; RAVEN; TRUFFER, 2012). Promoting sustainability transition involves the transformation of the ongoing transportation systems, mobility, agriculture, energy power, and others, in which the participation of actors from different sectors is key to advance such transformations.

2 *Sustainable Mobility* involves a broad concept in which the individual is valued in urban areas, implying actions that allow a healthier and more harmonious coexistence. Promoting the transition to sustainable mobility implies thinking about integrated public planning with actions to foster progress in this direction (BANISTER, 2008).

and quality of life at the same time? The challenge is not trivial and requires consistent and coordinated planning between economic, transportation, public health and environmental policies, aligned with urban development and the infrastructure of cities.

The implementation and growth of e-mobility, which in this publication comprises its various modes (cars, buses, trucks, bicycles, scooters), in which there is integration between them and active mobility, presents itself as an ally to advance in this complex challenge of sustainable mobility for cities. In addition, e-mobility, being zero or low-emission and practically soundless, is considered as a strategic technology that enables cities to transition to sustainable mobility. Those characteristics are a great differential to e-mobility when compared with other traditional modes dependent on fossil fuels: when inserted in its environment, that is, cities, the emission of pollutants is reduced or zeroed, which helps to decarbonize urban centers that demand urgent actions on air pollution.

It is noteworthy that when addressing the role of e-mobility in the transition to sustainability or sustainable mobility, it is not a matter of defining such electric modes as simply as technology and innovation instruments. We are adopting an approach that takes e-mobility as a means of enabling citizens to access clean and better quality means of transportation. Specifically, the implementation of electric and efficient public transportation systems can contribute to greater connectivity in urban areas and to greater social inclusion through the reduction of structural gaps and inequalities by allowing greater accessibility to opportunities for citizens and social groups residing in urban peripheries (BORBA, 2020). Thus, emobility, given its sustainable character, broadens citizens' access and respect for human rights in general.

This article aims to advance the reflection that links electric transportation modes with the concepts of citizenship and human rights by proposing arguments concerning benefits that citizens can obtain from actions and strategies that Brazilian cities undertake to implement e-mobility in urban areas.

In order to bring more elements to this debate, this article consists of four more sections additional to this introduction. Section 2 advances the discussion on e-mobility and its role in the transition to sustainable mobility in cities, seeking to establish links between this study and concepts related to the promotion of citizenship and human rights.

Section 3 reinforces the arguments already presented by addressing the various interfaces and the transversal side that e-mobility presents in relation to the global agenda put forward by the UN to be achieved by 2030, based on the proposal of Sustainable Development Goals (SDGs) (UN, 2015). The SDGs are a response to a purposeful agenda of coordinated and integrated actions on a global scale, whose objective is to address issues such as citizenship and human rights by setting goals and indicators for social, environmental, economic and institutional issues. In the context of cities, the SDGs can be seen as a methodology for organizing, analyzing, planning and implementing strategies for actions that can be integrated into the public budgeting (CNM, 2018). Thus, to highlight the relationship between e-mobility and the SDGs is a way of showing cities a possibility of moving forward to reaching this agenda and its potential benefits for citizens.

Section 4 provides arguments for reflection upon this issue from the perspective of Brazilian cities. Since e-mobility is a way of providing urban areas with higher quality, sustainable means of transportation, as well as a way to commit to the SDG goals, the guiding question for Section 4 is: how are Brazilian cities managing to advance in the implementation of e-modes of transportation?

Finally, we present conclusions concerning the approach that takes urban transportation *as a means to an end, not as an end in itself*. In other words,

urban transportation should be the means to enable the mobility of people so that they can access opportunities relevant for their lives, as Amartya Sen (1995) proposes, in the most efficient way possible (GUZMÁN; OVIEDO; ARDILA, 2019). Electric modes of transportation, which are way more than technical instruments, would be a means of contributing to sustainability transition.

2. Transition to sustainable mobility through e-mobility

The debate on sustainable mobility employs a new approach that, unlike conventional concepts, focuses on individuals and the social dimension of the relationship between people, traffic and urban space. It is about considering streets as a space for people, for active mobility, for public transportation, and not just for cars and their users (BANISTER, 2008).

The Transition to Sustainable Mobility requires the integration of clear planning strategies, combined with actions that aim at reducing the need for travelling and trips' duration; actions that promote the use and combination of modes of transportation, and encourage more efficient transportation systems by adopting low-emission technologies (BANISTER, 2008). Hence, it is a fact that discussing sustainable mobility implies thinking about modes that, being emission-free, contribute to the reduction of negative externalities of air pollution, noise and public health, especially in urban centers. It is in this scenario that e-mobility occupies an important space (albeit not the only one) in the transition to low-mission (NOEL et al, 2018a, 2018b) and places the responsibility on cities, so that they take the necessary decisions that aim to promote such transition.

Some reasons that justify the importance of looking at cities as key actors to stimulate transitions to sustainable mobility are (EEA, 2018; HOLTZ et al., 2018; KUOKKANEN; YAZAR, 2018):

- Cities have been increasingly concentrating power and available resources, and are a place of demand for goods and services (which can be environmentally specific), thus cities are central players in the transition to sustainable mobility.

- Cities provide special conditions for natural incubation of new technologies, demonstration projects and experiments that lead to learning about different sustainable innovations, and contribute to the reconfiguration of existing practices.

- Urban areas are places where changes in infrastructure, institutions, production and the behavior of consumers and citizens can occur.

- Urban areas can coordinate and promote joint developments in different sectors that can result in simultaneous processes of transition to sustainability.

- Brazilian municipalities, specifically those with more than 20 thousand inhabitants, are obliged to elaborate and approve a National Action Plan for Urban Mobility, as an instrument of implementation of NUMP.

Thus, based on the performance of local governments and collaboration of citizens and other actors in society, cities are fundamental to lead processes of transition to sustainability, because they can better understand, inform and guide local inhabitants, public managers, companies and organizations to achieve sustainability goals (VAGNONI; MORADI, 2018).

And among those goals there is the challenge of mitigating air pollution. We fully understand the impacts on human body caused by local air pollutants such as Particulate Material (PM), Nitrogen Oxide (NO_x), Carbon Monoxide (CO), Ozone (O_3) and Sulfur Dioxide (SO_2) (GAKIDOU; GLOBAL BURDEN OF DISEASE STUDY 2016 RISK FACTORS COLLABORATORS, 2017; MIRAGLIA; GOUVEIA, 2014; WHO, 2016; SALDIVA, 2018). In fact, According to the World Health Organization (WHO),

exposure to Particulate Matter ($PM_{2.5}$) contributed to 4.2 million premature deaths, 91% of which occurred in low and middle-income countries. The issue of sound or soundless vehicles, in the case of electric modes of transportation, is another dimension to be considered as it provides greater comfort and quality for citizens' commutes.

However, the reflection on e-mobility in urban spaces goes beyond health and environmental issues, which are the impacts most easily associated with it. It is about looking at e-mobility as an ally to advance sustainable mobility as it also impacts economic growth, industrial and technological development, access to energy, infrastructure and sustainable production and consumption, in addition to contributing with the creation of inclusive cities and enforcing the right to access public spaces. Thus, e-mobility can serve as a redistributive instrument to contribute to the reduction of inequalities as far as it can go/or provide citizens with better access to social life, education, health, leisure and economic opportunities (WILLOUGHBY, 2002); (GUZMÁN; OVIEDO; ARDILA, 2019). The elements mentioned before are shown in Figure 1, which illustrates connections between e-mobility, citizenship and human rights.

Figure 31. Connections between e-mobility, citizenship and human rights.

Source: Personal collection.

In this context, e-mobility can be understood as an innovation process that embraces the implementation of different modes of transportation (private, collective, freight, bicycles, mopeds) with electric and/or hybrid propulsion systems. Such technology has advantages over conventional vehicles with internal combustion engines, mainly in relation to energy efficiency, reduction of dependence on fossil fuels, and reduction of GHG and local pollutant emissions.

But e-mobility is not only about implementing certain types of EVs (as machines). On the contrary, it is associated with a series of political, economic, industrial, financial, market, technological, social, cultural and infrastructure elements, as well as new consumption habits and practices among users (GEELS, 2012).

In addition, e-mobility establishes connections with other economic sectors, such as the electric power sector, electric power distribution and mining with different areas of knowledge, such as information and communications technologies, chemistry, electronics, among others. This necessarily results in the participation of new actors from different positions of power and governance, in which users and citizens are a fundamental part of the transition process, since they need less polluting modes of transportation.

The interaction and the establishment of new relationships between those actors favor the emergence, expansion and consolidation of new networks and new business models and opportunities, which emerge with a view to overcoming several e-mobility-related technological challenges and the need for improving the configuration of urban mobility, for example, by EV sharing.

Hence, in the process of transition to sustainable mobility, e-mobility becomes a strategic asset since it allows the implementation of zero and low-emission technologies for different modes of transportation especially in cities, which are areas with the greatest pollution levels and traffic congestion, said implementation contributes to a better quality of life for city inhabitants.

3. Promoting SDGs and committing to 2030 Agenda through e-mobility

The Sustainable Development Goals (SDGs) are necessary means to advance in the achievement of human rights, citizenship, better living conditions, and environmental protection. In other words, the SDGs provide guidelines to ensure the achievement of sustainable development and its three components (a.k.a the sustainability tripod: social, economic and environmental), without disregarding the institutional dimension that makes such an achievement feasible, which must occur with harmony and social justice. A striking feature among all 17 SDGs is their transversal and complementary nature, which means that the efforts made to achieve the SDGs are unlikely to occur without causing profound structural changes in all sectors of society (SACHS et al, 2019).

This section addresses the case of e-mobility and aims to understand what place it occupies within the scope of the SDGs, and what contributions it can bring to the 2030 Agenda. In a complementary way, it is necessary to take e-mobility as a component that boosts sustainable urban mobility, which, in turn, represents a transversal theme to the totality of the SDGs, as already emphasized by the studies conducted by the UN (2016) and adapted for Brazil by the National Confederation of Municipalities (CNM, 2018). Specifically, the latter presents a mapping of sustainable mobility in Brazil in regards to each of the 17 SDGs in order to make this debate more accessible to city managers and technicians; its intention is to show that the goals and indicators associated with the SDGs represent a methodology for organization, analysis, planning and strategic actions;

actions that promote sustainable mobility can be integrated into cities public budgeting.

There is no doubt that the SDGs are part of a complex agenda that at the same time it leads to an end point it also comes up against difficulties related to its operationalization. Thinking of the SDGs as modular building-blocks, which represent structural changes, as proposed by Sachs et al (2019), can help to advance their achievement. Each of these blocks of transformation presented by the authors, a total of six[3], has their own priorities and needs defined, a call to action to the government and society, in the broad sense. The importance of making progress in promoting sustainable and low or zero-emission mobility is so latent it is described in two of those six major transformation blocks: in the Decarbonization of Energy and Sustainable Industry by adopting electrification and zero carbon fuels, which are used instead of fossil fuels; and in the Sustainable Cities and Communities block, by adopting efficient and sustainable mobility, with special attention to reducing transportation air pollution and ensuring its long-term sustainability (SACHS et al, 2019).

As for the 2030 Agenda specifically, we have identified at least seven Goals in which e-mobility has transforming potential, which are represented in Figure 2.

The diversity of local conditions in each region of the country has posed countless challenges as well as opportunities to achieve the SDGs of the 2030 Agenda. Among the main challenges, there are issues such as disagreements about local priorities, conflicting interests between interest groups, as well as future uncertainties. The bet on e-mobility, despite its contributions to the 2030 Agenda goals being evidenced, with achievements regarding human rights and the quality of life of citizens, is not a bet all managers have agreed to. Understanding the reasons for such antagonism involves proposing an agenda of commitments that mobilize actors and promote collaborative efforts. The next section addresses those issues and uses the Brazilian case as its object of inquiry.

4. Benefits for Brazilian cities from the promotion of e-mobility.

Given the importance of sustainable urban mobility to raise the quality of life of citizens, in 2012 the Brazilian government implemented the National Urban Mobility Policy (NUMP), Law n. 12,587/2012, whose main objective is "to foster universal access to cities, the creation and promotion of favorable conditions for the realization of the principles, objectives and guidelines of the urban development policy, through planning and democratic management of the National System of Urban Mobility" (BRAZIL – MINISTRY OF CITIES) , 2012).

NUMP's guidelines prioritize active transportation over motorized ones and public collective transportation over private motorized transportation and also the integration between the different modes of transportation. In addition, it promotes reduction of environmental, social and economic costs associated with urban mobility and encourages scientific-technological development and the use of renewable and less polluting sources of energy in transportation systems (BRASIL-MINISTÉRIO DAS CIDADES, 2012).

As we previously mentioned, e-mobility has become one of the alternatives to improve the quality of life of citizens regarding air quality in cities and public health in general, since it contributes to reduction of GHG emissions and of local pollutants generated by transportation systems that run on fossil fuels.

NUMP established that Brazilian municipalities with more than 20,000 inhabitants are obliged to develop

3 The six Transformations, introduced by Sachs et al (2019), are: (1) education, gender and inequality; (2) health, well-being and demography; (3) energy decarbonization and sustainable industry; (4) sustainable food, land, water and oceans; (5) sustainable cities and communities; and (6) digital revolution for sustainable development.

Figure 32. Electric mobility as a means to achieve the Sustainable Development Goals (SDGs)

3. Good health and well-being

e-mobility promotes reduction of GHG emissions from fossil fuels (local pollutants), especially in big urban centers.

7. Affordable and clean energy

e-mobility is an option to better energy efficiency in transportation and to integrate renewable energy sources.

8. Decent work and economic growth

e-mobility must be understood as an opportunity of economic, industrial and technological growth as it is a high value-added sector.

9. Industry, innovation and infrastructure

Opportunities of creating new e-mobility-related business and infrastructure. Electromobility promotes R&D in different areas of knowledge, which creates an environment for innovation to enhance industrial and technology capacity of developing countries like Brazil.

11. Sustainable cities and communities

Brazilian cities are going through disorganized, unplanned urban growth as well as urban exclusion. Prioritizing low-emission public transportation and active mobility is key to better urban mobility conditions that improve the quality of life of citizens and integrate them into the city.

12. Responsible consumption and production

It is important that the disposal of lithium batteries is managed correctly and that strategies regarding a second life for other discarded applications are implemented. That can result in a boost in the adoption of e-mobility since it becomes a means to expand energy access.

13. Actions to combat climate change

Transportation impacts GHG emissions and climate changes greatly. E-mobility can contribute to reduction of those impacts and promote better environments to citizens.

Source: Personal collection.

and approve an Urban Mobility Action Plan, which must be integrated with the city's Strategic Master Plan. However, by June 2020, out of the 3,476 municipalities that were supposed to prepare the Urban Mobility Plan, only 324 municipalities affirmed they have one. (BRAZIL-MINISTRY OF REGIONAL DEVELOPMENT, 2020). This shows that Brazilian municipalities must still work on defining specific actions and goals for the implementation of sustainable transportation modes, which result in additional benefits if they adopt and promote e-mobility.

Amongst large cities that have already designed their Mobility Action Plan, there is the city of São Paulo Urban Mobility Action Plan (PlanMob-SP/2015), which defined specific objectives to comply with NUMP's guidelines. Among the objectives, there is reduction of road transportation emissions, contributions to the policy of reducing social inequalities, making the macroaccessibility of cities more homogeneous, prioritizing public transportation and active mobility, and others (SÃO PAULO CITY HALL, 2015).

According to PlanMob-SP, for urban mobility to be considered a transformative policy, it must promote public transportation availability and access, with low environmental impacts and high economic and social impacts, guaranteeing the access of all inhabitants to opportunities offered by the city (SÃO PAULO CITY HALL, 2015). And to commit to such objectives, the Urban Mobility ActionPlan includes measures aimed at reducing emissions of local pollutants and GHG emissions as well as the collaboration of the Municipal Policy on Climate Change of São Paulo (Law n. 14,933/2009). More specifically, Article 50[4] provides that by 2018, the entire fleet of buses in the city shall use renewable non-fossil fuels. However, the incipient developments in low-emission bus technologies, among other factors, have prevented the city from implementing said law.

Thus, in 2018, Article 50 was modified by Law n. 16,802, which determines that the operators of the São Paulo Urban Passenger Transportation System must promote the progressive reduction of Carbon Dioxide (CO_2), Particulate Material (PM) and Nitrogen Oxide (NO_X), aiming at reaching 95% and 100% reduction rates in 20 years. These goals are ambitious for a Latin American city like São Paulo and necessarily involve the adoption of e-buses by the city's public transportation system if they aim to successfully fulfill such a commitment.

Another worth mentioning case refers to the city of Campinas (SP), which recently developed its Urban Mobility Action Plan (UMAP), established by Decree n. 20,571 of November 13, 2019, which encourages the development of actions and incentives for the use of less polluting and sustainable transportation and assessment over the adoption of a motor-vehicles-sharing system (CAMPINAS CITY HALL, 2019).

Among the strategies related to e-mobility, the UMAP aims to implement the use of e-vehicles in the public transportation system in a specific area of the city called the Área Branca (White Area), to reinforce the use of less polluting vehicles over traditional ones, to construct a network of charging stations together with partners and to regulate EVs, e-bikes and e-scooters sharing systems, (Campinas Municipal Secretary of Transportation; EMDEC, 2019). Shuc guidelines stress ongoing actions in Campinas, as for the implementation of battery powered e-buses in the public transportation system, there are 15 e-buses operating in 2020, one of the most representative fleets in Brazil.

The cities of São Paulo and Campinas are examples of Brazilian cities in which e-mobility has been promoted as part of the city's general plans to move towards sustainable mobility and becoming more convergent with the National Action Plan for Urban Mobility (NAPUM)

4 Article 50: "Municipal public transportation programs, contracts and authorizations must produce progressive reduction of fossil fuel use, the progressive reduction target of at least 10% shall be achieved each year from 2009 on and in 2018 the adoption of renewable non-fossil fuels by all buses operating in the public transportation system of the municipality"(São Paulo City Hall, 2009).

principles. In both cases reported, efforts made by cities concern the public transportation sector, which is a first possibility for Brazilian cities to adopt e-mobility in order to, afterwards, adopt other e-modes.

Through the electrification of public transportation systems, several Latin American cities became part of the electromobility cause. Santiago de Chile, for instance, is expected to end 2020 with approximately 800 e-buses operating in the city. The Santiago de Chile experience illustrates the Latin American context. From the creation of an innovative business model, which involved the collaboration between e-bus companies, electric power companies, fleet operators, and the local and national government, Santiago de Chile managed to evolve from a scenario of pilot projects and few e-buses to the deployment of one of the main fleets of e-buses in the world.

The benefits of e-fleet adoption are already being fely=t by the Chilean population. A research conducted by the World Bank (2020) identified that public transportation users in Santiago de Chile rate e-buses very positively. The most common answers in the survey were that e-buses contribute to reductions of environmental pollutants (83%), have a good air conditioning system (72%), offer a smooth ride (67%) and are less noisy than diesel buses (59%). In addition, public transportation users said they would be willing to wait an extra minute at the bus stop in order to be able to take an e-bus, rather than immediately boarding a diesel bus.

Thus, these results show the benefits enjoyed by citizens when opting for the use of zero-emissions public transportation systems, which embrace not only environmental quality, but also directly impact quality of life when cities offer more comfortable transportation that serves routes to citizen's work, study and leisure activities.

Other Latin American cities such as Bogotá and Medellín (Colombia), in addition to Guayaquil (Ecuador) and San José (Costa Rica), have already piloted e-buses projects aiming to carry out a large-scale implementation.

These experiences must be analyzed closely by governments of Brazilian cities as an opportunity to improve the quality of public transportation and reflect on what would be the best business model to enable large-scale implementation of e-buses in cities.

In Brazil, no research was carried out on assessing users' perception of public electric transportation, given that the adoption of e-modes in the country is still at an incipient stage. However, a study commissioned by the Institute for Climate and Society (iCS, 2020) on low-emission mobility and air quality, showed that the Brazilian population negatively evaluates the impact caused by the use of petroleum-based fuels on air quality and climate change[5]. Regarding the use of private transportation, 67% of the surveyees would be willing to give up the use of their own vehicle in favor of more eco-friendly modes of transportation. Such an answer is shared both by car owners and among those who do not own a car. In addition, the perception that an EV is a possible reality increased from 46% in 2017 to 71% in 2020. Regarding public transportation, 92% of surveyees would appreciate more e-buses operating in their city (Institute for Climate and Society, 2020).

Specifically on the impact on health associated with the implementation of public transportation, the study *"Evaluation and assessment of the impacts of air pollution on the health of the population resulting from the alternative energy matrix of public transportation in the city of São Paulo"*, prepared by the Environmental Sustainability & Health Institute and Greenpeace, built three scenarios of changes for the energy matrix of public transportation

5 In 2020, the percentage of surveyees who considered the impact of fossil fuels on air quality to be slightly negative was 60%, and very negative, 25%; in relation to climate change, 57% evaluated the impact as not very negative and 25% as very negative (Institute for Climate and Society, iCS, 2020).

between 2017-2050. The higher the percentage of clean modes of transportation in the fleet, the lower will be the emissions and the concentration of local pollutants, mainly $PM_{2.5}$ produced by use of diesel. The level of concentration of pollutants will impact public health costs, calculated in terms of premature deaths (loss of productivity that could be avoided) and the increase in hospitalizations for respiratory, cardiovascular and cancer diseases. In an ideal scenario, which foresees the replacement of 100% of diesel buses by e-buses by the fleet of São Paulo, 12,796 premature deaths would be avoided, resulting in the monetary benefit of R$ 3.8 billion (due to productivity gain by the reduction in number of deaths). The savings in public health expenditures due to the reduction in hospitalizations between 2017 and 2050 was estimated at R$ 46.5 billion in this scenario (DE ANDRÉ; VORMITTAG; SALDIVA, 2017).

Thus, the bill for the implementation of electrical transportation systems should not only result in monetary gains, but also gains in relation to environmental benefits, population health, productivity, comfort, and improving the quality of life in a positive way, as well as access to opportunities.

5. Conclusions

This article aimed to lead readers to reflections upon e-mobility from a perspective that had not yet been enough explored: its contribution to the construction of more human, just and inclusive cities.

Cities are great spaces for socialization and circulation. In cities, people move in order to meet their most diverse needs (work, education, leisure, etc.). Irregular, inhospitable and unhealthy conditions of transit and commuting seriously compromise those purposes and undermine our right, as citizens, to enjoy urban spaces; in other words, they prevent people from accessing opportunities that cities can offer. Proposing solutions to such problems is what is projected when discussing the necessary transition to sustainable mobility. There is no single solution for promoting said transition; urban space management actions, in the most diverse dimensions, must be (re)thought and (re)directed.

E-mobility is and should be treated as a strategic and necessary asset when considering the transition to sustainable mobility. The simple fact of eliminating or reducing emissions of pollutants would be more than enough reason for cities to get involved in projects aimed at promoting the various e-modes in urban centers in an integrated and complementary way composed of bikes, automobiles, buses, urban delivery vehicles and garbage trucks. This is an unquestionable argument that strengthens the cause: by reducing emissions in urban centers, e-mobility contributes to better quality of life for its inhabitants. However, the benefits of e-mobility go beyond the issue of public health as they involve more comfortable commuting (for users and drivers), noise reduction, and a less aggressive environment. Approaching the benefits that e-Mobility can provide in a broad way is also a means of getting closer to the complex UN 2030 Agenda, promoted by the Sustainable Development Goals.

There are many challenges for sustainable, inclusive and high-quality mobility to become a reality in urban spaces and to assess the existing options that promote this goal is a necessary prerequisite. Hence, far beyond restricting e-modes to technology and innovation, e-mobility must be seen as a means to advancing access to citizenship and respect for human rights in general.

References

BANCO MUNDIAL (2020). **Latin America Clean Bus in LAC. Lessons from Chile's Experience with E-Mobility**. September 11, 2020.

BANISTER, D. The sustainable mobility paradigm. **Transport Policy**, v. 15, n. 2, p. 73–80, 2008.

BERMÚDEZ, T. **Transiciones Socio-Técnicas hacia una Movilidad de Bajo Carbono: Un análisis del Nicho de los Buses de Baja Emisión para el Caso de Brasil**. Tese. Programa de pós graduação em Política Científica e Tecnológica, IG/Unicamp. 2018. Available at: <http://www.repositorio.unicamp.br/handle/REPOSIP/333639>

BORBA, B. Big Push para a Mobilidade Sustentável: cenários para acelerar a penetração de veículos elétricos leves no Brasil, Documentos de Projetos (LC/TS.2020/50; LC/BRS/TS.2020/2), Santiago, Comissão Econômica para América Latina e o Caribe (CEPAL), 2020.

BRASIL-MINISTÉRIO DAS CIDADES. **Política Nacional de Mobilidade Urbana**. Lei 12.587/12. Brasil, 2012.

BRASIL-MINISTÉRIO DE DESENVOLVIMENTO REGIONAL. Levantamento sobre a situação dos Planos de Mobilidade Urbana. Available at: <https://antigo.mdr.gov.br/index.php?option=com_content&view=article&id=4398:levantamento-sobre-a-situacao-dos-planos-de-mobilidade-urbana-nos-municipios-brasileiros&catid=233:planejamento-da-mobilidade-urbana>, 2020.

CIDADE DE SÃO PAULO. Diário oficial Cidade de São Paulo. Lei nº 16.802 de 17 de Janeiro de 2018, 2018.

CONFEDERAÇÃO NACIONAL DOS MUNICIPIOS CNM. **Mobilidade Urbana e os Objetivos de Desenvolvimento Sustentável**, 2018. Available at: <https://www.cnm.org.br/biblioteca/exibe/3478%22>

DE ANDRÉ, P. A.; VORMITTAG, E.; SALDIVA, P. Avaliação e valoração dos impactos da poluição do ar na saúde da população decorrente da substituição da matriz energética do transporte público na cidade de São Paulo. São Paulo, 2017. Available at: <https://www.saudeesustentabilidade.org.br/wpcontent/uploads/2017/05/GP_ISS_Relatorio_ImpactosOnibusSP-1.pdf>.

EEA EUROPEAN ENVIRONMENT AGENCY. **Perspectives on transitions to sustainability**. [s.l: s.n.].

GAKIDOU, E.; GLOBAL BURDEN OF DISEASE STUDY 2016 RISK FACTORS COLLABORATORS. Global, regional, and national comparative risk assessment of 84 behavioural, environmental and occupational, and metabolic risks or clusters of risks, 1990 – 2016: a systematic analysis for the Global Burden of Disease Study 2016. **Lancet**, v. 390, p. 1345–1422, 2017.

GEELS, F. W. A socio-technical analysis of low-carbon transitions: introducing the multi-level perspective into transport studies. **Journal of Transport Geography**, v. 24, p. 471–482, 2012.

GUZMÁN, L. A.; OVIEDO, D.; ARDILA, A. M. La política de transporte urbano como herramienta para disminuir desigualdades sociales y mejorar la calidad de vida urbana en Latinoamérica. **Centro de los Objetivos de Desarrollo Sostenible para América Latina y el Caribe (CODS)**, v. 2, 2019.

HOLTZ, G. et al. Competences of local and regional urban governance actors to support low-carbon transitions: Development of a framework and its application to a case-study. **Journal of Cleaner Production**, v. 177, p. 846–856, 2018.

INSTITUTO CLIMA E SOCIEDADE (iCS). Mobilidade de baixas emissões, qualidade do ar e transição energética no Brasil, 2020. Available at: https://59de6b5d-88bf-463a-bc1c-d07bfd5afa7e.filesusr.com/ugd/d19c5c_b4d9237514f64b02a7896fce6ef81a05.pdf

KUOKKANEN, A.; YAZAR, M. Cities in sustainability transitions: Comparing Helsinki and Istanbul. **Sustainability (Switzerland)**, v. 10, n. 5, p. 1–18, 2018.

MARKARD, J.; RAVEN, R.; TRUFFER, B. Sustainability transitions: An emerging field of research and its prospects. **Research Policy**, v. 41, n. 6, p. 955–967, 2012.

MIRAGLIA, S. G. E. K.; GOUVEIA, N. Custos da poluição atmosférica nas regiões metropolitanas brasileiras. **Ciência & Saúde Coletiva**, v. 19, n. 10, p. 4141–4147, 2014.

NOEL, L; ZARAZUA DE RUBENS, G.; SOVACOOL, B. K., Optimizing innovation, carbon and health in transport: assessing socially optimal electric mobility and vehicle-to-grid pathways in Denmark. **Energy** 153 (15), 2018a, pp.628–637.

NOEL, L; ZARAZUA DE RUBENS, G.; SOVACOOL, B. K., Beyond emissions and economics: rethinking the co-benefits of electric vehicles (EVs) and vehicle-to-grid (V2G). **Transport Policy**, 71, 2018b, pp130–137.

OMS (ORGANIZACIÓN MUNDIAL DE LA SALUD). **Ambient air pollution: A global assessment of exposure and burden of disease**. [s.l: s.n.]. Available at: <http://apps.who.int/iris/bitstream/10665/250141/1/9789241511353-eng.pdf>.

OMS (ORGANIZACIÓN MUNDIAL DE LA SALUD). **WHO | Air pollution**. Available at: <http://www.who.int/airpollution/en/>. Accessed: Jul 4, 2018.

ORGANIZAÇÃO DAS NAÇÕES UNIDAS (ONU). Transformando Nosso Mundo: A Agenda 2030 para o Desenvolvimento Sustentável. 2015. Available at: http://www.itamaraty.gov.br/images/ed_desenvsust/Agenda2030-completo-site.pdf

ORGANIZAÇÃO DAS NAÇÕES UNIDAS (ONU). **Mobilizing Sustainable Transport for Development**, 2016. Available at: <https://sustainabledevelopment.un.org/content/documents/2375Mobilizing Sustainable Transport.pdf>

PEREIRA, R; BRAGA, C; SERRA, B; NADALIN, V. Desigualdades socioespaciais de acesso a oportunidades nas cidades brasileiras. Brasília: Ipea, 2019. (Texto para Discussão, 2535). Available at: <http://repositorio.ipea.gov.br/bitstream/11058/9586/1/td_2535.pdf>.

PREFEITURA DA CIDADE DE SÃO PAULO. SECRETARIA DO VERDE E MEIO AMBIENTE. Lei 14.933 de 5 de Junho de 2009, 2009. Available at: <http://www.prefeitura.sp.gov.br/cidade/secretarias/meio_ambiente/comite_do_clima/legislacao/leis/index.php?p=15115>.

PREFEITURA DA CIDADE DE SÃO PAULO. Plano de Mobilidade de São Paulo. PlanMob/SP 2015. Available at: <https://www.prefeitura.sp.gov.br/cidade/secretarias/upload/chamadas/planmobsp_v072__1455546429.pdf>, 2015.

PREFEITURA MUNICIPAL DE CAMPINAS. Decreto nº¿20.571, de 13 de novembro de 2019. Plano de Mobilidade Urbana de Campinas. Available at: <http://www.emdec.com.br/eficiente/repositorio/1SiteNovo/2019/21535.pdf>, 2019.

SACHS, J.; SCHMIDT-TRAUB,G.; MAZZUCATO,M.; *et al*. (2019) Six Transformations to achieve the Sustainable Development Goals. **Nature Sustainability**, 2, pp.805-814.

SALDIVA, P. **Vida urbana e saúde. Os desafios dos habitantes das metrópoles**. São Paulo: Editora Contexto, 2018.

SECRETARIA MUNICIPAL DE TRANSPORTES DE CAMPINAS; EMPRESA MUNICIPAL DE DESENVOLVIMENTO DE CAMPINAS EMDEC. Plano de Mobilidade Urbana de Campinas 2019. Caderno F. Diretrizes, ações e propostas para a mobilidade urbana em Campinas. Available at: <http://www.emdec.com.br/eficiente/repositorio/1SiteNovo/Plano_Mobilidade_Urbana_2019/21495.pdf>, 2019.

SEN, A. (1995). **Inequality Reexamined**. Cambridge, M. A.: Harvard University Press.

SEN, A. (2010). **Desenvolvimento como liberdade**. São Paulo: Companhia das Letras. 461 pp.

VAGNONI, E.; MORADI, A. Local government's contribution to low carbon mobility transitions. **Journal of Cleaner Production**, v. 176, p. 486-502, 2018.

VENTER, C.; MAHENDRA, A.; HIDALGO, D. **Da mobilidade ao acesso para todos: Ampliando as opções de transporte urbano no Sul global**, 2019. Available at: <https://wrirosscities.org/sites/default/files/from-mobility-to-access-for-all-executive-summary-portuguese.pdf>

WILLOUGHBY, C. **Infrastructure and Pro-Poor Growth: Implications of Recent Research**. Available at: <https://assets.publishing.service.gov.ukmedia/57a08d3be5274a27b2001705/Infrastructure_and_ProPoor_Growth.pdf>. Accessed: Jul 6, 2020.

APPENDIX III

Lessons-learned articles from PNME Webinar Series

From a public health perspective: is this the best time to promote e-mobility in Brazil?

In the midst of a pandemic, we have urgent concerns on contagion and keeping health systems working, so stimulating e-mobility in Brazil may seem secondary. The electrification process was already taking shape – it was the subject of newspaper headlines thanking scooters multiplying on the streets of the capitals – but it is now in the background as we are facing daily struggles to save lives and tackle the social crisis caused by Covid-19. Hence, is this the right time to stimulate e-mobility in the country? For the participants of the webinar *"How can e-mobility contribute to your health?"* held on August 26th, 2020, it made perfect sense.

If we consider our well-being and full functioning of the body, or our longevity, the evidence is indisputable, as shown by a publication of The Lancet magazine of 2018, mentioned by Pedro de Paula, Country Director for Vital Strategies in Brazil. Air pollution is responsible for 40% of deaths caused by lung cancer, 25% by ischemic diseases and stroke, 22% by cardiovascular diseases, among others. In other words: we stopped talking about an invisible problem and started talking about a real life threat.

This is about the invisible, the air, that Carmen Araujo, Managing Director of the International Council on Clean Transportation (ICCT) in Brazil, draws our attention to. *"We experienced momentary driving declines in cities, unfortunately due to COVID-19 quarantine and isolation, and people started realizing the sky was more blue, they saw more stars, and those are elements that need to be rescued".* In addition, Evangelina Vormittag, director of the Health and Sustainability Institute, affirms that: *"If a person takes a glass and sees dirt in the water, they will not drink it. They cannot see if the air is contaminated and so people just live with it. Toxic air affects our lives much more , and we suffer from silent chronic effects."*

Obesity

Another villain in our current society, obesity, could not be left out of the equation. Along with some comorbidities – a term that unfortunately became part of our vocabulary after Covid-19 – excess body fat could be simply combated by a strategy recommended by WHO: daily 60 minutes of physical activity. However, not a third of the world's population does that.

An alternative to circumvent the problem would be walking as you commute to work or any other activity. Walking or cycling trips throughout the day that can be even combined with bus, train or car trips. Thath is active mobility, something that needs to be encouraged now, as pointed out by the participants of the webinar, as Brazilian people will start seeing e-bikes circulating on the streets, for example.

Victor Andrade, director at the Laboratory of Sustainable Mobility (LABMOB) and professor at the Federal University of Rio de Janeiro (UFRJ), describes an experiment that he has been developing for more than a decade in partnership with the Danish Comprehensive Cancer Center. The objective of said experiment is to increase the number of e-bike users, including the elderly. *"There has been a very positive impact on participant's health, who ended up migrating from inactive modes to active electric pedal-assist bikes"*. Professor Andrade poses the question: *"When will we actually address our reality with a systemic look that combines both mobility policy and health policy into account?"*

By adopting a systemic approach to transportation that includes more people traveling on foot or by e-buses, we will be fighting the evil of obesity and environmental diseases. In addition, thinking systematically helps to make our cities more inclusive, the population healthier and, to reach an answer to the title of this article: making the investment in e-mobility is indeed worthwhile.

COVID-19

Covid-19 is no different. Preliminary studies at Harvard University, brought up for discussion by Evangelina Vormittag, suggest that in American cities where there is a high concentration of air pollutants the incidence of COVID-19 is higher. There will be many studies addressing and linking environmental issues to Covid and, meanwhile, there is an urgent need for society and the electromobility sector to join efforts and solidify public policies in this regard.

The pandemic was also the incentive that many people needed to start using bikes instead of public transportation, avoiding agglomeration and crowded buses. In Brazil, however, this is the reality of only a portion of the population that lives close to work. Apart from those differences, active mobility is a trend complementary to electromobility and, if we can get anything good out of the crisis we are now experiencing, health is finally at the center of our debate.

We have always known that polluted air is a problem, but we have never taken command of it. We understand the benefit of clean energy, but we end up delegating all decisions to the public sphere. We have laws in this regard and goals for the electrification of municipal bus fleets, but those are running late. Air quality is currently monitored in only ten Brazilian states, and we do not ask for more accurate actions. Hence, placing responsibility only in the public sphere has not worked so far. Therefore, it is necessary to recognize that we must broaden the debate, dialogue with all the actors in this scenario, so that together we can build an institutional agenda in favor of mobility and health of the population.

Pedro de Paula reinforces that part of the solution also involves communication. *"We need to understand how to better communicate the impacts of air pollution on our health, to have that adequate incentive in shaping an agenda, in order to have the institutional changes that we need. We have to understand that we are losing between 50 and 70 thousand lives due to bad air quality in Brazil annually. That is, until now, equivalent to half a pandemic per year."*

This article was inspired by the webinar "How can e-mobility contribute to your health?", held in August 2020 and promoted by the National Platform for Electric Mobility (PNME) and the Research Development Foundation (Fundep).

From an environmental perspective: how will the environment benefit from e-mobility in Brazil?

Combustion engines have played a key role in the development of society in the last century, mainly in regards to infrastructure and transportation. Now, two decades into the new millennium, the adoption of e-mobility by the energy matrix seems urgent if we want to reduce particulates and gas emissions. In Brazil, the transportation sector is responsible for more than half of fossil fuel consumption for almost half of the energy sector greenhouse gas emissions. We are talking about trucks on the roads transporting goods and wealth, buses and automobiles on the streets of large cities, guaranteeing the transit and commute of people.

In this scenario, investing in cleaner technologies is necessary from several points of view, since air quality is also a public health issue directly linked to a country's economic performance and technological development. Held by the National Platform for Electric Mobility (PNME) on September 28th, the webinar addressed the topic *"How will the environment benefit from e-mobility in Brazil?"*. For all participants in the webinar it is unanimous that we approach the environment, transportation, and health in a systemic way.

They are interdependent elements and one affects the other in the current pollution scenario that Brazil is now facing. Davi Martins, project leader at Greenpeace, presented data from a research carried out jointly with the Health and Sustainability Institute which illustrates that reality. Annually, in the city of São Paulo alone, between 4,000 and 5,000 deaths are attributed exclusively to diseases caused by urban pollution – read gases emitted by buses. So in addition to the many lives lost, there is also an economic waste (i.e. hospital expenses) and losses in productivity.

"When we combine the issue of public health with the economy it results in productivity gains. Because people who get sick because of the ills of emissions from transportation are people who stop producing" says Mr. Martins. If today there are about 14,000 buses running in the city, the projection is that in 30 years the productivity loss will account for R$ 50 billion.

Buses were unanimously found to be the cause of diesel pollution according to the webinar's participants. And it is precisely public transportation that is considered the one element to leverage changes in the energy matrix in the sector. But for this, more sustainable financing models are needed, with emphasis on the role of recruitment and selection processes into public sector organisations for the purchase of buses by city halls.

For Kelly Fernandes, from the urban mobility program of the Brazilian Institute for Consumer Protection (Idec), "those recruitment and selection processes can foster changes, especially when addressed beyond mere bureaucratic procedures, highlighting their socio-environmental function and guiding financing policies". She also stresses that we need to be aware of this technological change, so that its implementation costs are not passed on to the consumer, and do not affect bus fares.

The EV, despite being more expensive when compared to diesel, ends up being cheaper in the long run. This is because the useful life of an urban bus is

ten years – and e-buses can run for 15 – which would be equivalent to acquisition prices 6% lower at the end ofa 15 year period. Not to mention the annual increase of oil prices.

Ms. Fernandes is blunt when she talks about e-mobility as a possibility to face the climate crisis. She points out that *"the negative impacts of using fossil fuels as an energy source for the transportation sector have intensified climate events that caused droughts, floods, fires, heat waves and other impacts that endanger human life and nature"*.

In contrast with fossil fuels, one cannot fail to mention biodiesel, which has been used in Brazil for years and presented important results.In the energy matrix of transportation fuels, 25% is renewable, 20% ethanol and 5% biodiesel. However, its use in combustion engines still contributes to air pollution, as Amanda Ohara, technical coordinator of the E+ Energy Transition Institute, affirms: *"It would be ideal to eliminate combustion engine vehicles from Brazilian urban transportation"*.

And there would be no shortage of clean resources to do so. Currently, 83% of the Brazilian electrical matrix comes from renewable sources. A large part (65%) of this energy is generated by hydroelectric plants; the rest by wind, solar and biomass sources. That shows that in our country the electric power produced does not pollute its source. In this respect, we are at an advantage over other nations whose energy power is generated by thermoelectric plants, for example.

Opportunities

In the coming months, a change in behavior that has been happening since the beginning of the Covid-19 pandemic may intensify. In order to avoid agglomerations, some people will choose to give up public transportation and go back to using – or even purchasing – cars or motorcycles to get around cities. If nothing is done, the number of single-occupant vehicles in Brazil may increase.

In such a scenario, as Ilan Cuperstein, from the C40 Cities Climate Leadership Group, affirms that public transportation will need to undergo a reset due to the Covid-19 crisis, in which various aspects of its operation will be rethought. Because of isolation we were able to see the reality when vehicle traffic decreased by 70%, which accounted for a 40% decrease of three polluting gases in diesel exhaust. So, our suggestion is that we start the change from what is most harmful: reduce the burning of diesel in the urban environment by increasing electrification.

It is necessary to take advantage of this window for change and to make transportation more attractive by offering users comfort and safety. This technological conversion is part of a transformation aimed at the public good, and therefore it shall be supported by society, academia, and governments. *"Electrification is part of something much more structural. And if we are going to take science seriously, the more support from society, the faster this change will take place"* says Mr. Cuperstein.

This article was inspired by the Webinar "From an environmental perspective: how will the environment benefit from e-mobility in Brazil?" promoted by the National Platform for Electric Mobility (PNME), in partnership with the Research Development Foundation (Fundep), in September 2020.

From an innovation perspective: what challenges and opportunities can e-mobility bring to the innovation environment in Brazil?

What comes to mind when you think of e-mobility innovations? Silent motorcycles? Flying cars? Yes, although it seems a distant reality, these are some examples that can become real in a short period of time. In addition to leveraging the area of innovation, EVs have been placed as a very consistent and irreversible solution to a variety of agendas, especially for the environmental and public health ones.

According to an estimate by Deloitte, in ten years 32% of the cars sold in the world will be electric or plug-in hybrids. This study also shows that by 2030, among the electrified vehicles sold, 82% will be fully electric and 18% hybrid. In absolute terms, we are talking about somewhere around 25 million EVs while hybrids will account for 8 million units around the globe. It is, therefore, a change that, although not abrupt, is irreversible.

In Brazil, despite being a new technology, e-mobility is being quickly inserted in the market. However, this does not mean that it is a fully developed technology. |This is an evolutionary process, with some weaknesses to be overcome.

During a meeting promoted by PNME on October 27th, Professor Wanderlei Marinho,PhD Electrical Engineering , stated that Brazil has an abundant energy matrix – mainly generated by hydroelectric power. Which gives us confidence in taking the path of electrification in a solid manner. "*We are facing a situation in which electrified cars are more electronic than mechanical, we are going through a transition. The answer, therefore, is to think about the ecosystem as a whole and our capacity to innovate."*

In other words, to stop using combustion engines and migrate to electrified engines is a disruption. If we picture a car and divide it into two parts, we will think of charging stations, energy, autonomy and costs regarding the chassis downwards. In other words, the solutions currently being discussed for the sector result from innovation.

Made in Brazil

To address the issue of mobility, Brazil must consider its mineral resources and thatis not about selling commodities, but adding value. The country can become a major supplier not only of lightweight materials, such as aluminum for vehicle structures, but, for example, also of batteries composed of various materials, such as lithium, manganese, phosphorus and nickel.

In addition, we must not disregard our trajectory regarding biofuels – which is already 50 years old. If we analyze the market, our annual vehicle sales are around 3 million, while global sales account for 100 million. Within this participation, about ten thousand vehicles are electric. However, hybrid cars do not make up that amount. These are not plug-in vehicles and they do not connect into the socket. In other words: we are combining electrification with ethanol, and these cars are increasingly taking the market.

Fernando Campagnoli, a UFRJ researcher in innovation economics, believes that it is possible to use this "Brazilian jabuticaba" (the Brazilian grapetree) solution of the combination of ethanol and electrification to assemble an electromobility matrix that is both hybrid

and hass elements of combustion. But as for innovation, from strategic minerals to the consumers there are other service packages and production chains to be considered, such as the mechanics and maintenance services of the vehicle. *"It is an interesting chain, as there are new businesses related to the charging infrastructure, for example, which may be public or private; or under concession contracts. Those are very Brazilian characteristics and should be part of our mosaic of opportunities"*, Mr. Campagnoli says.

Changes for the consumer

In fact, Brazil offers service packages and has supply chains that embrace strategic minerals and the consumer, who is at the end of the chain *"paying this entire bill"*. But who is this consumer? They are a person who is changing. In the past, they were passive in terms of electricity and fuel consumption by combustion engines. Today, we have an active consumer in the process, which starts to consider distributed and renewable generation as a possibility that can be even done from their own homes. When EVs come into the scene, consumers become – in addition to being active subjects in this scenario – energy managers that consume, insofar as other storage technologies can be used, from the car itself and from their homes.

Therefore, at the same time that technologies change and new production chains appear, the consumer also changes. They start implementing technology within their new universe, as in the case of cell phones. Changes in habits make consumers empowered by technologies to take an active role in the market. As for strategic minerals, which are extracted and enriched, from the formation of beams and the use of niobium (which can be used in batteries and steel plates), there is a combination of origin and services, where the consumer is.

For the subject to cause such change of habit, a qualified workforce with professional and strategic resources is necessary. For this, we must offer technology training courses – either for professionals who deal operationally with the technologies or to create enterprise models. According to Flávia Consoni, professor at Unicamp, Brazil also has its own experiences. *"You can't replicate models made by other countries, we have to study our consumers' behavior. It is important to draw on "pilots and experiences to get to know our market."*

That said, e-mobility is a trial balloon for innovation in Brazil. It is possible to operate it in a network, without forgetting the intersectoral relations, and still reflect on how each sector can contribute to having not only a national action plan for e-mobility but also a national policy.

This article was inspired by the Webinar "What challenges and opportunities can e-mobility bring to the innovation environment in Brazil?" National Platform for Electric Mobility (PNME), in partnership with the Research Development Foundation (Fundep), in October 2020.

From the economics perspective: why is e-mobility profitable for our economy?

In 1969, the American meteorologist and mathematician Edward Lorenz coined the butterfly effect. A butterfly flapping its wings at the poles can trigger air pressures capable of producing hurricanes on the other side of the world. In other words: small changes in the initial conditions of large systems can generate drastic and significant changes in them.

When we question the importance of e-mobility for the Brazilian economy, we are questioning whether small changes in habits and the development of technologies can produce significant impacts in the long term. The answer is yes. Results analyzed during the pandemic in Brazil prove how the simple decrease in circulation, and consequently in transportation, generated a significant gain for air quality in the country's major cities.

Data from a recent study by the WRI (World Resources Institute) Brazil – carried out during the pandemic – indicates that sustainable and low-carbon practices can generate significant growth in GDP (Gross Domestic Product), with cumulative gains of R$ 2.8 trillion by 2030 according to current patterns. Choosing e-mobility, according to the research, would lead to a net increase of more than 2 million jobs in the economy by 2030 with benefits from the first year.

During a meeting promoted by PNME on October 29th, the engineer and urban mobility manager at WRI Brazil, Cristina Albuquerque, explained that a tool developed by the institution monetizes the environmental benefits in some cities. "*This tool calculates costs when people are absent from work due to cardiovascular diseases caused by pollution and have to stop working. The estimate is R$ 30 million per year in costs for Brazil"*, she explained.

Another fact that demonstrates how environmental issues generate major economic impacts would be the exchange of bus fleets and how the reduction of emissions modifies health data, reducing, for example, the number of hospitalizations.

The neighbor's yard

Another aspect to be considered in terms of e-mobility and economy is in our neighboring countries. 80% of Latin American population live in urban areas. It is the most urbanized continent in the world. This has a number of implications in terms of production, economy and efficiency, since our GDP is associated with urban spaces.

Cities have to be increasingly efficient and, at that point, to move towards more sustainable mobility can become a great source of opportunities, technological innovation, urban redesign, productive efficiency and creation of jobs. For Luiz Krieger, Economic Affairs officer at the United Nations Economic Commission for Latin America and the Caribbean (ECLAC), it is possible to make e-mobility a reality in our continent. "*In Santiago, leasing conventional buses has an operating cost that is 70% lower in the country's economy, a total savings difference of 20%. It is necessary to think not only about how to produce, but also about the business model that allows e-mobility to be operating on streets,"* he said.

That our neighbors have a huge market, we know. We also know that Brazil has the industrial capacity to efficiently manage its production activities and meet the demand. However, it is necessary that we do not take e-mobility as a trend, but as a reality. Ricardo Zomer, coordinator at the Ministry of Economy, sug-

gests that if Brazil does not open the market in an initial moment, there will be no incentive for companies to invest in the country. *"For the production of light vehicles, we only have one company. The investment decision-making discussion takes place outside. If we do not have the market, it is difficult for those outside to decide if they will invest here"*, he said.

In fact, there are paths that must be explored so we can come up with a more sustainable solution for the city that we want to live and work in. And again: sometimes it is a butterfly flapping its wings that cause unpredictable economic realities. Germany, for example, uses solid-state batteries, which accumulate more energy. They are light and more durable. It is a generation that will replace lithium, which is often limiting.

The next in line

One of the examples of small changes that is popular nowadays is the creation of traffic zones in the center of large cities. For Wagner Setti, specialist in Government and Institutional Affairs at the WEG Group, the issue of public transportation is an important starting point. In addition, it is necessary to think about different business models, not only about tariffs and subsidies. *"The area of public transportation is the door to a growing market based on public policies that bring increased opportunities for the entire chain,"* he said.

Because it is a well-regulated topic, with municipalities that have arbitrary power in the system, in fact, public transportation is the first axis to leverage e-mobility in Brazil. In the city of São Paulo, for example, the municipal policy has reversed this into environmental goals within the contracts, so concessionaires are committed to employ a low-emission fleet. Not electric, but annual emission reduction targets. This becomes a gateway to start changes in the country.

In addition, as demonstrated earlier, the pandemic worsened the public transportation crisis, which reached its peak and so the topic has been discussed in all three spheres: municipal, state and federal. Therefore, it is necessary to discuss public transportation business models. It is necessary to start from a macro analysis and redefine the means of public transportation that were already crashing. E-mobility is a factor that can contribute positively to such a business model. But for that, we must study concession formats in cities and encourage these systems to be sustainable, clean and efficient. In summary: it is necessary to clean our fleets, but, above all, to improve the system as a whole.

On the butterfly effect, it is clear that when we question whether e-mobility is worthy for our economy, the answer is yes. However, it is necessary to remember that isolated policies have less chance of success, and it is necessary to articulate several policies at the same time so that the sector can take an important step and guarantee a great impulse for the country.

This article was inspired by the Webinar "Why is electric mobility profitable for our economy?" promoted by the National Platform for Electric Mobility (PNME), in partnership with the Research Development Foundation (Fundep), in October 2020.

References

ABVE. **Balanço: as principais conquistas e ações da ABVE no biênio 2018-2019 – ABVE**. *[s. l.]*, 2020.

AMBIENTE, M. do M. **Acordo de Paris**. *[s. l.]*, 2016.

ANFAVEA. **Anuário Anfavea 2020 – Associação Nacional dos Fabricantes de Veículos Automotores**. *[S. l.: s. n.]*.

ASSOCIAÇÃO PAULISTA DE MEDICINA. Um minuto de ar limpo – Manifesto. **Medicina e Sociedade**, *[S. l.]*, 2018.

AUTOESPORTE. **Importação de patinetes elétricos subiu 735% em 2019, aponta levantamento**. *[s. l.]*, 2020.

BARASSA, E. Trajetória Tecnológica do Veículo Elétrico: Atores, Políticas e Esforços Tecnológicos no Brasil. *[S. l.]*, n. 1, p. 1–106, 2015. Available at: https://doi.org/10.1007/s13398-014-0173-7.2

BARASSA, E. **A Construção de uma Agenda para a Eletromobilidade no Brasil: Competências Tecnológicas e Governança**. 2019. Instituto de Geociências, Unicamp, *[s. l.]*, 2019.

BERMUDEZ, L. T. **Transiciones Socio-Técnicas hacia una Movilidad de Bajo Carbono: un Análisis del Nicho de los Buses de Baja Emisión para el Caso de Brasil**. 2018. – Universidade Estadual de Campinas, *[s. l.]*, 2018.

BLOOMBERGNEF. **BNEF EVO Report 2020 | BloombergNEF | Bloomberg Finance LP**. *[s. l.]*, 2020.

BRANDÃO, C. **Território e Desenvolvimento**. *[S. l.: s. n.]*

BRASIL, A. **Efeito estufa: transporte responde por 25% das emissões globais | Agência Brasil**. *[s. l.]*, 2018.

BREATHELIFE. **Breathe Life**. *[s. l.]*, 2020.

CASTRO, B. H. R. de; BARROS, D. C.; VEIGA, S. G. da. Baterias automotivas : panorama da indústria no Brasil , as novas tecnologias e como os veículos elétricos podem transformar o mercado global. **BNDES Setorial**, *[S. l.]*, v. 37, p. 443–396, 2013.

CHAN, C. C. The State of the Art of Electric, Hybrid, and Fuel Cell Vehicles With their superior fuel economy and performance, hybrid vehicles will likely increase in popularity in coming years; further development of control theory for hybrids is essential for their. **Fellow IEEE**, *[S. l.]*, v. 95, n. 4, p. 704–718, 2007. Available at: https://doi.org/10.1109/JPROC.2007.892489

CONSONI, F. L. *et al*. **Estudo de Governança e Políticas Públicas para Veículos Elétricos**. Brasília D.F: Ministério da Indústria, Comercio Exterior e Serviços MDIC, 2018 a.

CONSONI, F. L. *et al*. **Estudo de Governança e Políticas Públicas para Veículos Elétricos**. *[S. l.: s. n.]*. *E-book*.

CONSONI, F. L. *et al*. Roadmap tecnológico para veículos elétricos leves no Brasil. *[S. l.]*, p. Promob-e, 2019.

DE SANT'ANA FONTES, F. A. Sistematização de Iniciativas de Mobilidade Elétrica no Brasil. *[S. l.]*, p. 1–52, 2018.

DENTON, T. **Electric and Hybrid Vehicles**. *[S. l.]*: Routledge; 1 edition (3 July 2017), 2017. *E-book*.

ELECTRONICS BELIEVER. **EV Charging Basic Things and Information You Need to Know**. *[s. l.]*, 2019. Available at: http://electronicsbeliever.com/ev-charging-basic-things-and-information-you-need-to-know/. Accessed: Feb 5, 2019.

EMDEC. **EMDEC – Empresa Municipal de Desenvolvimento de Campinas S/A**. *[s. l.]*, 2019.

EMOTORWERKS. **The Different EV Charging Connector Types**. *[s. l.]*, 2019. Available at: https://emotorwerks.com/eu/about/news/blog/552-ev-charging-connector-types. Accessed: Feb 16, 2019.

EV SAFE CHARGE. **DC Fast Charging Explained**. *[s. l.]*, 2019. Available at: https://evsafecharge.com/dc-fast-charging-explained/. Accessed: Feb 21, 2019.

FREEMAN, C. Japan: a new national system of innovation?. In: DOSI, G. et al. (Org.). Technical change and economic theory. London: Pinter, 1988, p. 330-348. IBGE. **National Household Sample Survey (PNAD) – Synthesis of indicators 2015**. *[S. l.: s. n.]*. *E-book*.

IBGE. **PINTEC Pesquisa de Inovação**. *[S. l.: s. n.]*. *E-book*.

IEA. **Global EV Outlook 2018**. *[S. l.: s. n.]*. Available at: https://doi.org/10.1787/9789264278882-en.

IEA. **Defying expectations of a rise, global carbon dioxide emissions flatlined in 2019 – News – IEA**. *[s. l.]*, 2019.

IEA. **Global EV Outlook 2020**. Global EV Outlook 2020, *[S. l.]*, 2020. Available at: https://doi.org/10.1787/d394399e-en

INFOMONEY. **Após real ser a pior moeda do mundo no 1º semestre, dólar continuará subindo em 2020?**. *[s. l.]*, 2020. Available at: https://www.infomoney.com.br/mercados/apos-real-ser-a-pior-moeda-do-mundo-no-1o-semestre-o-que-esperar-para-o-dolar-ate-o-fim-de-2020/. Accessed: Jul 25, 2020.

INFRAESTRUTURA, M. da. Anuário estatístico de transportes. *[S. l.]*, 2019.

INFRAESTRUTURA, M. da. **Frota de Veículos – 2019**. *[s. l.]*, 2020.

INSIDEEVS. **Jeep Renegade e Compass híbridos são adiados para 2021 no Brasil**. *[s. l.]*, 2020. Available at: https://insideevs.uol.com.br/news/414448/jeep-renegade-compass-hibridos-adiados/. Accessed: Jul 24, 2020.

LANIER, S.; MEDINA, S. The First and Largest 100 Percent Electric Bus Fleet: Shenzhen Bus Group. **Clean Tech Blog – Institute for the Environment**, *[S. l.]*, 2019.

Lundvall, B-Å. (ed.) (1992), National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning, London: Pinter Publishers.

MYEV. **EV Terminology**. *[s. l.]*, 2019. Available at: https://www.myev.com/research/ev-101/ev-terminology. Accessed: Feb 16, 2019.

NASA. **Longyangxia Dam Solar Park**. *[s. l.]*, 2020. Available at: https://earthobservatory.nasa.gov/images/89668/longyangxia-dam-solar-park. Accessed: Aug 7, 2020.

NELSON, R.; ROSENBERG, N. Technical innovation and national systems. In: NELSON, R. (Ed.). National innovation systems: a comparative analysis. Oxford: Oxford Univ., 199

NOTÍCIAS, S. **Projeto que proíbe carros a combustão deve virar marco da eletromobilidade, afirmam debatedores – Senado Notícias**. *[s. l.]*, 2019.

OICA. **Sales Statistics | OICA**. *[s. l.]*, 2017. Available at: http://www.oica.net/category/sales-statistics/. Accessed: Jul 31, 2017.

PLUGSHARE. **EV Charging Station Map**. *[s. l.]*, 2020.

PODPOINT. **Electric Vehicle Dictionary**. *[s. l.]*, 2019. Available at: https://pod-point.com/guides/driver/ev-dictionary. Accessed: Feb 16, 2019.

PROMOB-E. **Eletromobilidade no transporte coletivo: o caso da cidade de São Paulo**. *[S. l.: s. n.]*.

QUATRO RODAS. **'FêNêMê' vai voltar à ativa com caminhões elétricos fabricados na Agrale**. *[s. l.]*, 2020. Available at: https://quatrorodas.abril.com.br/noticias/feneme-vai-voltar-a-ativa-com-caminhoes-eletricos-fabricados-na-agrale/. Accessed: Jul 24, 2020.

RADAR, E. **E-BUS RADAR**. *[s. l.]*, 2020.

REICHENBACH, M. Electric Mobility. **ATZ worldwide**, *[S. l.]*, v. 120, n. 10, p. 3-3, 2018. Available at: https://doi.org/10.1007/s38311-018-0161-1

RIBEIRO, SUZANA KAHN; SANTOS, A. S. **Tecnologias disruptivas de baixo carbono para Setores chaves no Brasil – Painel Brasileiro de Mudanças Climáticas**. *[S. l.: s. n.]*.

SAÚDE, M. da. **Mortes devido à poluição aumentam 14% em dez anos no Brasil**. *[s. l.]*, 2018.

SINDIPEÇAS. O anuário da indústria de autopeças Number of vehicles in circulation worldwide 2015. *[S. l.]*, 2019.

SINDIPEÇAS; ABIPEÇAS. Relatório da Frota Circulante 2018 I – Frota circulante total A frota brasileira está predominantemente. *[S. l.]*, p. 13, 2019.

SLOWIK, P. et al. International Evaluation of Public Policies for Electromobility in Urban Fleets. *[S. l.]*, p. 89p, 2018.

TESLA. **Tesla Gigafactory**. *[s. l.]*, 2020.

UNICAMP, J. da. **Rumo a um sistema de mobilidade de baixo carbono | Unicamp**. *[s. l.]*, 2019.

UOL CARROS. **Volvo XC40 híbrido esgota em quarentena; fila de espera chega a 120 dias**. *[s. l.]*, 2020. Available at: https://www.uol.com.br/carros/noticias/redacao/2020/05/13/volvo-xc40-hibrido-esgota-em-quarentena-fila-de-espera-chega-a-120-dias.htm. Accessed: Jul 24, 2020.

WRI BRASIL. **Mobilidade urbana em tempos de coronavírus: o impacto no transporte coletivo | WRI Brasil**. *[s. l.]*, 2020. Available at: https://wribrasil.org.br/pt/blog/2020/04/mobilidade-urbana-em-tempos-de-coronavirus-o-impacto-no-transporte-coletivo. Accessed: Jul 24, 2020.

Glossary

VEHICLE ARCHITECTURES

Term	Definition
Micro hybrid	Vehicles that use regenerative braking and automatic start-stop function aiming at energy efficiency and fuel economy.They are not strictly hybrid electric vehicles, as they do not have electric traction.
Mild hybrid	In addition to an internal combustion engine, mild hybrids have an electric motor and a traction battery that allows the engine's regenerative braking, automatic start-stop function, assisted starting and electrically assisted internal combustion engine is obtained.
Electric Vehicles (EVs)	Generic term for BEVs, PHEVs and REX, but often used to refer to pure electric vehicles, i.e. BEVs.
Battery Electric Vehicles (BEVs) or pure electric vehicles	Vehicles with purely electric propulsion systems, which are powered by electricity stored in an internal battery.
Extended-Range Electric Vehicles (EREV or REx)	A Hybrid Electric Vehicle (HEV) whose power is provided by an electric motor, but with a small ICE present that acts as a generator operating the motors once the battery has reached its minimum state of charge. In practice, REx are hybrids with an automotive serial system.
Fuel Cell Electric Vehicles (FCEVs)	An EV that uses hydrogen fuel cells to charge its traction battery and thus power its electric motor. A fuel cell uses the chemical energy of hydrogen or another fuel to cleanly and efficiently produce electricity through electrochemical reactions.
Hybrid Electric Vehicles (HEVs)	Vehicles that have an electric motor in parallel, whose energy is supplied by a battery and a conventional combustion engine, supplied by liquid or gas fuels (fossil or renewable). They have a small traction battery, charged through regenerative braking and by the internal combustion engine.
Plug-In Hybrid Electric Vehicles (PHEVs)	PHEVs use batteries to power an electric motor for traction and another fuel, such as gasoline, to power an internal combustion engine, allowing pure electric driving or the extended range combination of the gasoline engine and the electric motor. Its battery can either be charged using a wall outlet or charging equipment, by the ICE, or through regenerative braking.
Plug-In Vehicles	Vehicles that can be recharged from an external source of electricity, such as wall sockets, include BEVs and PHEVs.

EV CHARGING CONNECTOR TYPES

Term		Definition
CHAdeMO plug		One of the many charging connectors available in the market today, CHAdeMO is an abbreviation of "CHArge de MOve", equivalent to "move using charge". It is a connector with four normal power supply pins which predominantly applies to rapid charging and is compatible with EVs manufactured by Japanese automakers, such as Mitsubishi and Nissan. It can operate on systems with Vehicle-to-Grid (V2G) technology, but it has less electric power transfer capability if compared to CCS, provides power at 50 kW DC and requires two separate sockets and is commonly known as DC fast charging.
GB/T (AC) plug		Chinese-manufactured connector similar to Type 2 (European), applied in AC Level 1 (provides charging through a 120V AC socket) and AC Level 2 charging (offers charging through a 240V AC outlet).
GB/T (DC) plug		Chinese-manufactured connector, which composes the GB/T DC fast charging, is applied in DC mode of charging, offering 237.5kW at 950V and 250A.
Type 1 Combined Charging System (CCS)		Standardized by SAE, this connector combines two DC pins arranged below the Type 1 AC connector, which has 3 power supply pins.
Type 2 Combined Charging System (CCS2)		Standardized by the EU, this connector combines two DC pins arranged below the Type 2 AC connector, which has 3 power supply pins.
Tesla plug		A Tesla Supercharger is a 480-volt DC fast-charging technology. Tesla Plug is a proprietary connector, homonymous to its manufacturer, with 5 power supply pins, exclusive to Tesla vehicles, with the exception of the European market, and which allows all modes of charging (DC level 1 and 2).
Type 1 plug (SAE ou J1772)		A five-pin connector that also has a clip, this connector is commonly found in the USA and normally in EVs manufactured by Asian and American automakers (for example, Nissan, Mitsubishi and GM/Vauxhall/Opel). However, its prominence is fading due to Nissan switching to Type 2. It covers the general physical, electrical and communication protocol.
Type 2 plug (Mennekes)		A seven-pin connector with a flat edge. Originally preferred by European automakers, such as BMW and the VW group; it has become the most popular type of EV connectors. MENNEKES' type 2 plugs can carry a 3-phase power voltage and have an interlocking actuator that locks the plug in place during the charging process.

KEY CONCEPTS	
Term	**Definition**
AC (alternated current)	An electric current which periodically reverses direction with time.
EV on-route charging	Normally, on-route charging involves rapid, high-powered chargers, which charge more than 100 kilometers of EV autonomy done while drivers stop for coffee or snack breaks, for example.
EV charging away from home	Charging the EV while it is parked away from home, as many drivers will charge their cars while they are parked. This helps to avoid range anxiety.
DC (direct current)	A one directional flow of electric charge.
Charging point	A machine that connects EVs to the grid and supplies electric energy to charge vehicles.
Charging station	Infrastructure composed of charging points that supply electric energy to charge vehicles (BEVs and PHEVs). A.k.a Electric Vehicle Supply Equipment (EVSE).
Home charging	Charging the EV while it is parked at home, usually overnight. It can be done with the charger that comes with the vehicle in a conventional residential outlet (approx. 2.2 kW) or through a domestic charging point installed at home (up to 22 kW).
EV charging app	Recharging the EV without using RFID cards, via a mobile app instead to find a charging station and start the charging session.
RFID charging	A RFID charging station is a station with protected access. By the same technology used in public transportation smart cards, one shall pass a RFID card in front of the station to start the session.
Contactless payment	Available in some fast chargers, the consumer can start and pay for the charging session by tapping the payment card near a terminal equipped with the technology.
Kilowatt-hour (kWh)	The kilowatt-hour is a unit of energy equal to 1,000 watts. The kilowatt-hour is commonly used to measure the energy stored in batteries.

Range anxiety	The feeling of fear by the user when driving an EV and running out of battery during its trip. This fear can be mitigated with the construction of charging stations in parking lots, residential areas, companies, supermarkets, shopping malls, gas stations, etc.
Slow charging or level 1 charging (residential)	Its charging rates range between 2.3 kW and 3 kW, 120V AC, with no communication between the EV system and the charging station network.
Fast charging	It rates between 7kW and 22kW, and draws AC current from the grid and relies on the car's converter to turn it into DC, it connects the charging station network and the EV through CAN or PLC communication protocol.
Rapid charging	Rapid AC charging uses more power, at 43kW, than conventional fast AC charging. Rapid DC chargers work at 50kW or more and connect the charging station network to the EV through the CAN or PLC communication protocol.
Semi-fast charging or Level 2 charging	It operates at 208-240 V and outputs from 3 kW to 19 kW of AC power, it connects the charging station network and the EV through CAN or PLC communication protocol.
Smart charging	Generic term for a series of functions that a charging station connected to the Wi-Fi network can perform. This usually refers to the performance of functions related to load balancing and energy monitoring/management, optimizing the EV recharge during periods of lower prices and energy demand of the grid.
Vehicle to grid (V2G)	Technology in which BEVs or PHEVs are connected to the electrical grid to supply or obtain electricity, taking into account local demands for power and peak hours.
Vehicle to home (V2H)	System in which the EV is being used to meet the electricity demand of a home, which can use power from the EV battery.
Vehicle to vehicle (V2V)	Technology in which an EV is connected to another EV in order to transfer power or to provide information related to traffic conditions and updates.

EV SPECIFIC TECHNOLOGIES	
Term	**Definition**
Battery	A device that accumulates energy and through electrochemical reactions between its elements (oxidoreduction) produces electric current.
Regenerative braking	A process in which the kinetic energy of the vehicle, which would be dissipated in the form of heat through the mechanical brake system, is captured and converted into electrical energy through the traction motor, acting as a generator, ultimately being stored in the battery.
Energy inverters	A power electronic device that changes direct current (DC) to alternating current (AC).
Electric motor	An electrical machine that converts electrical energy into mechanical energy.
Battery management system (BMS)	BMS is an electronic system (hardware + software) that manages a rechargeable battery (cell or battery pack), such as by monitoring its state, battery "health", maximum and minimum limits of energy, and temperature, controlling the flow of electric current in the batteries.
Start/stop	Technology in which the ICE is switched off whenever the vehicle is stopped (a few seconds after total braking) and activated immediately after detecting the need for traction (when the accelerator or clutch pedal is pressed).
Supercapacitor	A capacitor with a capacitance value much higher than other capacitors, but with lower voltage limits

Source: Personal collection amended from Barassa,2019; Denton, 2017; Electronics Believer, 2019; Emotorwerks, 2019; Ev Safe Charge, 2019; Myev, 2019 and Pod Point, 2019.

Contents

List of figures

List of tables

List of abbreviations

ABDI	Brazilian Agency for Industrial Development
ABNT	Brazilian Association of Technical Standards
ABRAVEI	Association of Innovative Electric Vehicle Owners
ABVE	Brazilian Association of Electric Vehicle
ANEEL	National Energy Agency
ANFAVEA	National Association of Vehicle Manufacturers
BEV	Battery Electric Vehicle
BMS	Battery Management System
BNDES	Brazilian Development Bank
BRT	Bus Rapid Transit
BYD	Build Your Dreams
CAMEX	Brazil Foreign Trade Chamber
CE	State of Ceará
CNPQ	National Council for Scientific and Technological Development
COP21	Conference of Parts
CPFL	Electric energy generation company
DF	Federal District
EMBRAPII	Brazilian Company of Research and Industrial Innovation
EstaR	Regulated parking
EV	Electric Vehicle
FAP	Research Support Foundation
FCEV	Fuel Cell Electric Vehicle
FEI	Educational Foundation of Ignatius
FINDES	Federation of Industry of the State of Espírito Santo
FINEP	Funding Agency for Studies and Projects
GDP	Gross Domestic Product
GHG	Greenhouse gases
HCV	Heavy Duty Commercial Vehicle
HEI	Higher-educational institution
HEV	Hybrid Electric Vehicle
IBGE	Brazilian Institute of Geography and Statistics
IEA	International Energy Agency
INMETRO	National Institute of Metrology, Standardization and Industrial Quality
INPI	National Institute of Industrial Property

IPI	Tax on industrialized product
IPVA	Auto-motor Vehicles Property Tax
IST	Institute of Science and Technology
LCV	Light Commercial Vehicle
MA	State of Maranhão
MCTI	Ministry of Science, Technology and Innovation
Mercosul	Southern Common Market
MS	State of Mato Grosso do Sul
NDC	Nationally Determined Contribution
NOI	Net Operating Income
OICA	Organisation Internationale des Constructeurs d'Automobiles
PE	State of Pernambuco
PHEV	Plug-in Hybrid Electric Vehicle
PI	State of Piauí
PINTEC	Technological Innovation Research
PR	State of Paraná
PROCONVE	Motor Vehicle Emission Control Program in Brazil
RJ	State of Rio de Janeiro
R&D	Research and Development
RN	State of Rio Grande do Norte
SENAI	National Service of Industrial Apprenticeship
SINDIPEÇAS	National Association of Brazilian Auto Parts Manufacturers
SOFC	Solid Oxide Fuel Cell
SP	State of São Paulo
SUS	Unified Health System
UFMG	Federal University of Minas Gerais
UFPB	Federal University of Paraíba
UN	United Nations
UNDP	United Nations Development Program
UNFCC	United Nations Framework Convention on Climate Change
UNICAMP	University of Campinas
VWCO	Volkswagen Truck & Bus
WHO	World Health Organization

PNME
Plataforma Nacional
de Mobilidade Elétrica