POLICY INSTRUMENTS TO PROMOTE ELECTRIC MOBILITY IN BRAZIL

Abstract

Brazil does not present the impulses and motivations that led other countries to establish policies for electric mobility, as there are other peculiarities in its energy matrix that disperse efforts towards vehicular electrification. This article seeks to collaborate in establishing a vehicle electrification model in Brazil, which is already a reality today, and can reach 6 million vehicles by 2030. A review of the main policy instruments for mobility is performed involving the production, technological development, infrastructure and consumption aspects. This article contributes to the establishment of a vehicle electrification model in Brazil, establishing the main stakeholders of the process and proposing actions, mainly from the State, in the federal, state and municipal spheres, that can impact the model. Stakeholders should be encouraged by tax incentives or subsidies in order to overcome market inertia, provide infrastructure and stimulate consumption. The automakers, in turn, will offer the vehicle models that Brazilian policy will determine.

1 Introduction

The impulses and motivations that lead other countries to adopt electric vehicles (EV) do not apply to the Brazilian case, since there is no latent social or environmental movement that promotes, by itself, a direction for actions of both public and private partnerships in the electric mobility way. The country has other characteristics in its energetic matrix that are insufficient to boost the motivations of adopting EVs. The vision for the adoption of EV should be strategic, since the Brazilian situation is contextualized in a potential situation, justifying the adoption of EV by its potential to open paths for development, and not to correct deficiencies generated by using fossil-based energies or their economic and social unfolding. The prism is to explore a new technological route, whose leadership is not yet fully consolidated in a segment that can contribute to the country's development. Moreover, a new mobility logic to promote the use of Brazilian´s natural and human resources (ANEEL, 2018).

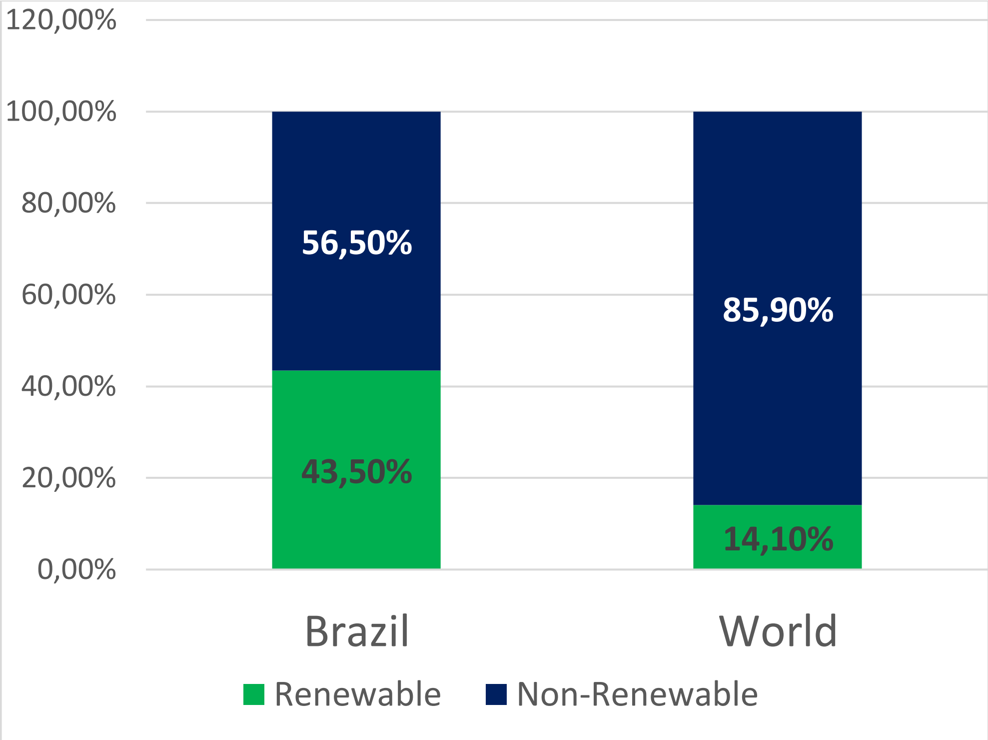
Therefore, unlike the experiences of electric mobility of other similar and emergent countries, Brazil is not relevant in the segment. On the other hand, this is not related to the relative importance of the country in the segment of Internal Combustion

Vehicles (ICE), since the country is one of the ten largest producers of vehicles and has an outstanding fleet in circulation of 65.835 million vehicles: automobiles, motorcycles, buses, trucks and vans (Amaral, Yazbek, & Olenike, 2018). The rate of motorization is still in exponential growth with about 36.3 vehicles per 100 inhabitants. Meanwhile, the country has a fleet of only 2,5 thousand electric and hybrid cars (Delgado, Costa, Febraro, & Silva, 2017). Thus, other elements would justify the implementation of public policies to accelerate the establishment of the EV segment in Brazil, articulating the actors in the direction of electric mobility (Consoni, et al., 2018). It reinforces the lack of clear goals and objectives by the federal government in relation to the EV, since the country faced previous energy problems with other technological options, for example bioethanol through the Proalcool Program (1975-1990).

The motivations that led other countries to boost the EV segment are different in the Brazilian case:

a) The participation of renewable sources in the Brazilian energy matrix was 43.5% in comparison with the world average of 14%, according to Figure 1, and this fact relatively minimizes the effect of the emission of greenhouse gases (GHG) (Brasil, Empresa de Pesquisa Energética (EPE), 2018). Meanwhile, the country has commitments in the Paris Agreement to reduce emissions by 37% in 2025 and 43% by 2030, below 2005 levels, stimulating, as an example of a solution, measures of efficiency and infrastructure in public transport and urban areas (CEBDS, 2017). However, the new Brazilian federal administration, which took office in early 2019, already signals possible changes that could affect those commitments, in line with the US Environmental Protection Agency (EPA) policies that determined that the GHG standards set during the Obama´s administration were very strict in the light of these factors and should be revised as appropriate. The details of the standards resulting from this decision still need to be defined (Notice EPA, April 13, 2018). Brazil has an opportunity in relation to other countries, such as China, in the "well to wheel" (W2W) analysis, since it presents a more sustainable and non-anchored fossil fuel matrix. In addition, for environmental and technological reasons the country is pointed out, in most studies, as the country that leads the bioenergy sector (Masiero & Lopes, 2008).

Figure 1: The Brazilian energy matrix is more renewable than the global



Source: Brasil, EPE, 2018.

b) The problem of the balance of payments with the importation of oil and its derivatives was partially solved through the Proalcool Program (1975-1990) and later in the first decade of the 21st century with the flex fuel car fleet (ethanol-gasoline). However, in 2017, due to the adjustment in Petrobrás pricing policy in July 2017, there was a significant increase in gasoline and diesel imports in the last two years (2017 and 2018). Petrobrás has established a policy of placing high premiums on gasoline and diesel to cover losses in previous years and this has influenced the market to import more of these products (Brasil, ANP, 2018). Brazil needs to buy gasoline and diesel abroad because it is not yet self-sufficient in oil refining. In the country the distribution of fuel is free, however refining is state monopoly through Petrobrás.

c) According to Consoni et al. (2018) environmentalist pressure is always suppressed by interests of other natures. Meanwhile, the country has a National Air Quality Plan and a National Air Quality Control Program (PRONAR), whose basic strategy is to limit, at a national level, emissions by type of source and priority pollutants, reserving the use of air quality standards as a complementary control action. The emission ceilings are defined through specific Resolutions of the National Environmental Council, CONAMA (Instituto de Energia e Meio Ambiente, 2014). Added to the fact that the country has extremely populous metropolises, such as São Paulo, with air pollution conditions that contribute to worsen the health conditions of its residents. Thus, in order to reduce and control air pollution and noise emission by mobile sources (motor vehicles), CONAMA created, through the Resolution nº 18/1986, the Air Pollution Control Programs for Motor Vehicles: PROCONVE (vehicles, trucks, buses and road and agricultural machinery) and, by the Resolution n° 297/2002, PROMOT (motorcycles and similar products) setting deadlines, maximum emission limits and establishing technological requirements for domestic and imported motor vehicles (IBAMA, 2011).

d) Establishment of a strategic vision to develop new economic sectors and to take advantage of the windows of opportunity through the technical increase in the industrial material is established only in the beginning of the years 2000. However, the constant instabilities of the Brazilian macroeconomic environment restrict medium and long-term policy actions by imposing budgetary constraints. But this could be an opportunity for Brazil, since countries of recent industrialization such as China and South Korea have aligned themselves in this motivation in search of the global leadership of the future of electric mobility. In Brazil, the electric car can become an important alternative, if it adopts, in the short term, a policy to encourage its use (Baran & Legey, 2011).

CNPEM's Report on "Vehicle Electrification and the Future of Fuel Ethanol in Brazil" (2018) address the risks of importing a model of electric mobility for the country, as there are some technical advantages in electrification - energy efficiency and reduction of local pollution. However, the report draws attention to the fact that the country has a position of follower in the electric mobility and that electrification can put the country as a major importer of supplies for the sectors of energy and mobility, thus generating disparities in its payments balance (Brasil, CNPEM, 2018).

In the absence of a strongly identified motivation, Brazil does not present policies that lead to actions and goals for electric mobility. This can be seen in the lack of governance around the theme that can drive actions around a model to be adopted in the Brazilian case (Consoni, et al., 2018). This article seeks to collaborate to establish a model of electrification of vehicles in the country, which are already a reality today and can reach 6 million vehicles by 2030 (Câmara dos Deputados, 2017). A bibliographic review of the main Brazilian initiatives for electric mobility is performed and a proposal for a model for electric mobility in Brazil is created.

2. Bibliographic review of Brazilian initiatives and policies to encourage EV

It is necessary to start with a characterization of the EVs, which are usually classified into three main categories: battery electric vehicles (BEV), hybrid electric vehicles (HEV) and fuel cell electric vehicle (FCEV). There are also plug-in hybrid electric vehicles (PHEV) where the battery of the hybrid cars can be charged in an electric station. A BEV already has rechargeable battery packs that accumulate chemical energy instead of an internal combustion engine (ICE). An HEV involves both systems: an ICE system and an electric propulsion system (Carvalho & Lamas, 2009). Finally, FCEV uses fuel cells in combination with a battery or a super capacitor that feeds an electric motor.

In EV the energy is stored by electrochemical batteries with energy density, such as lithium ion batteries, of 0.7 MJ/kg, lower than the energy densities of liquid fuels such as hydrous ethanol of 26 MJ/kg or gasoline of 39 MJ/kg. This limits the use of batteries to small amounts of energy and translates into limits of autonomy for EVs (Brasil, CNPEM, 2018).

The policies implemented in other countries, promoted by the motivations already mentioned, stand out of new legislation that foresee the end of the sale of combustion models (ICE) in the coming decades or the restriction of their circulation:

- In Netherlands, Norway and Sweden the forecast for the end of the sale of ICE is 2025, Germany and India 2030, the United Kingdom, 2040 and Brazil, according to a Federal Senate proposal bill (PLS 454/2017) in 2060 (CNN Business, 2017).

- The city-state of Singapore announced in October 2017 a plan to reduce the vehicle growth rate from 0.25% per year to 0%. Due to the limited space available, Singapore controls the number of vehicles on the road to a large extent (Auto Evolution, 2017).

- On October 23, 2017, the mayors of London, Paris, Los Angeles, Copenhagen, Barcelona, Quito, Vancouver, Mexico City, Seattle, Auckland and Cape Town undertook a series of ambitious goals to make their cities more green, healthier and more prosperous. By signing the C40 Non-Fuel Streets Declaration, these mayors have committed to purchase only zero-emission buses from 2025 onwards and ensure that an important area of their city has zero emissions by 2030. Policies are designed to combat air pollution. improve the quality of life for all citizens and help combat the global threat of climate change (C40 Cities, 2017).

• In January 2019, China's automobile emissions law came into force. It is seen as one of the most important at a global level in the acceleration of the adoption of electric vehicles. All automakers that sell or manufacture more than 30,000 cars a year will have to meet the new rules that define production minima for new energy powered vehicles (NEVs) - electric, plug-in hybrids and hydrogen. Thus, 10% of all brand vehicles will have to be NEVs and this quota increases every year until all vehicles powered by internal combustion engines are banned (Bloomberg, 2018).

• In December 2017, two years ahead of schedule, the Chinese city of Shenzhen of 20 million people showed its new fleet of more than 16,000 electric buses. The new fleet will come with 8,000 cargo points at 510 stations to cover half the fleet at any time. Estimates indicate that the new electric fleet could save up to 345,000 tons of fuel per year and reduce the emission of carbon dioxide by 1.35 million tons. China has established integrated emission control policies and measures since the 1990s, including implementation of emission standards for new vehicles, inspection and maintenance programs for in-use vehicles, improvement in fuel quality, promotion of sustainable transportation and alternative fuel vehicles, and traffic management programs (Wu, et al., 2016).

According to Consoni et al. (2018), there is no strategic planning at the Brazilian federal government level to guide public policies for electric mobility. Table 1 presents the results of the mapping of pro-EV public policies in Brazil.

Table 1: Main policy instruments for electric mobility in Brazil.

Production	1986: Proconve - Air Pollution Control Programs by Automotive Vehicles
	2008: Vehicle Labeling Program
	2011: BNDES Program Climate Fund
	2013 – 2017: INOVAR-AUTO Program (Law n°12.715/2012)
	2018: Route Program 2030 - Mobility and Logistics (Law n°13.755/2018)
Technological Development	2002: Brazilian Program of Fuel Cell System (Finep)
	2003-2016: Search Projects (CNPq)
	2005-2007: Strengthening of the Center for the Development of Energy and Vehicles (Finep)
	2008-2018: Aneel R&D projects related to electric vehicles
	2010-2016: Funding under the CT-Energy Sector Fund (Finep)
	2011-2015: Call of the Brazilian System of Technology (SIBRATEC) - Network of Technologies for Electric Vehicles
	2011-2013: BNDES Investment Support Program
	2011: Technological Fund (Funtec/BNDES)
	2012: Normalizations of ABNT related to electric vehicles
	2017: Aneel – creation of the Technological Innovation Network in the Electric Sector – RISE

	2018: BNDES and Embrapii – projects of electric vehicle recharge networks
	2018: Aneel – Priority Strategic Call for Public Consultation on the subject of Electric Mobility
Infrastructure	2013: Inova Energia - Inclusion of pilot projects of recharging systems for electric vehicles in online financing
	2016: Aneel's public consultation on the need to regulate aspects related to electric power supply to electric vehicles
	2017: Public Hearing of Aneel for the improvement of the regulation of electric power supply to electric vehicles
	2018: ANEEL Resolution nº819/2018 - which regulates the procedures and conditions for the performance of electric vehicle recharging activities
Consumption	2015: Camex Resolution nº97 - reduction of imports of electric vehicles
	2016: Camex Resolution on Import Tax Reduction for Electric Vehicles for Freight
	State/Municipal:
	2014: State exemptions of IPVA for electric vehicles (Rio Grande do Sul, Maranhão, Piauí, Ceará, Rio Grande do Norte, Pernambuco and Sergipe) and differentiated rates for: Mato Grosso do Sul, São Paulo and Rio de Janeiro.
	2015: Rotation exemption in the city of São Paulo (Law n°15.997/2014)

Source: adapted from Consoni et al. (2018).

Let's get a little closer to Table 1 with details of the main policies for electric mobility in Brazil.

2.1. Production

The Program for the Control of Air Pollution by Motor Vehicles (Proconve), coordinated by the Brazilian Institute of Environment and Natural Resources (IBAMA), defined the first emission limits for light vehicles, contributing to the air quality standards established by the National Program of Air Control (Pronar). Law nº. 8.723/1993 establishes maximum emission limits and determines minimum technological standards for motor vehicles, domestic and imported.

The National Environment Council (Conama) has approved a resolution in 2018 that establishes two new phases, L7 and L8, for Proconve. The objective of the measure is to reduce emissions of pollutants by new vehicles, to promote the technological updating of the automobile industry and to establish control mechanisms based on parameters and environmental quality criteria already adopted by the United States legislation, reference in the area.

The L7 phase imposes emission limits even more restrictive than the L6 and determines that this performance is maintained by double the mileage: before 80 thousand km, now 160 thousand km. Another requirement is the adoption of technology that allows the vapors emitted during the filling to be stored in an integrated container to the vehicle, to avoid their dumping into the atmosphere. Until 2025, the year in which Phase L8 comes into force, all vehicles must leave the factories with this resource. From the entry into force of phase L7 to the end of L8 until 2031), emissions of particulate matter will be limited by up to 85%; volatile organic compounds and nitrogen oxides will be reduced by 90.62% (Brasil, IBAMA, 2018).

The Vehicle Brazilian Labeling Program (Vehicle PBE) is an energy efficient labeling program for light vehicles. Coordinated by the National Institute of Metrology, Quality and Technology (INMETRO) in partnership with the National Rationalization Program for the use of petroleum-based products and natural gas (Conpet), it was created in 2008 to provide useful information that can assist consumers in the decision and at the same time stimulate the manufacture and import of more efficient and economical vehicles. This initiative included Brazil in the list of countries that develop fuel efficiency and fuel efficiency programs in vehicles such as the USA, Japan, Australia, China, Canada and European Union members. Voluntary adhesion of automobile manufacturers and importers is renewable each year and in order to participate, the supplier must report the energy consumption figures of at least 50% of all of its zero km car models planned for marketing in the period (INMETRO, 2019).

The Climate Fund Program of the National Economic and Social Development Bank (BNDES) was intended to apply the portion of reimbursable resources of the National Fund on Climate Change, or Climate Fund, created by Law n° 12.114 on December 9, 2009 and regulated by Decree 7.343, 10/26/2010. It was intended for projects that have contributed to reduce the emission of greenhouse gases and local pollutants in public urban passenger transport and to improve urban mobility in metropolitan areas, limited to heavy vehicles (BNDES, 2019).

Law nº 12.715/2012 created the Program for the Incentive to Technological Innovation and the Automotive Vehicle Productive Chain (Inovar-Auto) Incentive Program whose objective was to create conditions for increasing competitiveness in the automotive sector, producing more economical vehicles and insurance, investing in the supply chain, engineering, basic industrial technology, research and development and supplier training. The program was valid for the period from 2013 to 2017. The program's tax incentives were directed to new investments, to the elevation of the technological standard of vehicles and their parts and components, and to vehicle safety and energy efficiency. However, it did not promote the production of electric vehicles in Brazil (MDIC, 2017). Studies point to the low level of research and development (R&D) investments of the INOVAR-AUTO Program, since while the main automakers invest 3% to 5% of their revenues, the Program required R&D investment of only 0.5 % of eligible companies (Pascoal, Delamaro, Ibusuki, Tsukada, & Rocha, 2017).

Law nº. 13.755/2018 created the Route 2030 - Mobility and Logistics Program (Rota 2030), valid from 2019 for a period of 15 years with 3 cycles of 5 years each, with the objective of supporting technological development, competitiveness, innovation, vehicle safety, environmental protection, energy efficiency and the quality of cars, trucks, buses, engine chassis and auto parts. The Rota 2030 Program has as its guidelines:

i) increase in energy efficiency, structural performance and the availability of assistive technologies in the direction of vehicles commercialized in Brazil;

ii) increase investments in research, development and innovation in the country;

iii) stimulation of the production of new technologies and innovations, according to the global technological trends;

iv) increase the productivity of industries for mobility and logistics;

v) promotion of the use of biofuels and alternative forms of propulsion and valorization of the Brazilian energy matrix;

vi) guarantee of technical training and professional qualification in the mobility and logistics sector; and

vii) guarantee the expansion or maintenance of employment in the mobility and logistics sector. Route 2030 encourages hybrid vehicles equipped with an alternative or simultaneous gasoline and alcohol (flexible fuel engine) engine, which must have a reduction of at least three percentage points on taxes over industrialized products (IPI) for conventional vehicles of similar class and category, fitted with the same type of engine. As the Rota 2030 Program is the main incentive and the one that has the greatest impact on research and development in the Brazilian automotive sector, the fact that it does not encourage direct electric car can have future consequences in the process of introduction of electric mobility.

2.2. Technological Development

Consoni et al. (2018) raised the main initiatives that occurred for electric vehicles in the country according to Table 2 below.

Table 2: Main Brazilian initiatives for EV

Financial Institution	**Initiatives**	**Resources (R$million)**
Finep	Brazilian Program of Fuel Cell Systems (2002)	1,105
	Center for the Development of Energy and Vehicles (2005, 2007 e 2013)	9,5
	SIBRATEC – Network of Technologies for Electric Vehicles (2011-2015)	1,896
	Sectorial Fund CT-Energia (2010-2012)	12,789
	Sectorial Fund CT-Energia (2011-2016) with Itaipu Binational sodium battery	20,2
	Sectorial Fund CT-Energia (2013-2016) Itaipu Binational hybrid electric bus to ethanol.	10,0
BNDES	BNDES PSI in the form of credit for the development of electric motors for electric vehicles of the company WEG	7,5
	FUNTEC with the CPqD and the company Electric Dreams for the development of an electric vehicle	6,3
	FUNTEC two network infrastructure projects to recharge	6,7
CNPq	Financing 43 projects between 2003 and 2016	3,164
P&D Aneel	Financing of 10 R & D projects for electric vehicles between 2008 and 2018.	51,795
Finep/BNDES/Aneel	Inova Energia (2013). Initiative with 14 projects approved in a Call for Tender, which seeks to finance credit projects for electric vehicles and recharge network.	Not disclosed

Source: Adapted from Consoni et al. (2018).

Fuel cells are devices that enable the electrochemical conversion of fuels, especially hydrogen, into electrical energy. Interest in this type of device has been noticeably increasing, given that its energy efficiency is superior to that of thermal machines, with benefits for fuel economy and more rational use of energy from the point of view of the environment (Chum, 2002).

The main goal of the Brazilian Fuel Cell Systems Program was to promote integrated and cooperative actions between research institutions and private companies to enable the national development of fuel cell systems technology to enable the country in this technology (Brasil, MCT, 2002). The program promoted, among other initiatives, a project to develop a hybrid bus with batteries and fuel cells made between COPPETEC of the Federal University of Rio de Janeiro, Petrobrás, Caio-Induscar, Eletra and Lactec. Currently COPPE/UFRJ, in partnership with the Tracel and Furnas companies, has a fuel cell bus, Figure 2, which is already in the third generation and has autonomy for 330 km (COPPE/UFRJ, 2017).

Figure 2: Fuel cell bus

Source: Coppe, UFRJ.

The Energy and Vehicle Development Center (CEDV) of Pontifical Catholic University of Rio de Janeiro (PUC-Rio) received contributions from Finep and Petrobrás between 2005 and 2013, and was designed to operate in the energy production line through the use of fuels in an efficient and sustainable manner, one of the initial objectives of replacing diesel with other fuels (CEDV, 2019).

The Brazilian System of Technology Network (Sibratec) Technologies Innovation Centers for Electric Vehicles was established by Finep in 2011 after some meetings with participants of 15 science and technology institutions, and the ITAIPU-Brazil Technology Park Foundation as contractor. It there was the promotion of a single project between Institute of Energy and Nuclear Research (IPEN) and the company Electrocell in 2011 for the integrated technological development of lithium-ion batteries with autonomous unit of charge by means of fuel cells for the propulsion of urban electric vehicles in the value of R$895 thousand (Portal da Transparência, 2015).

The CT-Energ Sectoral Fund, which is one of the funds of the National Fund for Scientific and Technological Development (FNDCT), aims to stimulate research and innovation aimed at finding new alternatives for generating energy with lower costs and better quality; the development and enhancement of the competitiveness of national industrial technology, with an increase in international exchange in the R&D sector; the training of human resources in the area and the promotion of national technological training. The source of its resources is between 0.3% and 0.4% of the net revenue of concessionaires of generation, transmission and distribution of electric energy (Brasil, MCTIC, 2014). According to Consoni et al. (2018), between 2010 and 2012, CT-Energ financed four technological development projects directly linked to electric vehicles through the companies Whirpool, WEG, ACs and Moura Accumulators.

Finep, funded by CT-Energ, financed in 2012 the development of the first sodium battery with national technology by the Itaipu Technological Park Foundation, Figure 3, in partnership with Itaipu Binacional, the Electric Energy Research Center (Cepel) and the Swiss company Battery Consult.

Figure 3: One of three sodium battery prototypes developed at Itaipu Technological Park, financed by Finep.

Source: (Itaipu Binacional, 2017) .

Finep, also using the CT-Energ Fund, financed in 2013 Itaipu Binacional with partner companies Eletra, Mitsubishi Motors do Brasil, Magnet Marelli, WEG Equipamentos Eletricos, Mascarello, Tutto Transport, Euroar, FZ-Sonik and MES SA, which developed a hybrid electric powered ethanol powered bus (OEHE). The OEHE has proven to be a comfortable vehicle with low levels of noise emission and pollutant gases. Its energy performance has been optimized by the fact that its sodium chloride batteries enable the recharging by means of conventional 220V sockets. The autonomy calculated was of about 300 km, considering the operation in route typical of a special corridor for buses (Itaipu Binacional, 2017).

The BNDES Investment Support Program (BNDES PSI) was the lender in the credit modality (reimbursable resource) in the project with WEG for the development of electric motors specifically for electric vehicles.

The Technological Fund of BNDES (Funtec) financed in 2011, through CPqD in partnership with Electric Dreams, of São José dos Campos, an electric sports car with four individually controlled motors, one for each wheel. The investment was about R$6.3 million (CPqD, 2014).

In 2018, the National Bank for Economic and Social Development (BNDES) approved the support of R$3.4 million and R$3.3 million for two projects of electric vehicle recharge networks. The funds will come from BNDES Funtec, a non-reimbursable fund, focused on applied research projects, technological development and innovation. The initiatives were selected in a public call made in 2016 and will be developed by two units of the Brazilian Enterprise for Research and Industrial Innovation (Embrapii): Foundation CPqD - Center for Research and Development in Telecommunications and the Foundation Center of Reference in Innovative Technologies (CERTI).

The CPqD project has a total investment of R$5 million and has as its stake PHB Eletrônica Limitada, a Brazilian company with more than 30 years of experience in innovation projects in the area of power electronics applied to power systems. The CERTI initiative provides for investment of R$7.5 million and counts on WEG, a national manufacturer of industrial electronics with more than 50 years of market that already operates in the sector of smart grids and electric mobility. The projects also have non-reimbursable financial support from Embrapii, in the total amount of R$2.9 million. Institutions will develop models of slow recharge (8 to 16 hours), semi-rapid (2 to 4 hours) and rapid (up to 1 hour) recharge models. The stations can be installed in homes, malls, parking lots, petrol stations and roads (BNDES, 2018).

The Inova Energia Joint Action Plan was an initiative undertaken in 2013 to coordinate actions to foster innovation and improve the integration of the support instruments provided by Finep, BNDES, the National Electric Energy Agency (Aneel), which one of the purposes (Line 3) of supporting initiatives that promote the development of integrators and component chain densification in the production of hybrid/electric vehicles, preferably ethanol, and improving the energy efficiency of motor vehicles in the country. The result of the Call for Proposals shows at least 14 approved projects with credit and/or economic subsidy (Finep, 2014).

Thus, it can be seen that in the last 15 years several actions have been financed for the development of electric vehicles and their components, but: the actions are not robust, that is, despite expenditures totaling about US$40.7 million in fifteen years are values that approximate what Japan spends per year; there are no precise science and technology objectives, the objectives are dispersed and without strategic planning; the actions and the actors are disarticulated and these do not have continuity (Consoni, et al., 2018). This demonstrates the need for a model for electric mobility in Brazil.

2.3. Infrastructure

There is a limitation in public policy initiatives in providing the infrastructure for electric vehicles such as recharge stations. However, as mentioned previously, there have been previous initiatives such as the Aneel, BNDES and Finep Joint Public Call for support to technological innovation in the power sector within Inova-Energia, which took place in 2013, with a specific project selection line for the supply infrastructure for the development and implementation of pilot projects for electric recharging/hydrogen supply systems for electric traction vehicles (Finep, 2014). However, Consoni et al. (2018) reports that there were no specifically approved proposals along these lines.

In 2018, as already shown, BNDES and Brazilian Industrial Research and Innovation Company (Embrapii) finance two projects totaling R$6.7 million with Fundation CPqD, PHB Eletrônica Ltda, Fundation CERTI and WEG, to execute a project in electric cars charging stations (BNDES, 2018).

However, there have been advances, albeit still limited, in the area of regulation, through ANEEL Resolution No. 819/2018, which regulates the procedures and conditions for carrying out electric vehicle recharging activities. Therefore, in June 2018, this minimum regulation on the recharge of electric vehicles was approved by those interested in providing this service (distributors, gas stations, shopping malls and entrepreneurs). It is intended that this will avoid the interference of the activity in the tariff processes of electric energy consumers, when the service is provided by the distributor, and, thus, the elimination of barriers to this development (ANEEL, 2018).

2.4. Consumption

EVs have the disadvantage of being perceived as more expensive than conventional vehicles for internal combustion (ICE). This perception can be derived from the higher cost of capital, making it easier for consumers to assess the operational cost. however, existing studies show that the operational cost may be lower for EVs than for conventional vehicles (Wu, Inderbitzin, & Bening, 2015).

First, EV batteries are being recharged at home. The idea is that the owner uses the vehicle during the day and recharges during the night. In the United States, the electricity tariff is lower during the early morning hours, to discourage use during peak hours, usually in the late afternoon and early evening. Applications can manage this smart charging, allowing recharges when energy has a lower cost. This still does not happen in Brazil, but these smart charging should be prioritized in the future so as not to overload the system and have an over-tarry (yellow or red flag) that is paid by all consumers.

In Brazil, since 2015, energy tariff flags appear in light accounts throughout the country, except in Roraima, which is not part yet of the National Interconnected System. The tariffs are classified by colors, according to Figure 4, and indicate monthly, whether there will be an increase in the value of energy, due to the use of thermoelectric plants.

Figure 4: Energy tariff flags

Energy Tariff Flags		
GREEN	YELLOW	RED
Rate does not go up	Rate goes up R$1,50 per 100 kWh	Rate goes up R$3,00 per 100 kWh

Source: Aneel (2018).

The public policies of countries that want to incentivize the demand for EVs seek to encourage the reduction of the cost of capital for the acquisition (Vaz, Barros, & Castro, 2015). Consoni et al. (2018) identified two initiatives: the Camex resolutions of 2015 and 2016, and the financing line for Efficient Capital Goods of the BNDES.

The resolutions of the Chamber of Foreign Trade (Camex) of the Ministry of Industry, Foreign Trade and Services (MDIC), reduced the aliquot of import taxes for vehicles with high energy efficiency. Camex Resolution No. 97/2015 reduced the Import

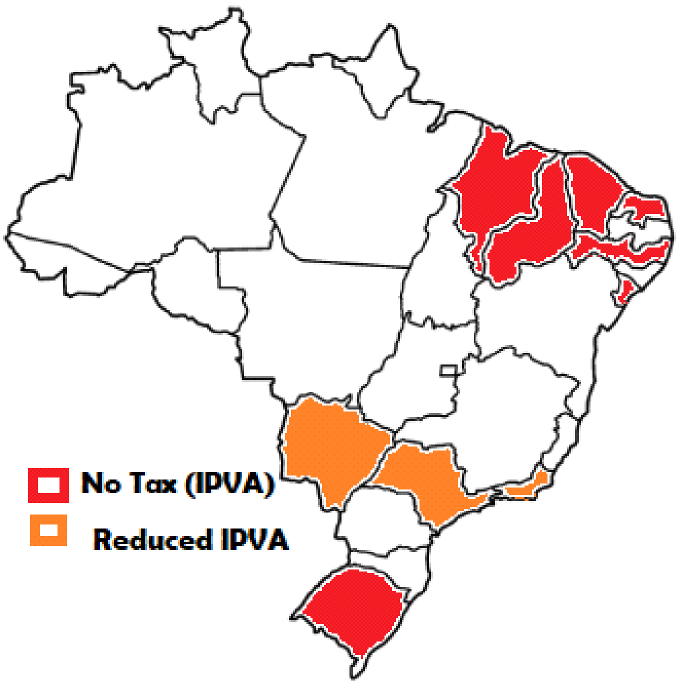
Tax rate for electric cars and moved them to fuel cells from 35% to zero. The amendment was made through the inclusion of the code 8703.90.00 of the Mercosur Common Nomenclature (NCM), in the List of Exceptions to the Common External Tariff (Letec). The Executive Management Committee of Camex (Gecex) also decided to extend the scope of the tariff reduction for some categories of hybrid cars (combustion engine that works with the help of electric or pneumatic traction system), altering the description of the tariff highlights. codes 8703.22.10 and 8703.23.10 to contemplate the vehicles with technology of external recharge, reducing the same aliquot of 35% to a percentage between 2% and 7%, depending on the displacement and energy efficiency (Brasil, CAMEX, 2015).

Camex Resolution n ° 27, of March 24th, 2016, set zero the aliquot of the import tax for cars for the transport of goods with electric propulsion motor with energy from accumulators or fuel cells, with autonomy of at least 80 km within the code 8704.90.00 of "Other" (Brasil, CAMEX, 2016).

The operational policies of the BNDES financing lines for machines and equipment, in 2017, sought to reduce the cost of energy efficiency-inducing equipment or lower relative energy consumption. Thus benefiting equipment, machines or vehicles that have higher energy efficiency rates or directly contribute to the reduction of GHG.

The IPVA (Tax on the property of motor vehicles) is a state tax with the objective of raising money on motor vehicles. However, the tax does not refer only to cars or motorcycles, but to all vehicles that have motor, whether automobile, motorcycle, aircraft or boats. At the state level, according to the Brazilian Association of Electric Vehicles, there is an exemption from the Tax on the Automobile Vehicle Property (IPVA) in seven states: Rio Grande do Sul, Maranhão, Piauí, Ceará, Rio Grande do Norte, Pernambuco and Sergipe. In three other states the aliquot is differentiated: Mato Grosso do Sul, São Paulo and Rio de Janeiro.

Figure 5: Brazilian states with tax exemption or with differentiated rates.



Source: Authors.

In the State of São Paulo, for example, the value of the IPVA is treated in Law 13.296/2008, being that for vehicles in general, the value is 4%. São Paulo has a 50% reduction in this aliquot for vehicles moved to electric power or hydrogen, in addition to hybrid vehicles (PHEV or HEV).

It is perceived, that there are some policies for the incentive of the consumption of electric vehicles in Brazil, but still timid and uncoordinated.

3. Proposal for a Model of Electricity for Brazil

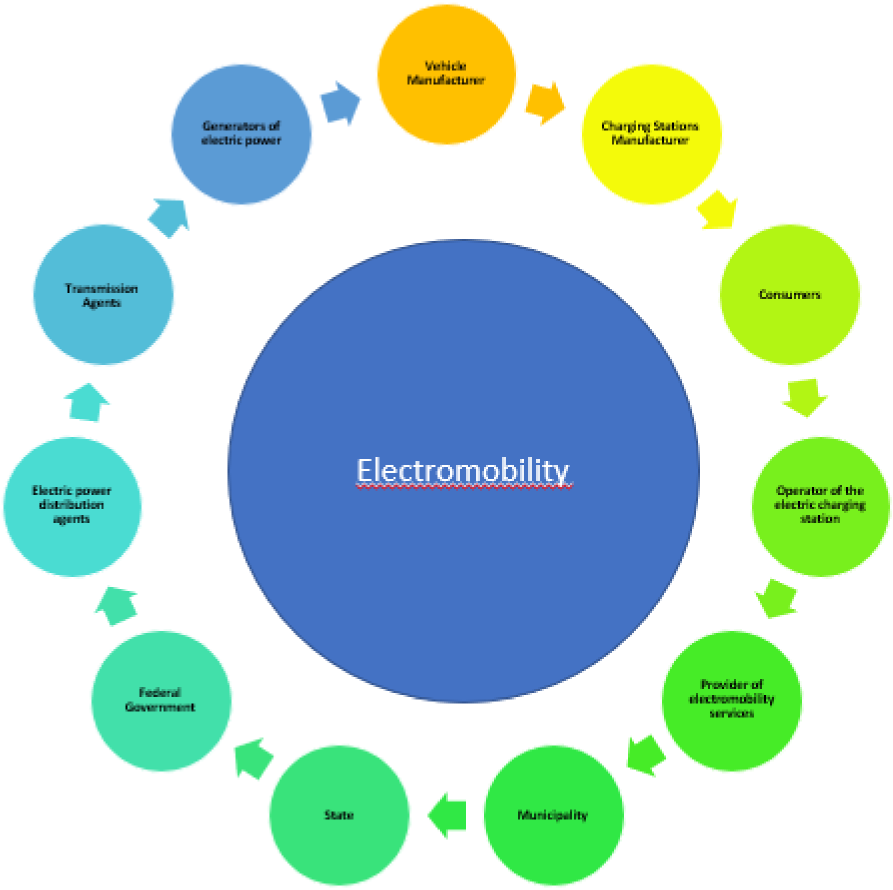
Following there is a proposal of an electric mobility model for Brazil with the identification of the stakeholders of the electric mobility ecosystem, according to Figure 6:

- Manufacturer of vehicles: the companies that manufacture electric or hybrid vehicles. Exemples: Nissan, Toyota, Volskwagen, Renault, Tesla, Volvo, Eletra, etc.
- Manufacturer of charging stations: the companies that manufacture their components. Example: Electric Mobility Brazil.
- Consumers: the people or companies that acquire, rent or use electric or hybrid vehicles.

- Operator of the electric charging station: the companies, distributors of electrical energy or not, that operate the electrons, identify the consumer, measure the capacity of loading (metering), can execute the charging of the recharge, and, provide the maintenance services to the voters.
- Provider of electric mobility services: companies that provide services to the consumer through applications that provide access and availability of the electros, check the charging of recharges, provide remote support and can intermediate the user with other parties, such as the aggregators in the case of negotiation of tariffs for smart charges. Example: Plugshare.
- Municipality: is the municipality that provides the public location of the electric stations, the rules of parking and circulation for electric vehicles, establishes codes for the installation of the electric stations and enables the distributor of electric power in the installation works of the cables for electric recharge stations buildings. Example: municipality of São Paulo.
- State: the federated entities that establish incentives on the motor vehicle property tax (IPVA) and can incentivize concessionaires to have differentiated toll rates for electric vehicles on state roads. Example: State of São Paulo.
- The Federal Government: the organs of direct and indirect administration, including regulatory agencies such as Aneel, which establish the tax rates of industrialized products for the import or manufacture of electric vehicles, provide tax incentives for research and development, establish open patterns and national regulations, provide directives for the States and Municipalities and may incentivize concessionaires to have differentiated toll rates for electric vehicles on federal roads. Example: Aneel.
- Electric power distribution agents: who operate a distribution system in their concession area, participating in the Interconnected System and being users of the Basic Network. They contract energy transmission services and ancillary services from the National Electric System Operator (ONS). They are the companies that supply electric power to the electric charging stations, they can do the installation and operation of the same and they can give prizes to the intelligent loads.

- Transmission Agents: companies holding a concession for transmission of electric power, with facilities in the basic network.
- Generators of electric power: authorized or concessionaires of electric power generation, which operate generation plants and provide ancillary services.

Figure 6: Electric mobility Ecosystem of Brazil



Source: Authors.

There are, basically, four types of government actions to encourage the diffusion of the electric car:

i) bonuses to electric vehicle buyers, an instrument not previously provided by the Brazilian legislation;

ii) tax rebates: in the acquisition, through the exemption or reduction of the import tax (II) and/or the tax on industrialized products (IPI), federal taxes, and exemption or reduction of the Tax on the Circulation of Goods and Services (ICMS), a state tax, and, in annual property taxes, such as the tax on property of motor vehicles (IPVA), which is also a state tax;

iii) adoption of restrictions on the use of conventional vehicles, such as the case of carriage, at the end of the license plate and on the day of the week, in the city of São Paulo; and

iv) assistance in the research and implementation of infrastructure by

A proposal for an electric mobility model for Brazil should begin with one of the most important stakeholders, who is the consumer. We must understand what motivates the consumer to acquire an electric or hybrid vehicle and, mainly, to minimize the anxiety of this consumer in the matter of autonomy of the vehicle. Zhang, Bai, & Shang (2018) report that economic incentives, environmental impact, and associated risks are the most relevant factors that consumers consider when purchasing an EV.

The findings of Zhang, Bai and Shang (2018) provide a strategy to promote large-scale adoption of EV in a post-subsidy era. This is to (1) classify consumers as promotion versus prevention-focused groups, with consumers focusing on promotion being more sensitive to perceived environmental benefits and taking more positive attitudes toward EV purchase, while focus groups in prevention they are not; (2) increase the environmental benefits of EV through technological advances and reduce perceived risks by providing more supply facilities, (3) announce the environmental benefits of EV to attract advocate-focused adopters, (4) disclose perceived reduced risks with the objective of attracting adopters from both groups, (5) taking these early EV users as important reference groups for more people focused on prevention, improving the requirements of EVs, which in turn can improve EV's purchase intent. The proposed strategy implies a roadmap where the large scale of EV adoption can be implemented by early followers, from metropolises to medium and small cities.

The consumer is thus motivated by incentive policies, Table 3, which help lower the costs of EVs by making them more economically competitive and attracting consumers with:

- monetary facilities: reduction of capital cost (acquisition, leasing or availability of use as a service), operation cost (recharge, maintenance, IPVA and reduction or exemption from toll tariff); and,

- non-monetary facilities: ease and availability of supplies, freedom of movement (without carriage), priority parking in urban centers and exclusive taxi lanes.

Table 3: Opportunities for consumer incentives

Monetary	Capital Cost	Acquisition	Reduction of IPI (Federal)
			Reduction of ICMS (State)
			Bonus for deduction of Individual or Legal Income Tax (Federal)
		Leasing and Service	Reduction of ISSQN (Municipal)
	Cost of operation	Recharge (kwh)	Reduction of ICMS (State)
		Property (yearly)	Reduction of IPVA (State)
Non-Monetary	Facility Supply	Encouraging the use of route and destination fueling applications	
	Circulation	Exemption of rotation or restriction of circulation (Municipal)	
		Use of exclusive lanes	
	Parking	Priority parking	

Source: Authors.

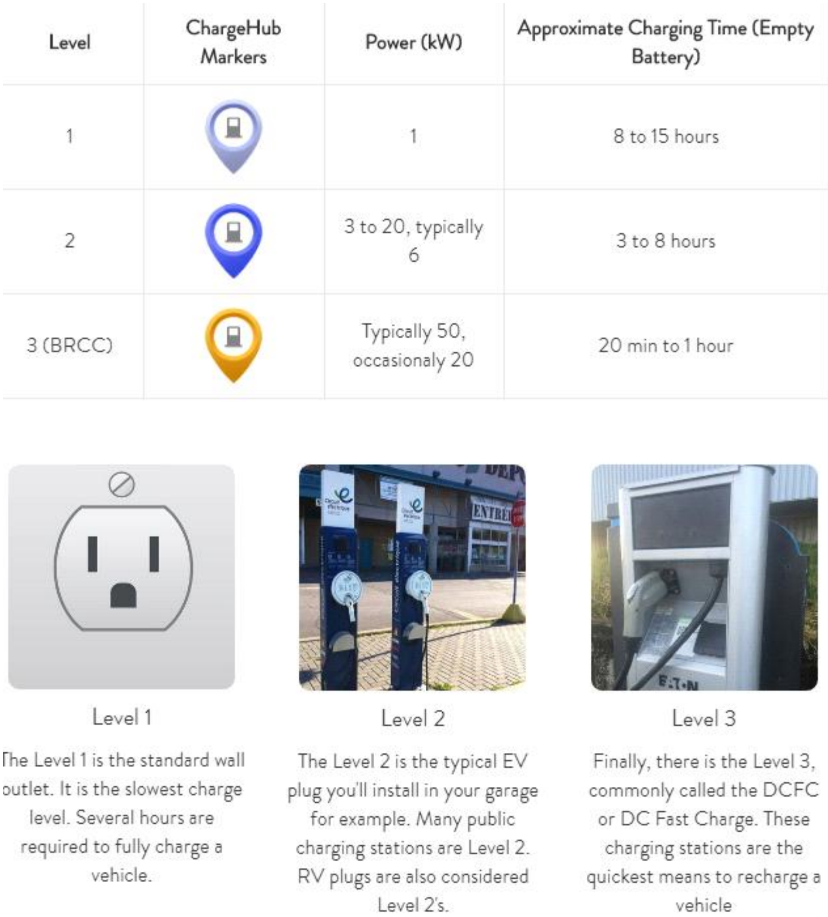
However, these consumer incentives may not have an effect if there is no supply infrastructure available as charging stations. The consumer has an anxiety about the autonomy of the vehicle, however studies reveal that most consumers make daily trips below 100 miles (160.9 km) and most EVs today already serve this autonomy (Franke, Günther, Tratow, & Krems, 2017) and (Woodjack, et al., 2012).

The second important stakeholder is the electric energy distributor that will make the infrastructure of the supply elements and, in case of private companies, there is a need to seek monetary results. The risk is high, because in case of there is no consumption there is no way to reverse the use of installation capital.

There are three key places to recharge an electric vehicle: at home, in public place and at destination (workplace). There are two types of home supply: Level 1 and Level 2, Figure 7. Level 1 occurs when the vehicle's own charger is used for fueling. This charger can be plugged into any 120 V outlet with the cable connected directly to the vehicle. At Level 2, chargers are sold separately from the vehicle and are connected to the 240 V network, requiring the work of an electrician. The level 2 charger type is most recommended for EV or PHEV. There is also fast charge level 3 chargers DCFC (DC

Fast Charge), which is the fastest way to charge the EV, but some vehicles cannot be loaded in this type.

Figure 7: Types of supply levels



Level	ChargeHub Markers	Power (kW)	Approximate Charging Time (Empty Battery)
1		1	8 to 15 hours
2		3 to 20, typically 6	3 to 8 hours
3 (BRCC)		Typically 50, occasionaly 20	20 min to 1 hour

Source: Chargehub (2019).

To illustrate, there are already 55,000 public supply points available in 19,300 stations (including 8,800 DCFCs) in the United States, which continue to grow on offer each week. These numbers, however, are not enough to support the expected EV growth for decades to come, as a US Department of Energy study estimates that if we have 15 million EVs in 2030, we will need 27,000 DCFC and 600,000 Level 2 in public places. Most of these EV supply equipment would be needed in cities, as well as in smaller cities, rural areas, and interstate corridors. In order to encourage the adoption of EV, it is essential to increase the supply of electricity to long-distance travel on highways and supply in residential and office areas (Engel, Hensley, Knupfer, & Sahdev, 2018).

The state of California in the US is doing its best to promote the deployment of the electric stations. It has already invested US$80 million in EVs infrastructure and

US$128 million in fuel cell infrastructure, thus funding 38% of the recharge points in the state. California is not the only state to act, and a coalition of US states (Colorado, Nevada, Utah, Idaho, Montana, New Mexico, Wyoming, and Arizona) are investing to create a network of fast refueling stations covering 5,000 miles of and on 11 interstate highways (CA.gov, 2019).

To eliminate the resulting waste from the inefficiently designed load infrastructure and maximize the usage rate of each loader, it is recommended that an optimum design model be used and load site priority to improve the availability and accessibility of a network charging (Viswanathan, et al., 2018). This maximizes the return on investment at the filling station.

The electricity distributor is the one that performs the works of installation of the electric charging stations are thus motivated by incentive policies, Table 4, that help to lower the costs of the investments in the infrastructure by means of:

- monetary facilities: reduction of capital cost (installation of the infrastructure of EV charging stations), operation cost (incentives to reduce the cost of the service provided); and,
- non-monetary facilities: allocation of noble areas for usufruct, concession of central areas and clear and predictable regulatory process.

Table 4: Opportunities for incentives to the energy distributor.

<table>
<tr><td rowspan="5">Monetary</td><td rowspan="3">Capital Cost</td><td rowspan="3">Installation</td><td>Reduction/Exemption of IPI (Federal)</td></tr>
<tr><td>Reduction/Exemption of ICMS (State)</td></tr>
<tr><td>Subsidy or bonus for reduction of Corporate Income Tax (Federal)</td></tr>
<tr><td rowspan="2">Cost of operation</td><td rowspan="2">Service</td><td>Reduction of ICMS (State)</td></tr>
<tr><td>Reduction of ISSQN (Municipal)</td></tr>
<tr><td rowspan="2">Non-Monetary</td><td>Concession</td><td colspan="2">Allocation of central and noble areas for usufruct</td></tr>
<tr><td>Regulation</td><td colspan="2">Predictable and clear regulatory procedure</td></tr>
</table>

Source: Authors.

Finally, we mention the technological deficiencies that need to be filled by science and technology institutions in association with companies, because otherwise, without this necessary technological development, Brazil will be a mere replicator and follower of already developed technologies. Here the opportunity is for the filling of niche markets that do not depend on volume of demand to be competitive. An example, may be the development of lithium ion batteries without the use of Cobalt in the cathode, depending on the availability difficulties of this mineral. Thus, the electric mobility model needs to define priorities for technological development and promote innovation either by established companies or by the creation of startups.

The differential of the electric mobility will be in the open technological opportunities that cannot dispense with policies of incentive for other type of vehicles like electric bicycles, motorcycles, skates, scooters, etc. The Brazilian auto parts industry is strong in Brazil and can benefit from the global model. It is necessary for Brazil to deepen technological development research for both components and for electric car architectures.

4. Conclusion

EV business models are still emerging and evolving, so they must respond to context changes (Wells & Nieuwenhuis, 2014). One example is the difficulties faced by the French Autolib, which despite having nearly 150,000 active users on its platform and being a relative on the streets of Paris, faces competition with other forms of mobility. The Paris local authorities thus ended the contract to operate the EV fleet due to the difficulties of the car-sharing scheme (Reuters, 2018). This fact shows that EV's business still presents high risks for the definition of stable and profitable business models, making it difficult to attract capital.

Brazil still does not have an electric mobility model based on the absence or low relevance of reasons that lead other countries to travel on the road to vehicular electrification. However, this article did a review of the main initiatives of the country in the search for electric mobility, however there is no established model, which leads to the lack of objectives and duplication of efforts. The initiatives were important, but they are still at a prototype technological maturity level that are far from a massive production of these products or components. The absence of a Brazilian model for electro mobility does not allow these cases of prototype success to advance at the level of mass production as already occurs in the Chinese model.

This article collaborates in the establishment of a Brazilian vehicle electrification model, establishing the main stakeholders of the process and proposing actions, mainly from the State, in the federal, state and municipal spheres, which can impact the process. Stakeholders must be incentivized by tax incentives or subsidies to overcome the inertia of the market, offering an infrastructure and stimulating consumption. Car manufacturers will offer vehicle models that the country determines.

However, for a national model to gain strength and establish itself as an incentive policy for electro mobility, it is necessary to create a governance of institutions with several federal ministries and organizations that should consider this issue as strategic for Brazil.

References

Amaral, G. L., Yazbek, C. L., & Olenike, J. E. (2018). *Frota Brasileira de Veículos em Circulação.* IBPT.

ANEEL. (19 de June de 2018). *ANEEL*. Fonte: ANEEL: http://www.aneel.gov.br/sala-de-imprensa/-/asset_publisher/zXQREz8EVlZ6/content/id/16794740

ANEEL. (2018). *Nota Técnica n°0251/2018-SPE/NAEEL de 19/11/2018.* ANEEL.

Auto Evolution. (25 de October de 2017). *Auto Evolution*. Fonte: Auto Evolution: https://www.autoevolution.com/news/singapore-bans-all-new-passenger-cars-in-2018-to-fight-congestion-121242.html

Baran, R., & Legey, L. F. (2011). Veículos Elétricos: história e perspectivas no Brasil. *BNDES Setorial, n.33*, 207-224.

Bloomberg. (2018, November 14). *Bloomberg*. Retrieved from Bloomberg: https://www.bloomberg.com/news/articles/2018-11-14/china-is-leading-the-world-to-an-electric-car-future

BNDES. (16 de October de 2018). *BNDES*. Fonte: Banco Nacional de Desenvolvimento Social: https://www.bndes.gov.br/wps/portal/site/home/imprensa/noticias/conteudo/bndes-aprova-r-6-7-milhoes-para-estacoes-de-recarga-de-veiculos-eletricos

BNDES. (16 de Outubro de 2018). *BNDES*. Fonte: BNDES: https://www.bndes.gov.br/wps/portal/site/home/imprensa/noticias/conteudo/bndes-aprova-r-6-7-milhoes-para-estacoes-de-recarga-de-veiculos-eletricos

BNDES. (2019). *BNDES*. Retrieved from BNDES: https://www.bndes.gov.br/wps/portal/site/home/financiamento/produto/fundo-clima-maquinas-equipamentos-eficientes

Brasil, ANP. (2018). *Relatório de Comércio Exterior - Superintendência de Distribuição Logística n°7.* Rio de Janeiro: Agência Nacional de Petróleo, Gás Natural e Biocombustíveis (ANP).

Brasil, CAMEX. (27 de October de 2015). *CAMEX*. Fonte: CAMEX: http://www.camex.gov.br/noticias-da-camex/262-camex-aprova-reducao-da-aliquota-do-imposto-de-importacao-para-carros-eletricos-e-movidos-a-celulas-de-combustivel

Brasil, CAMEX. (24 de March de 2016). *Camex*. Fonte: Camex: http://www.camex.gov.br/noticias/62-resolucoes-da-camex/em-vigor/1624-resolucao-n-27-de-24-de-marco-de-2016

Brasil, CNPEM. (2018). *Eletrificação de Veículos e o Futuro do Etanol Combustível no Brasil.* file:///C:/Users/usuario/Downloads/e2575070116ae1e4d52c29c803b5ae4d%20(1).pdf : Centro Nacional de Pesquisa em Energia e Materiais (CNPEM).

Brasil, Empresa de Pesquisa Energética (EPE). (2018). *Balanço Energético Nacional 2018: Ano Base 2017.* Rio de Janeiro: Ministério das Minas e Energia.

Brasil, IBAMA. (2018, Novembro 29). *IBAMA*. Retrieved from IBAMA: http://www.ibama.gov.br/noticias/436-2018/1782-conama-reduz-limites-de-emissao-de-poluentes-por-veiculos-novos-no-pais

Brasil, MCT. (2002). *Sistemas a Célula a Combustível Programa Brasileiro PROCaC CTBrasil.* http://livroaberto.ibict.br/bitstream/1/977/1/9804%20-%20Sistemas%20c%C3%A9lulas%20a%20combust%C3%ADvel%20programa%20brasileiro%20PROCaC.pdf, 31p.: Ministério da Ciência e Tecnologia (MCT).

Brasil, MCTIC. (2014). *Diretrizes Estratégicas para o Fundo Setorial de Energia CT-Energ.* file:///C:/Users/usuario/Downloads/Diretrizes-Estrategicas-CT-energ.pdf: Ministério da Ciência, Tecnologia, Inovações e Comunicações (MCTIC).

C40 Cities. (2017, October 23). *C40 Cities*. Retrieved from C40 Cities: https://www.c40.org/other/fossil-fuel-free-streets-declaration

CA.gov. (2019, February). *CA.gov. Zero-Emission Vehicles*. Retrieved from CA.gov.: http://www.cpuc.ca.gov/zev/

Câmara dos Deputados. (2017, Dezembro 7). *Câmara dos Deputados*. Retrieved from Câmara dos Deputados: https://www2.camara.leg.br/camaranoticias/noticias/TRANSPORTE-E-TRANSITO/550529-DEBATEDORES-DEFENDEM-REDUCAO-DE-IMPOSTOS-PARA-INCENTIVAR-A-COMPRA-DE-VEICULOS-ELETRICOS.html

Carvalho, C., & Lamas, W. (June de 2009). The use of hybrid vehicles as a proposal for reducing CO2 emissions and its contribution to reducing greenhouse gas emissions. *Engenharia Térmica (Thermal Engineering) Vol.8 n.01*, pp. 07-11.

Castro, B. H., & Ferreira, T. T. (2010). Veículos elétricos: aspectos básicos, perspectivas e oportunidades. *BNDES Setorial 32*, 267-310.

CEBDS. (2017). *Oportunidades e Desafios das Metas da NDC Brasileira para o Setor Empresarial.* Rio de Janeiro: Conselho Empresarial Brasileiro para o Desenvolvimento Sustentável (CEBDS).

CEDV. (2019). *Centro de Desenvolvimento em Energia e Veículos*. Fonte: CEDV PUC-Rio: https://www.cdev.com.br/

Chargehub. (24 de January de 2019). *Chargehub*. Fonte: Chargehub: https://chargehub.com/en/

Chum, H. (2002). *Programa Brasileiro de Células a Combustível Proposta.* https://finep.gov.br/images/a-finep/fontes-de-orcamento/fundos-setoriais/ct-energ/programa-brasileiro-de-celulas-a-combustivel.pdf, Brasília: Centro de Gestão e Estudos Estratégicos (CGEE).

CNN Business. (2017, September 11). *CNN Business*. Retrieved from CNN Business: https://money.cnn.com/2017/09/11/autos/countries-banning-diesel-gas-cars/?iid=EL

Consoni, F. L., Oliveira, A. d., Barassa, E., Martínez, J., Marques, M. d., & Bermúdez, T. (2018). *Promob-e. Estudo de Governança e Políticas Públicas para Veículos Elétricos.* Brasília: GIZ e MDIC.

COPPE/UFRJ. (2017). *COPPE, UFRJ*. Retrieved from COPPE: http://www.coppe.ufrj.br/pt-br/a-coppe/coppe-produtos/onibus-hibrido-a-hidrogenio

CPqD. (2014). *CPqD*. Fonte: CPqD: https://www.cpqd.com.br/inovacao/armazenamento-de-energia/

Delgado, F., Costa, J. E., Febraro, J., & Silva, T. B. (2017). *Cadernos FGV Energia Carros Elétricos Ano 4 n°7.* FGV Energia.

Engel, H., Hensley, R., Knupfer, S., & Sahdev, S. (2018). *Charging ahead: electric-vehicle infrastruture demand.* McKinsey & Company.

Finep. (07 de January de 2014). *Finep*. Fonte: Edital de seleção pública conjunta ANEEL/BNDES/FINEP de apoio à inovação tecnológica no setor elétrico - Inova Energia - 01/2013: http://www.finep.gov.br/chamadas-publicas/chamadapublica/547

Franke, T., Günther, M., Tratow, M., & Krems, J. F. (2017, July 4). Does this range suit me? Range satisfaction of battery electric vehicle users. *Applied Ergonomics 65*, pp. 191-199.

IBAMA. (2011, April 18). *Programa de Controle da Poluição do Ar por Veículos Automotores.* https://www.ibama.gov.br/phocadownload/veiculosautomotores/manual_proconve%20promot_portugues.pdf: IBAMA. Retrieved from IBAMA.

INMETRO. (2019). *Programa Brasileiro de Etiquetagem (PBE).* http://www.inmetro.gov.br/consumidor/pbe/veiculos_leves_2019.pdf: Inmetro.

Instituto de Energia e Meio Ambiente. (2014). *1° Diagnóstico da rede de monitoramento da qualidade do ar no Brasil.* http://www.forumclima.pr.gov.br/arquivos/File/Rosana/Diagnostico_Qualidade_do_Ar_Versao_Final_Std.pdf: Instituto de energia e Meio Ambiente.

Itaipu Binacional. (20 de Janeiro de 2017). *Itaipu Binacional*. Fonte: Itaipu Binacional: https://jie.itaipu.gov.br/conte%C3%BAdo/bateria-de-s%C3%B3dio-pode-ganhar-selo-de-produto-estrat%C3%A9gico-de-defesa

Itaipu Binacional. (2017). *Itaipu Binacional*. Fonte: Itaipu Binacional: https://www.itaipu.gov.br/tecnologia/veiculos-eletricos

Masiero, G., & Lopes, H. (2008). Etanol e biodiesel como recursos energéticos alternativos: perspectivas da América Latina e Ásia. *Revista Brasileira de Política Internacional 51 (2)*, pp. 60-79.

MDIC. (2017). *Ministério da Indústria, Comércio Exterior e Serviços (MDIC)*. Fonte: Ministério da Indústria, Comércio Exterior e Serviços (MDIC): http://inovarauto.mdic.gov.br/InovarAuto/public/login.jspx?_adf.ctrl-state=m02boj6x5_9

Notice EPA. (April 13, 2018). *Mid-Term Evaluation of Greenhouse Gas Emissions Standards for Model Year 2022–2025 Light-Duty Vehicles .* https://www.govinfo.gov/content/pkg/FR-2018-04-13/pdf/2018-07364.pdf: US Federal Register.

Pascoal, E., Delamaro, M., Ibusuki, U., Tsukada, O., & Rocha, H. (2017). The new Brazilian automotive policy and its impact on the competitiveness of multinational automobile and auto parts manufacturers. *International Journal of Automotive Technology and Management, Vol.17, n.3*, pp. 225-247.

Portal da Transparência. (28 de julho de 2015). *Portal da Transparência, SIAFI 667503 N° 2101/10*. Fonte: Portal da Transparência: http://www.portaldatransparencia.gov.br/convenios/667503?ordenarPor=data&direcao=desc

Reuters. (21 de June de 2018). *Reuters*. Fonte: Reuters: https://www.reuters.com/article/us-france-autos-autolib/paris-ends-autolib-electric-car-sharing-contract-with-bollore-idUSKBN1JH2CM

Vaz, L. F., Barros, D., & Castro, B. (2015, March). Veículos híbridos e elétricos: sugestões de políticas públicas para o segmento. *BNDES Setorial Automotivo 41*, 295-344.

Viswanathan, S., Appel, J., Chang, L., Man, I., Saba, R., & Gamel, A. (2 de March de 2018). Development of an assessement model for prediction public electric vehicle charging stations. *European Transport Research Review. https://doi.org/10.1186/s12544-018-0322-8.*, pp. 1-15.

Wells, P., & Nieuwenhuis, P. (2014, December 28). EV Business Models in a wider context: balancing change and continuity in the automotive industry. *Electric Vehicle Business Models*, pp. 3-16.

Woodjack, J., Gara, D., Lentz, A., Turrentine, T., Tal, G., & Nicholas, M. (2012, January 1). Learning about electric vehicle range: findings from UC Davis MINI E consumer study. *Transportation Research Record 2287(1).https://doi.org/10.3141/2287-01*, pp. 1-8.

Wu, G., Inderbitzin, A., & Bening, C. (14 de February de 2015). Total cost of ownership of electric vehicles compared to conventional vehicles: A probabilistic analysis and projection across market segments. *Energy Policy*, pp. 197-214.

Wu, Y., Zhang, S., Hao, J., Liu, H., Wu, X., Hu, J., . . . Stevanovic, S. (14 de October de 2016). On-road vehicle emissions and their control in China: a review and outlook. *Science of the total environment 574 (2017)* , pp. 332-349.

Zhang, X., Bai, X., & Shang, J. (30 de April de 2018). Is subsidized electric vehicles adoption sustainable: consumer's perceptions and motivation toward incentive policies, environmental benefits, and risks. *Journal of Cleaner Production*, pp. 71-79.