Researching Electromobility in Brazil: Elements for Building a National Policy

Sérgio Roberto Knorr Velho
Mechatronics Systems Postgraduation Program
Technology College (FT) - University of Brasília
Brasília, DF 70910-900, Brazil
knorrtec@gmail.com, sergio.velho@mctic.gov.br

Sanderson César Macêdo Barbalho
Mechatronics Systems Postgraduation Program
Technology College (FT) - University of Brasília
Brasília, DF 70910-900, Brazil
sandersoncesar@unb.br

Cláudio Albuquerque Frate
Mechanical Engineering Department
Technology College (FT) - University of Brasília
Brasília, DF 70910-900, Brazil
claudiofrate@unb.br

Abstract

Brazil does not present the impulses and motivations that led other countries to establish policies for electromobility, as there are other peculiarities in its energy matrix that disperse efforts towards vehicular electrification. This article presents a documental analysis of the main policy instruments for mobility, the main stakeholders, and some propositions, mainly from the State, in the federal, state and municipal spheres, that can impact the process. This analysis allows to build a framework which was taken as basis for a research protocol under a Q-method, which combines qualitative and quantitative techniques, to describe and analyze subjectivity among Brazilians key specialists regarding their views on opportunities and treats to electromobility in the country. The purpose is to propose a Brazilian electromobility policy model. This article presents the first steps into this effort.

Keywords
Electric vehicles, electromobility, policy, Q-method, model.

1. Introduction
The impulses and motivations that lead the 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 of actions both public and private partnerships in the electromobility aspect. The country has other characteristics in its energy matrix that are insufficient to boost the motivations of adopting EV. The vision for the adoption of EV should be strategic, since the Brazilian situation is contextualized in a potential position, justifying the adoption of EV by its potential to open paths and not to correct deficiencies generated using fossil energies or their economic and social unfolding.

Therefore, unlike the experiences of electromobility of other countries, Brazil is not relevant in this 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 et al. 2018). The rate of motorization is still in exponential growth with about 36.3 vehicles per 100 inhabitants. Meanwhile, the country had in 2015 a fleet of only 2,5 thousand electric and hybrid cars (Delgado et al. 2017). But it is increasing fast with new

11.858 licensed EV in 2019 (Anfavea 2019). 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 electromobility (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 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).

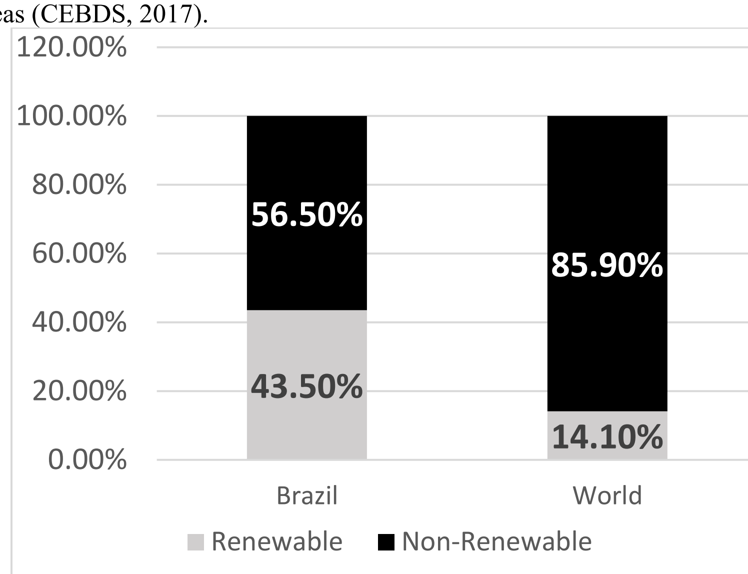

Figure 1: The Brazilian energy matrix is more renewable than the global. Source: Brasil, EPE 2018.

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).
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 limits 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 (internal combustion engines vehicles, ICE), 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) In the last five years alone, at least 84 countries, which account for 90% of world GDP, have announced industrial policy or adopted explicit political plans for industrial development (Almeida and Cagnin 2019). However, the constant instabilities of the Brazilian macroeconomic environment restrict medium and long-term policy actions by imposing budgets constraints. But this should be an opportunity to 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 electromobility. In Brazil, the EV can become an important alternative, if it adopts, in the short term, a policy to encourage its use (Baran and Legey 2011).

However, 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 strong identified motivation, Brazil does not present policies that lead to actions and goals of electromobility. 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 by 2030 (Câmara dos Deputados 2017). This framework was taken as basis for a research protocol under a Q-method, which combines qualitative and quantitative techniques, to describe and analyze subjectivity among Brazilians key specialists regarding their views on opportunities and treats to electromobility. The first steps are presented here.

2. Bibliographic Review

The transportation sector is expected to provide one of the largest contributions to the reduction of greenhouse gas (GHG) emissions according to scenarios supporting policymaking (IEA 2016; Slowik et al. 2018). Environmental policies, to reduce these emissions and diversify energy sources, often promote the use of alternative fuels (including electricity). In order to quantify possible GHG and energy savings, policy makers need to consider shared scientific methodologies allowing comparisons among “cleaner” (with a lower carbon intensity) and conventional technologies.

Ahmadi (2019) presents a comprehensive lifecycle emission and cost comparison among electric vehicles. Hybrid electric vehicles (HEV), plug in hybrid electric vehicles (PHEV), full battery electric vehicles (BEV), hydrogen fuel cell electric vehicles (FCEV) are compared with gasoline vehicle (ICE) as the base case. Moro and Lonza (2017) make some examples of calculation of GHG emissions from the use of electric vehicles (EVs) compared to ICE vehicles. These calculations are provided to all EU Members States.

From this framework it is important novel business case to support the efforts from cities and countries. So, Nian, Hari, and Yuan (2018) propose a new business model for promoting EVs in cities without policy support taking into consideration the different interests among vehicle dealers, buyers, and the government in the life cycle of vehicle ownership using Singapore’s market situation as an example. In this study, a new business model conceived through a dealer-buyer cost sharing scheme along the lines of a post-paid mobile device purchase arrangement practiced by the telecommunication industry to alleviate EV’s cost disadvantages. They further test the viability of the proposed business model using a worse-case market environment (scenario) for EV deployment.

But now, subsidies policies are less effective and financial incentive will be abrogated in the future, such as intend by governments of China, America and Germany. Then different policies as communication and marketing strategies, and traffic regulation policy may become an important driving force for development of EV (Benvenutti et al. 2017; Wang et al. 2018).

Because inadequate driving range, or ‘range anxiety’, is reported as key technological barrier to customers purchase EV, Napoli et al. (2019) propose a methodology to optimal locations of electric vehicle infrastructures in a highway. The goal is to estimate the basic number of charging stations and determine their correct allocation on the road network by analyzing the supply and demand and considering the psychological component of the driver, or the ‘range anxiety’. It’s worth mentioning that high density charging infrastructure network can effectively solve it and influence the EV adoption by customers (Wang et al. 2018).

Besides driving range and infrastructure, important to customers is the vehicle base price and fuel (energy) price. Then, another factor influencing EV adoption is technology. So, from a technological perspective, Cano et al. (2018) provide a comprehensive evaluation of various batteries and hydrogen fuel cells that have the greatest potential to succeed in commercial applications. Showing that technology needs to evaluate in batteries, even in Li-ion batteries.

Nykvist and Nilsson (2015) show the cost of Li-ion battery packs used by market-leading BEV manufacturers has declined by 8% annually. Even so, Cano et al. (2018) review's discuss that Lithium–Sulfur batteries could completely replace Li-ion batteries to enhance the long-range and low-cost EV markets, while Zn–air and Li–air batteries could serve as range-extenders to succeed in these sectors as well. Finally, fast-refueling and grid-compatible hydrogen fuel cells are a natural fit for high-utilization transportation, while the high specific energy and energy density of hydrogen also make them attractive for long-range consumer EVs.

Thus, Brazil is far behind electromobility country leaders. Silva et al. (2018) tried to answer how energy prices and subsidies accelerate the integration of electric vehicles in Brazil. They consider only a set of integrated policies that include subsidies as, full exemption from annual tax payment, a reduction in the investment cost and in price of electricity for EV owners can accelerate the integration of such vehicles in Brazilian cities. Benvenutti et al. (2017) investigate the impact of government policies on the long-term diffusion of Alternative Fuel Vehicles (AFV) in Brazil. In order to do so, they developed a System Dynamics (SD) model, based on the Generalized Bass Diffusion model with price as external variable. It conducts several simulation experiments by testing four policies and the best result indicates that even a highly aggressive policy would take a very long time to produce a relatively large AFV installed base.

That shows further research is needed to combine qualitative and quantitative techniques, to describe and analyze subjectivity among Brazilians key specialists regarding their views on opportunities and treats to electromobility in the country. Our contribution starts with a documental analysis, once a general framework must be needed for gathering, processing and analyzing data from a set of sources from a series of stakeholders in the area.

3. Methodology

As followed, we made a documental analysis in the Brazilian reports and policies from official government reports and regimentations to set the present situation of EV policies. Content analysis makes up a set of methodological tools that can be used for very diverse discourses (content). The researcher uses a tool capable of reducing the subjective character of the discourse analysis work. Content analysis allows an increase in the productivity of the study in each text, as it provides techniques for lexical analysis, evaluations, discourse, phraseology, etc. that surround the analyzed communication of data that allow precise inferences regarding its theoretical interest.

According to Bardin (1979, apud Barbalho, 2006, p.83) the most well-known aspect of document analysis is the so-called "categorial", according to which the researcher uses a series of indexes to describe the analyzed communication. Thus, inferences are made in order to interpret the sociological structures of the statements emphasizing their meaning. The categorical analysis is eminently qualitative, but it can present structural subdivisions of the absence or presence type or intensity scales (Barbalho and Rozenfeld, 2013).

The following work will employ the Q-method, which combines qualitative and quantitative techniques (Frate et al. 2019), to describe and analyze subjectivity among Brazilians key specialists regarding their views on opportunities and treats to electromobility in the country. The general protocol of this method begins by defining a question to ask specialists. We defined the question: "What are the key issues involved opportunities and treats of electromobility in Brazil?". Interviews are then planned and executed according specific rules the method suggests (Frate, 2011). The interview is transcript to identify statements based on balance among respondents and wide spectrum of views and opinions. These statements relied on criteria of relevance, frequency, and similarities. We then create a concourse of statements from semi-structured interviews regarding electromobility opportunities and treats in Brazil under que question asked to interviewees.

Then, this scoring process arrived in a reduction of statements for the Q-set. After that we will group it into some categories of opportunities and treats for electromobility.

In this phase, we analyzed the documents here reported, we defined our research question and made our first interview to try our research protocol. The document search and analysis and this first interview are reported here.

The next phase of Q-method involved the correlation and factor analysis using dedicated freeware to determine the correlation matrix, extract and rotate significant factors, and calculate statement z-scores for each factor. In the last phase of Q-method we interpret factors accompanied by a validation phase with the interviewers.

4. Results

4.1. Electromobility in Brazil – results from documental analysis

According to Consoni et al. (2018), there is no strategic planning at the Brazilian federal government level to guide public policies for electromobility. 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 2030 - Mobility and Logistics Program (Law n°13.755/2018) – Rota 2030
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: Normatizations 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).

4.1.1. 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).

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 (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 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. (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, invest 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. (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 et al. 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:

- increase in energy efficiency, structural performance and the availability of assistive technologies in the direction of vehicles commercialized in Brazil.
- increase investments in research, development and innovation in the country.
- stimulation of the production of new technologies and innovations, according to the global technological trends.
- increase the productivity of industries for mobility and logistics.
- promotion of the use of biofuels and alternative forms of propulsion and valorization of the Brazilian energy matrix.
- guarantee of technical training and professional qualification in the mobility and logistics sector; and
- 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.

4.1.2. 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.

The Brazilian System of Technology Network (Sibratec) Technologies Innovation Centers for Electric Vehicles was established by Finep in 2011 to promote the use of fuel cells into urban EVs (Portal da Transparência, 2015).

The CT-Energ Sectoral Fund, 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. (Brasil, MCTIC, 2014).

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

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). (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. (CPqD, 2014).

In 2018, the National Bank for Economic and Social Development (BNDES) approved the support for projects of electric vehicle recharge networks. 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 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 lack for a model on electromobility in Brazil.

4.1.3. Infrastructure

There is a limitation in public policy initiatives in providing the infrastructure for electric vehicles such as recharge vehicles. 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, (Finep, 2014).
In 2018, as already shown, BNDES and Brazilian Industrial Research and Innovation Company (Embrapii) finance two projects with Fundation CPqD, PHB Eletrônica Ltda, Fundation CERTI and WEG, to execute a project in electric cars charging stations (BNDES, 2018). The result of these charging stations can be seen on Figure 2,

Figure 2: Charging station to EV. Source: Authors

4.1.4. 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 et al. 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.

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 et al. 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 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.

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).

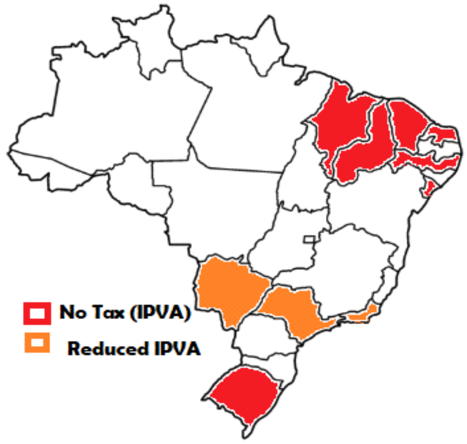

Figure 3: Brazilian states with tax exemption or with differentiated rates. Source: Authors.

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

4.2. Electromobility in Brazil – results from specialist´s interview

The first expert concourse revealed nine statements that inaugurate the ongoing research. Among these statements, five refer to the governmental absence of a national strategy for electromobility, ranging from the lack of an electromobility policy, the lack of a roadmap for the expansion of the EV fleet, the difficulty of political coordination between sectors (oil and gas, alcohol, mineral, etc.) and the absence of tax incentives and subsidies for technological diffusion. One of the statements points to the difficulty of a productive matrix of mineral products for the current technology of Li-ion batteries (Li-ion).

On the other hand, a single statement points to advantages, which is the existence of a national automobile industrial park already consolidated and which represents a differential for the diffusion of electromobility. Two other statements point to investment in research and development as a facilitator and the need for digital platforms to iterate with the user to facilitate the location of charging stations. These last statements indicate the need for the existence of an infrastructure and applications that facilitate the life of the EV user.

5. Discussion

Countries like Brazil need to leapfrog strategies, if they want to join the leading countries in electromobility. The main motivation of countries is to reduce GHG emissions and to be part of global efforts such as the Paris Agreement. The country is one of the emerging countries in the biotechnology sector for agriculture (Niosi et al. 2018) and has a “clean” energy matrix (EPE, 2018). These are important attributes to boost motivation for electromobility, once the transport sector is expected to provide a great contribution to reduction in GHG emissions (Slowik et al. 2018).

Countries must establish their own strategies according to their energy matrix, infrastructure and industrial production chain and not just follow the strategies of the leading countries. Benvenutti et. al (2017) and Wang et al (2018) report that subsidy policies are less effective and are being abrogated by several leading countries. Therefore, marketing strategies and traffic regulations should be used, such as the restriction of the circulation of ICE vehicles in large urban centers. The city of São Paulo already applies this concept, having no restrictions on the circulation of EVs.

These national strategies must be supported by business models that promote electromobility so as not to burden the State with the costs of its implementation. Thus, Nian et al (2018) proposes a new way of sharing the costs of the initial capital investment of the EV. States must be efficient in applying their resources and, whenever business models for private initiative participation are well structured, this facilitates the promotion of public policies and does not compromise the state budget.

Technological advances are still under construction, such as battery and fuel cell technology, as they impact the base price of vehicles. Thus, as demonstrated in Nykvist and Nilsson (2018) and Cano et al. (2018), battery costs have been declining, but there are technical and economic barriers to be overcome to determine the next generation of batteries. This allows non-leading countries to still bet on innovative and disruptive technologies and occupy global niches in electromobility.

Finally, electromobility strategies involve several aspects such as the high electricity prices in Brazil, due to the tax burden. Researchers as Silva et al. (2018) discusses energy prices and subsidies to facilitate EVs adoption in Brazil.

The proposal of the ongoing research tries to raise these and other aspects of the opportunities and threats of electromobility through the opinion of key Brazilian experts. The research seeks to describe and analyze these opinions using the Q method combining qualitative and quantitative techniques.

6. Conclusions

In conclusion, the purchase of BEV in Brazil is difficult given the payback period of purchasing, the electricity price, (Silva et al. 2018), the current number of fuelling stations and infrastruture (Benvenutti et al. 2017) and the lack of electromobility policies beyond subisidies (Consoni et al. 2018).

Thus, this article presents a review of the main policy instruments for electromobility and some initiatives, mainly from the State, in the federal, state and municipal spheres, that should impact the process. Brazil State eagers develop a electromobility business model. It might come from a future research protocol under a Q-method, which combines qualitative and quantitative techniques, to describe and analyze subjectivity among Brazilians key specialists regarding their views on opportunities and treats to electromobility in Brazil. The purpose is to propose a Brazilian electromobility policy model. This article presents the first steps into this effort.

References

Ahmadi, P. (2019, July 10). Environmental impacts and behavioral drivers of deep decarbonization for transportation through electric vehicles. *Journal of Cleaner Production. Vol. 225.*, pp. 1209-1219.

Almeida, J. C., & Cagnin, R. F. (2019). *A Indústria do Futuro no Brasil e no Mundo.* IEDI.

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

Anfavea. (2019). *Estatísticas.* http://anfavea.com.br/estatisticas-copiar-2.html: Anfavea.

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

Barbalho, S. C. (2006, Maio). Modelo de Referência para o desenvolvimento de produtos mecatrônicos: proposta e aplicações. *Tese de Doutorado - Escola de Engenharia da Universidade de São Paulo*. São Carlos, SP, Brasil: USP.

Barbalho, S. C., & Rozenfeld, H. (2013). Modelo de referência para o processo de desenvolvimento de produtos mecatrônicos (MRM): Validação e resultados de uso. *Gestão da Produção, v.20, n.1*, pp. 162-179.

Benvenutti, L. M., Ribeiro, A. B., & Uriona, M. (2017, July 7). Long term diffusion dynamics os alternative fuel vehicles in Brazil. *Journal of Cleaner Production*, pp. 1571-1585.

BNDES. (2018, October 16). *BNDES*. Retrieved from 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. (2018, Outubro 16). *BNDES*. Retrieved from 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, 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).

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

Cano, Z. P., Banham, D., Ye, S., Hintennach, A., Lu, J., Fowler, M., & Chen, Z. (2018, April). Batteries and fuel cells for emerging electric vehicle markets. *Nature Energy. Vol. 3,* , pp. 279-289.

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).

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).

CNPEM. (2018). *Eletrificação de Veículos e o Futuro do Etanol Combustível no Brasil.* https://unica.com.br/wp-content/uploads/2019/06/Eletrificacao-de-Veiculos-eo-Futuro-do-Etanol-Combustivel-no-Brasil.pdf: CNPEM.

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.

CPqD. (2014). *CPqD*. Retrieved from 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.

Finep. (2014, January 07). *Finep*. Retrieved from 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

Frate, C. A. (2011, Agosto). Etanol e sustentabilidade: avaliação sistêmica de segurança alimentar e nutricional. *Tese de Doutorado - Política e Gestão Ambiental*. Brasília, DF, Brasil: Universidade de Brasília, UnB.

Frate, C. A., Brannstrom, C., Morias, M. V., & Caldeira-Pires, A. d. (2019, May 17). Procedural and distributive justice inform subjectivity regarding wind power: A case from Rio Grande do Norte, Brazil. *Energy Policy*, pp. 185-195.

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.

IEA. (2016). *Energy Technology Perspectives 2016.* Paris, pp.2016: International Energy Agency (IEA).

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. (2017, Janeiro 20). *Itaipu Binacional*. Retrieved from 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*. Retrieved from Itaipu Binacional: https://www.itaipu.gov.br/tecnologia/veiculos-eletricos

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

Napoli, G., Polimeni, A., Micari, S., Andaloro, L., & Antonucci, V. (2019, November 20). Optimal allocation of electric veihicle charging stations in a highway network: Part 1. Methodology and test application. *Journal of Energy Storage*, p. pp.9.

Nian, V., Hari, M., & Yuan, J. (2018, November 19). A new business model for encouraging the adoption of electric vechicles in the absence of policy support. *Applied Energy*, pp. 1106-1117.

Niosi, J., Hanel, P., & Reid, S. (2012, September). The international diffusion of biotechnology: The arrival of developing countries. *Journal of Evolutionary Economics. V.23. Issue 4.*, pp. 767-783.

Nykvist, B., & Nilsson, M. (2015, March 23). Rapidly falling costs of battery packs for electric vehicles. *Nature Climate Change*, pp. 329-332.

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

Silva, R. E., Sobrinho, P. M., & Souza, T. M. (2018, April 25). How can energy prices and subsidies accelerate the integration of electric vehicles in Brazil? An economic analysis. *The Electricity Journal. v.31*, pp. 16-22.

Slowik, P., Araujo, C., Dallmann, T., & Façanha, C. (2018). *Avaliação Internacional de Políticas Públicas para Eletromobilidade em Frotas Urbanas.* Brasília: Brasil, MDIC and GIZ.

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.

Wang, N., Tang, L., & Pan, H. (2018, November 02). A global comparison and assessment of incentive policy on electric vehicle promotion. *Sustainable Cities and Society*, pp. 597-603.

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

Biographies

Sérgio R. Knorr Velho holds a Master's degree in Engineering (PPGE3M/UFRGS, 2016), a degree in Chemical Engineering from the Pontifical Catholic University of Rio Grande do Sul (PUCRS, 1991) and a degree in Accounting Sciences from the Federal University of Rio Grande do Sul (UFRGS, 1987), specialist in Production Administration and in Occupational Safety Engineering. Doctoral student at the Mechatronics Systems Postgraduate Program in the University of Brasília (PPMEC/UnB). He is a science and technology analyst working at the Brazilian Ministry of Science, Technology, Innovation and Communications (MCTIC).

Sanderson C. M. Barbalho has a degree in Electrical Engineering from the Federal University of Rio Grande do Norte (1993), a master's degree in Mechanical Engineering from the Federal University of Rio Grande do Norte (1997) and a doctorate in Mechanical Engineering from the University of São Paulo (2006), both master's and PhD, developed in the area of Production Engineering. He is a professional in project management with a PMP (Project Management Professional) certificate, by the Project Management Institute (PMI). He is currently an adjunct professor in the Department of Production Engineering at the University of Brasília and ex-Director of the Technological Development Center (CDT) at UnB. He worked between January 2003 and January 2008 as a senior development engineer and project manager, and between January 2008 and August 2012 as Project Manager at OPTO ELETRÔNICA SA He has experience in the areas of Electronic Engineering, Manufacturing Processes, Production Management and Product Development.

Cláudio A. Frate is an associate researcher at the University of Brasília - UnB, investigates the nexus of the # Food-Water-Energy # production chains. Power Systems Electrical Engineer from the University of Fortaleza, Master and Doctor in Sustainable Development from the University of Brasília (CDS / UnB), he did a post-doctoral internship at Geosciences College of Texas Agriculture and Mechanical (Texas A & M / USA). Visiting Professor at the University of Brasília (UnB / Brazil) taught the disciplines of: Energy economics, Biofuels and Energy systems. He participated in dozens of research projects in the area of energy, environment and society and from them he published in several national and international journals where he is also a reviewer.