

DIFFUSION OF ELECTRIC VEHICLES IN BRAZIL: CHALLENGES AND INCENTIVE POLICIES

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Introduction

The concern about the climate effects of CO₂ emissions, which comes largely from the transport sector, has motivated the search for less polluting alternatives in this sector. The introduction of electric vehicles is one of the ways to reduce CO₂ emissions from the transport sector. In addition, the diffusion of electric vehicles could help to achieve other objectives, such as the reduction of oil dependence in importing countries, the reduction of noise in urban areas, as these vehicles have quiet operation, and improved air quality.

Brazil has specific characteristics that should influence the way in which electric vehicles will be introduced. The high share of biofuels makes the issue of emissions less relevant. The high cost of batteries makes it difficult to adopt these vehicles in low-income countries, which implies a concentration of the fleet in low value cars.

The lack of recharging infrastructure is also a challenge in a country with continental dimensions. Thus, public policies play an important role in encouraging the adoption of electric vehicles. These policies can be effective in the dissemination of these in the Brazilian market, considering the international experience and the characteristics of this sector in Brazil.

Methodology

In order to analyze the challenges in the diffusion of electric vehicles in the Brazilian market, we revised the literature on electric cars, about experiences with the introduction of these vehicles in others countries and on the Brazilian specificities regarding the diffusion of alternative automotive technologies, specifically ethanol.

The indirect network effects approach was also used because of the interdependence between the adoption of electric vehicles and the investment in charging stations. Users have advantages with the expansion of the network and it can even reduce the issue of range anxiety, that is the concern about the existence of properly distributed charging stations. In addition, the product life cycle approach was also used to analyze the diffusion of electric vehicles in the world, considering that electric vehicles are in the introductory stage of life cycle.

In order to evaluate the attractiveness of the acquisition of an electric vehicle in Brazil, we made a feasibility study, comparing an electric, hybrid and a flex-fuel vehicle acquisition. It is important to note that attractiveness is not limited to financial elements. Therefore, we also evaluate the need for recharging infrastructure in Brazil.

The Brazilian Experience

Ethanol and Flex-Fuel Cars

After the oil crisis, Brazil adopted in 1975 the National Ethanol Program called *Pró-Álcool*. The Fiat 147 was the first ethanol car in Brazil in 1979. The Brazilian state was very interventionist and adopted protectionist measures against imports and ethanol cars were successful. In 1986, the price of the barrel of oil in the international market reduced, which hampered the programs of substitution of fossil energy. In 1990, since cheap oil made it unfeasible to keep subsidies on fuel ethanol, the *Pro-Álcool* program was discontinued.

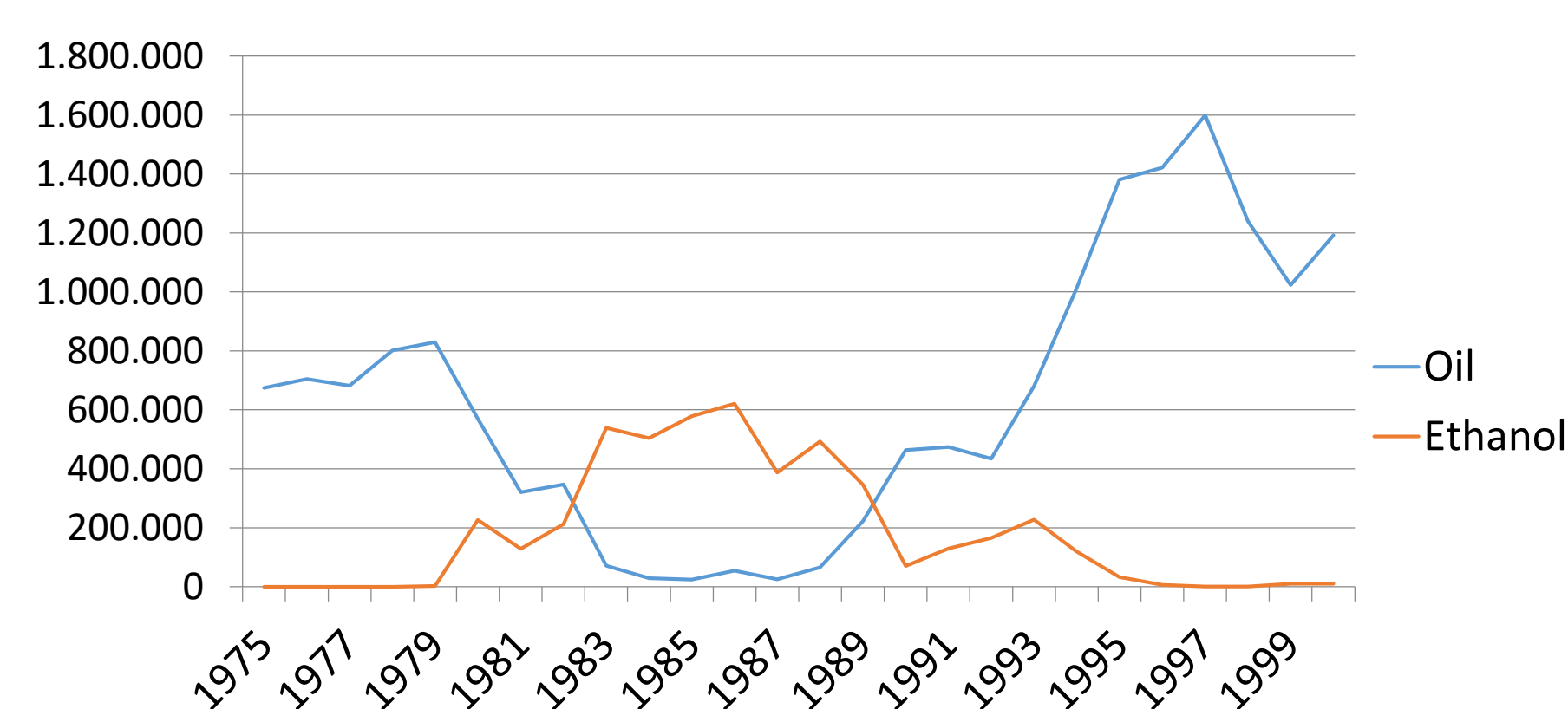


Figure 1- Diffusion of Ethanol Cars
(Own elaboration based on ANFAVEA , 2018).

Regarding the flex-fuel cars, this diffusion was facilitated by two factors. The Brazilian market has the characteristic of adding ethanol to gasoline, which generates the need for mechanical adjustments of the engines. Thus, Brazil already had adapted car engines. In addition, the country already had an ethanol distribution and marketing infrastructure. Therefore, the flex fuel car did not face difficulties to gain the largest market share. In March 2003, Volkswagen started selling Gol 1.6, the first flex fuel car in Brazil.

It is important to note that there is a difference between the diffusion of ethanol and flex-fuel cars and electric vehicles. Ethanol and flex-fuel cars use the same supply infrastructure, which is not the case of plug-in electric vehicles that need a recharging infrastructure that does not exist.

Brazilian Electric Matrix

The integration between electric vehicles and renewable sources have to be a focal point of the incentive policies and the Brazilian electric matrix can contribute to this integration.

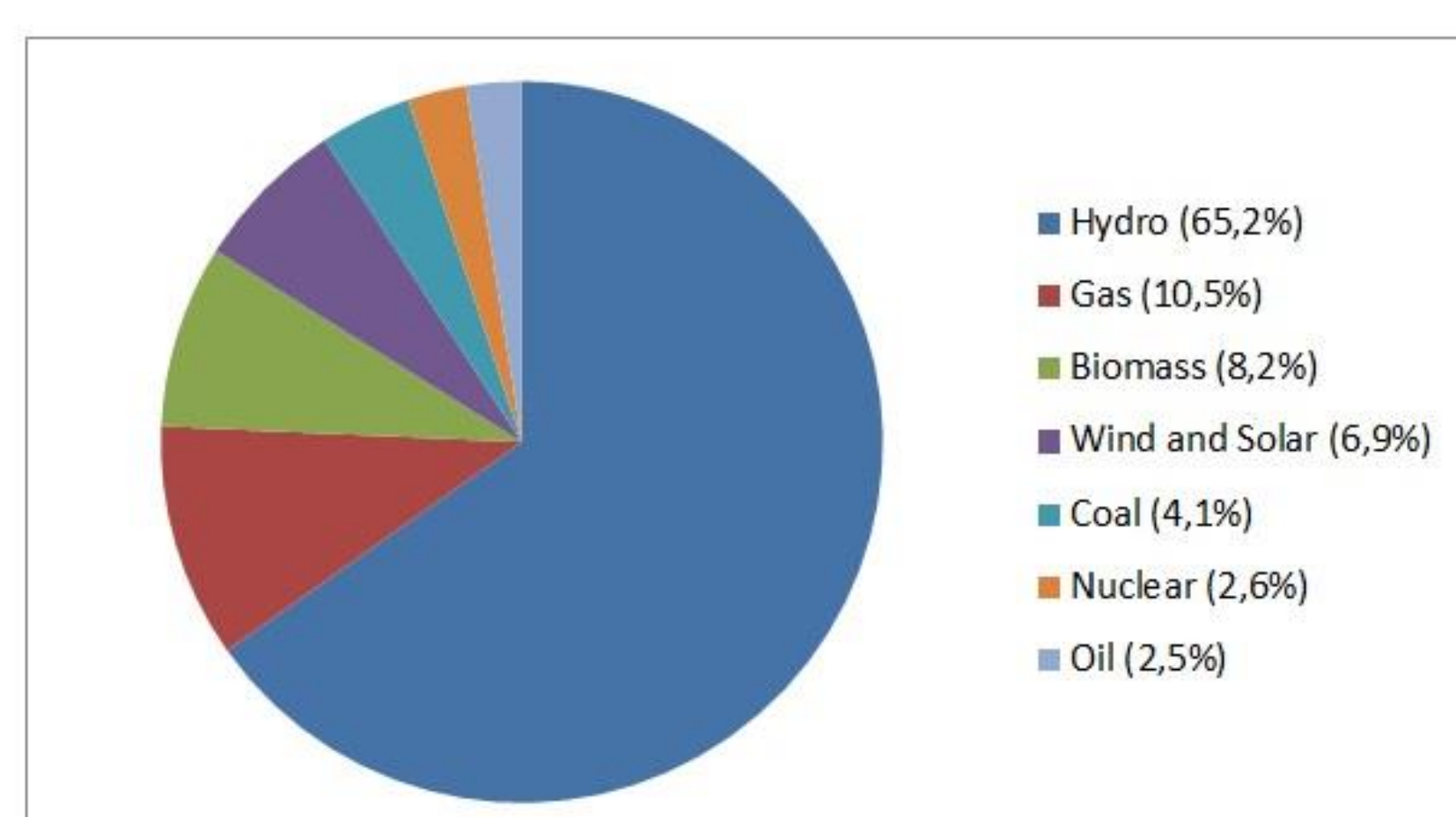


Figure 2 - Brazilian Electric Matrix 2017
(BEN , 2018).

Incentive Policies in Brazil

Regarding the incentive policies in Brazil, it is important to note that the policies are incipient.

In 2015, the government implemented an import subsidy equivalent to 100% Import Duty exemption for fully electric models with a range of at least 80 kilometers.

In addition, *Rota 2030* is a program established in 2018 that has as one of the objectives the incentive to the production of electric and hybrid vehicles and the increase of the safety of the automobiles. In this way, an increase in the supply of electric cars in Brazil is expected.

Moreover, in October 2018, the National Bank for Economic and Social Development (BNDES) approved support of R \$ 3.4 million and R \$ 3.3 million for two projects of recharge networks for electric vehicles. The funds will come from BNDES Funtec, a non-refundable fund focused on applied research, technological development and innovation projects.

Electric Vehicles in Brazil

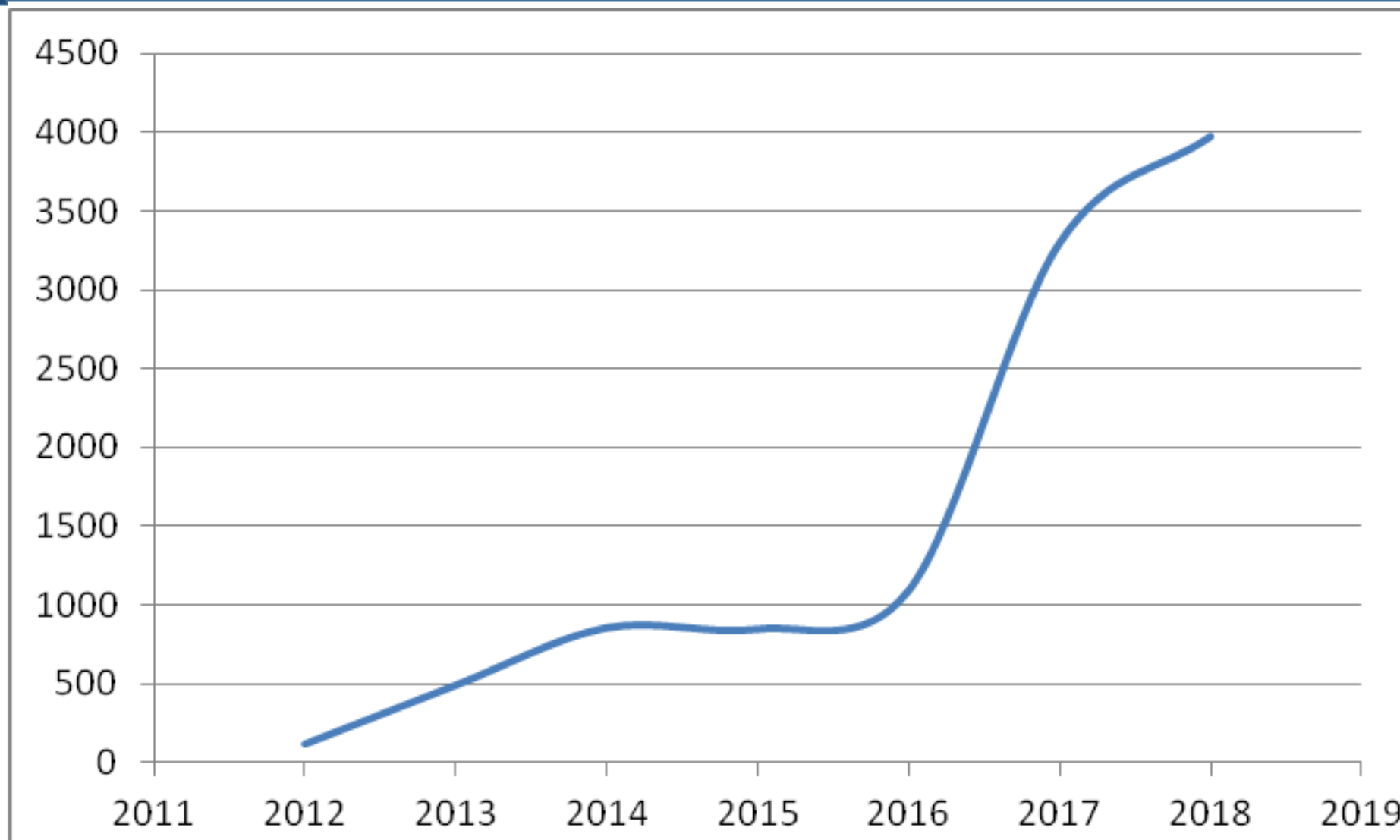


Figure 3 - Sales of Electric Vehicles in Brazil
(ANFAVEA , 2018).

Type of Fuel	Number of Vehicles	Market Share
Gasoline	81,932	3,31 %
Electric	3,970	0,16 %
Flex Fuel	2,168,176	87,59 %
Diesel	221,278	8,94 %

Total licensing of cars by fuel in 2018
(ANFAVEA, 2019).

Electric Vehicles in Brazil

In the feasibility study, we compared in a cash flow a Toyota Corolla 1.8 Gli with a Toyota Prius (hybrid) and with a Nissan Leaf (electric car). We assume that the consumer lives in Rio de Janeiro and drives 15,000 kilometers per year in the city. From INMETRO and U.S. Department of Energy data on energy consumption, we consider a consumer who buys his vehicle, drives 15,000 kilometers per year and resells after four years

Vehicle	Toyota Corolla	Toyota Prius	Nissan Leaf
Purchase Price	R\$ 90.900,00	R\$ 125.450,00	R\$ 180.000,00
Fuel Supply - Cidade (km/l)	11,4	18,9	53,14
Fuel Supply - Estrada (km/l)	13,2	17	42,51
Resale Price after 4 years	R\$ 62.618,00	R\$ 82.142,00	R\$ 73.716,57

Toyota Prius x Toyota Corolla

	0	1	2	3	4
Purchase Price / Resale Price	-R\$ 34,550.00	R\$ 0.00	R\$ 0.00	R\$ 0.00	R\$ 19,524.00
Fuel Economy in R\$		R\$ 2,675.96	R\$ 2,675.96	R\$ 2,675.96	R\$ 2,675.96
Cash Flow Results	-R\$ 34,550.00	R\$ 2,675.96	R\$ 2,675.96	R\$ 2,675.96	R\$ 22,199.96
Net Present Value	-R\$ 12,732.41				

Nissan Leaf x Toyota Corolla

	0	1	2	3	4
Purchase Price / Resale Price	-R\$ 89,100.00	R\$ 0.00	R\$ 0.00	R\$ 0.00	R\$ 11,098.57
Fuel Economy in R\$		R\$ 5,126.23	R\$ 5,126.23	R\$ 5,126.23	R\$ 5,126.23
Cash Flow Results	-R\$ 89,100.00	R\$ 5,126.23	R\$ 5,126.23	R\$ 5,126.23	R\$ 16,224.81
Net Present Value	-R\$ 65,270.06				

The results of this study concluded that the fuel economy afforded by the hybrid Toyota Prius is not enough to make the vehicle economically attractive due to the high value of the vehicle's acquisition. The same goes for the Nissan Leaf, the electric vehicle reduces consumer spending, because recharging with electricity is cheaper than spending on gasoline. However, the high purchase price makes the vehicle even less attractive than the Toyota Prius.

It would be necessary to drive about 37,515.48 km per year so that the consumer would be indifferent between a Toyota Corolla and a Toyota Prius under the conditions considered in the study. In the case of the Nissan Leaf, it would require an even bigger run, a total of 75,251.24 km per year.

We can interpret the net present value in these cases as the amount of subsidy needed to make these vehicles attractive. However, these amounts of subsidies are very large, not making this policy feasible on a large scale. Therefore, policies in different areas, monetary and non-monetary, would be necessary to make these vehicles attractive. As incentive policies we can highlight subsidies to purchase, tax exemption, free parking, permission to use exclusive expressways and especially the construction of recharge infrastructure, reducing the problem of range anxiety.

A major challenge in electric vehicles diffusion is called range anxiety, that is the concern of owners with the existence of properly distributed charging stations, which can hamper the diffusion process. In the case of electric vehicles, the market for plug-in electric vehicles suffers indirect network effects due to the interdependence between the adoption of electric vehicles and the investment in charging stations. It is important to note that these effects have influence in the design of public policies to encourage adoption, since encouraging the adoption of electric vehicles by subsidizing the purchase generates effects in the development of recharge infrastructure, as well as the incentive to construct recharge infrastructure impacts on the purchase of new vehicles.

Conclusions

Considering the dynamics of the diffusion of ethanol and the flex-fuel car, we can assume that an alternative to conventional technology, such as hybrids and electric vehicles, has the potential to spread in Brazil. For this, this technology must be stimulated by the government, in order to get a significant share of the Brazilian market. It is important to note that with the introduction of electric vehicles, electricity would not necessarily compete with the ethanol and oil, it can be a complement through hybrid cars. Solutions such as hybrid or electric vehicles that have recalibrated auxiliary combustion engines to use ethanol would be of interest to the country

In addition, the spread of the electric car is expected to happen later than in other countries due to some factors. We can highlight the fact that the country has a well-developed biofuels sector, which could hinder the introduction of electric cars, considering that the use of ethanol already allows the reduction of greenhouse gas emissions.

Another relevant factor is that electric cars in Brazil is introduced as a good of the high-income classes, once that the price range does not make them competitive when compared to the internal combustion vehicles. This issue may delay the diffusion of electric vehicles in Brazil, since the Brazilian automotive market is composed mostly of low value cars.

Considering the particularities of each country, the diffusion of electric vehicles will happen in an asymmetric way around the world. Experiences from other countries should be analyzed to identify which initiatives have had the best results and can be applied in Brazil. However, it is necessary to pay attention to the specificities of the Brazilian market. Although electric vehicles are not widely diffused in the Brazilian market initially, since these vehicles have a high acquisition value, these cars can increase the market share in the coming years.