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PESTEL analysis and the macro-environmental factors that influence the development of the electric and hybrid vehicles industry in Brazil

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ABSTRACT

Electric and hybrid vehicles have existed since the end of the 19th century. With the current demand for sustainable development of many countries, they emerged as a potential solution for some transportation sector problems. In Brazil, not differently, these vehicles become an essential part of the discussions about the future of the country's transportation system. With an important automotive industry and a huge electric system, 72% renewable energy-based, this country appears to be the right place to develop this industry. It is well known that, in general, nations offer support, within their capacity, for the development of their economic sectors. For strategic management, the factors offered by a country are found in the so-called organizational macro-environment, which can be organized in political, economic, legal, technological, socio-cultural and ecological, among other segments. The importance of assessing the macro-environment's influence on developing Brazil's electric and hybrid vehicles industry can be noted. In this way, this article presents a comprehensive analysis of the Brazilian scenario showing potential opportunities and threats offered by its macro-environment. The PESTEL framework was used. The results show that Brazil has profitable segments that could impulse the electric and hybrid car industry. Technological and ecological segments are the leading positive influencers. Political and legal segments also are positive forces for the sector, despite the current crisis faced in the country. The economic and social segments present the least potential opportunities and the most significant amount of potential threats.

1. Introduction

Hybrid and electric vehicles have been around for a long time, principally since the 1900 s. They have always represented a small portion of the total vehicles produced and consumed worldwide (Barros and Pedro, 2012). Despite the beginning of the 20th century, for example, more than a quarter of cars produced in the US were electric, this segment reduced its participation to a small business share (approximately 2.5% in 2021). Also, in 2014, electric vehicles represented a small sales volume (less than 3% of global vehicles sales) compared to vehicles powered by combustion engines, which use gasoline and liquid biofuels (U.S. Department of Energy, 2014). The combustion engine still dominates the road modality today, as it is cheaper and has vehicles with high autonomy (Baran and Legey, 2011; Barros and Pedro, 2012).

However, in the first two decades of the 21st century, we hear about electric and hybrid vehicles being designed and even put on production lines by automakers worldwide, such as Toyota with the Prius or Ford with the Fusion. The electric ones gained strength in the market after developing lithium batteries, which present more outstanding durability and autonomy than those produced until then. An example is Tesla, with its models that can easily reach 400 km of autonomy, very similar to the range of what many vehicles with an internal combustion engine can do, on average, with a fuel tank. There is an international growth which has shown that there is interest in changing the type of energy that powers road transport vehicles, given worldly concerns about socio-environmental issues, moving to a more significant presence of alternative and more sustainable sources of energy (Baran and Legey, 2011; Barros and Pedro, 2012; Chattopadhyay and Chattopadhyay, 2020; Gottschamer and Zhang, 2016; Richards and Al Zaili, 2020). This trend is not different in the Brazilian market, aligned with the international front, seeking to replace fossil fuels with alternative sources like biofuels (such as ethanol) and electricity (Castro and Ferreira, 2010; Vaz et al., 2015).

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In Brazil, which is increasingly important for the automotive sector worldwide, the interest in hybrid and electric vehicles has increased and been enforced. The renewable energy sources available and the fact that some automakers are already selling some models in the country have been the main drivers (ANFAEVA, 2020; Barros and Pedro, 2012; Machado, 2019).

It is well known that, in general, nations offer support, within their capacity, for the development of their economic sectors, being no different in Brazil, which has the support of the National Bank for Economic and Social Development (BNDES), including for the development of the automotive sphere. Among other factors, these conditions provided by countries constitute, for example, basic configurations that can enhance and accelerate the growth of the sector in the country, integrating the Macro-environment concept, whose analysis allows us to identify potential opportunities and threats for competitive advantage and development in the market (Barros and Pedro, 2012; Hitt et al., 2018; Vaz et al., 2015).

In strongly globalized economic sectors, such as the automotive sector, the macro-environment analysis becomes elementary because it can reveal opportunities and threats to corporations' internationalization claims. Each country has institutional, economic, logistical and conjectural factors, which can influence competitive decisions of organizations as they are monitored and translated by their primary stakeholders (Peng et al., 2009; Hitt et al., 2018).

Scientific studies on the Macro-environment of several sectors in the Brazilian market have been developed recently, whether in banking, retail, automotive, or energy, to identify possible opportunities and threats for their competitiveness, using strategic analysis methods, such as the PESTEL framework. Some of them are Faller and Almeida (2014), Gottschamer and Zhang (2016), Leviäkangas (2016), Lima (2016), Segura et al. (2018), Song et al. (2017).

Thus, it is questioned whether the Brazilian environment has the capacity and potential to meet possible demand and change in vehicles' energy sources in the following years. Therefore, this work aims to develop a PESTEL framework of the conditions that the Brazilian macro-environment currently offers to develop Brazil's hybrid and electric vehicles industry.

2. Background

2.1. Macro-environment influence for electric and hybrid vehicles

The macro-environment means the external environment both for a company and for an economic sector. A company hardly controls this environment while it continually exerts its influence. The macro-environment exerts influence through several segments such as: demographic, economic, political, legal, socio-cultural, technological, global and legal. All of these segments can offer opportunities and threats to organizations' strategies and development, so it is imperative that decision-makers continually monitor and analyze the macro-environmental conditions (Hitt et al., 2018).

This monitoring allows companies to identify the opportunities and threats provided by the surrounding conditions and create or sustain a competitive advantage in the industry. It is necessary to scan and identify these macro-environmental segments, monitor their possible changes and trends, and assess the company's situation before the studied sphere (Barney and Hesterly, 2017).

In the strategic analysis, it is worth seeing that the macro-environmental segments are interconnected and influence each other. This will be necessary for the competitive advantage and the possibility of developing an economic sector (Hitt et al., 2018; Song et al., 2017).

Also, the competitive sector or industry where the company is inserted can be put into the analysis. Methods such as the Five Forces Model allow an analysis of the competitive dynamics and facilitate choosing how the company will position itself strategically in the industry. An example of an industry with potential opportunities for a current competitor firm would be one whose entry barriers are high. The bargaining powers of customers and suppliers are relatively small, with minor threats of substitute products and few direct competitors (Barney and Hesterly, 2017).

2.2. Automotive industry in Brazil

According to the information available in the 2020's Brazilian Automotive Industry Yearbook of the Brazilian Automotive Industry Association (ANFAEVA), by the end of 2019, 26 manufacturers with 65 industrial units were present in the national market, with the capacity to produce more than 5 million units in one year, with Brazil ranking eighth place worldwide in vehicle producers (ANFAEVA, 2020). Despite being in decline since 2010, from 2017, the sector began to show a slow recovery. The Brazilian economic activity and the Latin American partners are still low, with the gain influenced by the lower interest rates and access to credit (Machado, 2019). Brazil has the road modal as the most representative in the national energy consumption, which indicates that it is still promising and that its demand is still high (Vaz et al., 2015; ANFAEVA, 2020; Machado, 2019). In Table 1, it is possible to see the Brazilian fleet size by vehicle type, which has grown continuously since 2000. In Fig. 1, it is possible to see the growth pattern in the industry, reestablished in the last three years.

The transport sector plays a crucial role in energy use and GHG emissions. This sector is the largest consumer of oil-derived fuels worldwide, requiring almost 60% of demand. Approximately 15% of global anthropogenic emissions came from transport activities (Bunsen et al., 2018). Besides, in the 19th century, 2% of the world's population lived in urban areas, but more than half of all people lived in them after two centuries. This rapid urbanization process tends to cover almost 70% of the global population by 2050 (Zhang, 2016; Gonçalves et al., 2019).

The continuous growth in the size of cities is resulting in the necessity of more essential services as housing, sanitation and transport. However, it is essential to consider each city's peculiarities determined by its historical construction, geography, and population. Brazil, for example, has territorial development that happened intensely between 1960 and 1970. The country industrialized, grew economically and invested in the road system. However, this process was quick and caused issues such as poor road infrastructure, urban sprawl, inefficient transport systems and, consequently, more negatives environmental impacts (Silva and Teles, 2020)

Brazil's automotive industry is in the top ten worldwide (OICA,

Table 1
Brazilian vehicle fleet size estimate 2000/2019. ANFAEVA, 2020.

Year	Cars	Light commercials	Trucks	Buses	Total
2000	15,531,100	2,461,564	1,141,563	195,043	19,329,269
2001	16,207,108	2,545,542	1,147,509	202,514	20,102,674
2002	16,880,806	2,603,833	1,147,220	209,758	20,841,616
2003	17,464,856	2,613,997	1,149,693	216,049	21,444,594
2004	18,140,132	2,649,975	1,170,928	223,572	22,184,606
2005	18,925,909	2,692,052	1,192,596	227,987	23,038,543
2006	19,892,106	2,743,982	1,212,522	235,721	24,084,332
2007	21,296,739	2,843,088	1,256,368	246,320	25,642,516
2008	22,917,127	3,007,434	1,325,121	260,251	27,509,933
2009	24,814,730	3,200,720	1,382,473	269,324	29,667,247
2010	26,887,679	3,498,652	1,440,274	283,730	32,110,335
2011	28,945,920	3,850,844	1,608,972	303,762	34,709,499
2012	31,122,609	4,193,868	1,696,803	317,355	37,330,635
2013	33,091,814	4,544,065	1,800,194	334,946	39,771,018
2014	34,676,220	4,878,952	1,885,467	346,641	41,787,280
2015	35,471,465	5,019,747	1,905,138	346,923	42,743,272
2016	35,757,762	5,090,827	1,902,546	341,035	43,092,169
2017	36,190,079	5,171,398	1,900,291	335,540	43,597,308
2018	36,883,423	5,301,789	1,920,876	333,113	44,439,200
2019	37,720,122	5,457,903	1,964,692	335,932	45,478,649

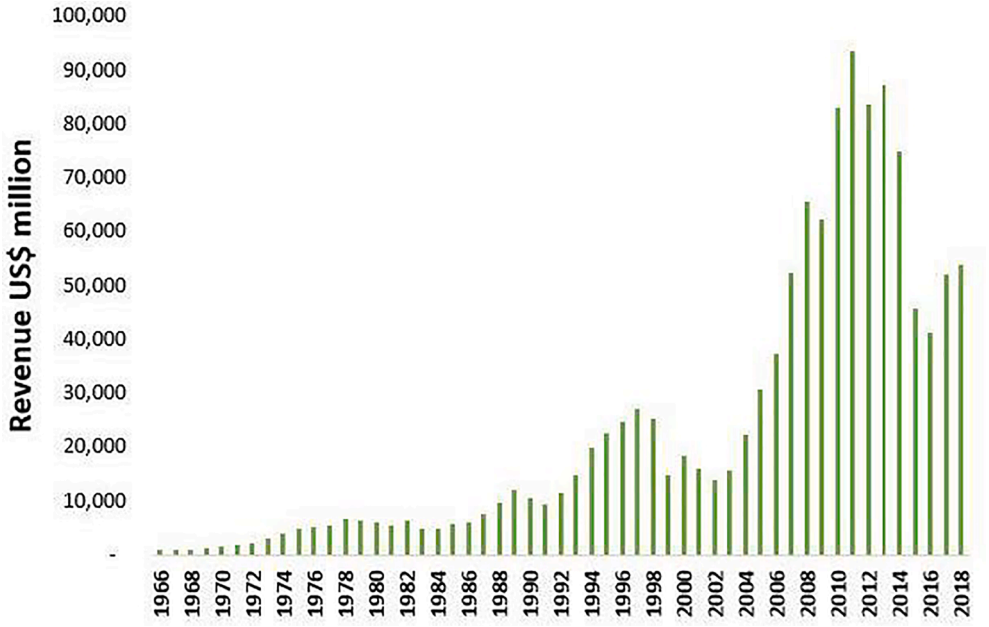

Fig. 1. Vehicles sales yearly net revenue in Brazil. ANFAEVA, 2020.

2019). In this country, from 2005 to 2017, energy demand in the transport sector increased by 60%, representing the use of 35% of total energy and 68% of fossil fuel (EPE, 2019), while GHG emissions increased 46%, representing 13.8% of national GHG emissions (Gonçalves et al., 2019). After two decades of the 21st century, the Brazilian transport matrix continues to be dominated by road transport (more than 60%), rail (almost 20%), waterway (more than 13%), pipeline (almost 5%) and air (approximately 5%) (CNT, 2020). Ethanol has contributed to decreasing the growth of transport emissions in the country. However, increased ethanol production has led to other problems, such as deforestation, soil contamination, water and air pollution (from biomass burning), and the possibility of competing with food production. That is why the electric vehicle is an affordable technology and low GHG emission option; even more than 4/5 of the electric generation comes from renewable sources (Costa et al., 2020).

In 2009, 13 countries (Canada, Finland, France, Germany, Japan, Netherlands, New Zealand, Norway, Poland, Portugal, China, Sweden, and the United Kingdom) signed the Electric Vehicles Initiative (EVI). In 2017 the EVI was updated with more challenging targets for 2030, where electric vehicles (EVs) are expected to hold 30% of the transport market in member countries (Thorne and Hughes, 2019; Massiani, 2015). The United States (Andress et al., 2011) and Spain (Sánchez-Braza et al., 2014) are other examples of political and institutional efforts to spread EVs and accelerate their market development. In general, it can be said that in developed countries, there is more robust organization, policies, and plans in favor of EVs.

If current worldwide trends persist, transport's share will likely increase to 40% by 2030 and even 60% by 2050 (ITF, 2019). Considering the rapid growth of mobility demand, mainly in emerging countries like Brazil, decarbonizing these countries' transport sectors will be a challenge (Arioli et al., 2020). Table 2 compares some of the mitigation efforts in the transport sector found in Brazil and other emerging countries.

Table 2
Compares some of the mitigation efforts in the transport sector found in Brazil and other emerging countries. Arioli et al. (2020).

Country	Mitigation efforts
Brazil	The country committed to reducing 37% by 2025 and 43% by 2030, based on estimated emission levels of 2005. Although the current government has halted most climate policy action, the country aims to implement measures in the transport sector related to promoting efficiency measures and improving the infrastructure for transport and public transportation in urbanized areas. Also, the share of sustainable biofuels in the Brazilian energy mix should increase from 8.5% to approximately 18% by 2030.
Vietnam	In recent decades, the country has seen urban and economic growth along with the rates of motorization. This rapid growth is associated with a high growth rate in transport demand and significantly impacts energy resources for transportation. Although there are no evident efforts to develop the electric vehicle industry, some commitments are: Develop and improve the public transport system; Reform freight transport; Establish standards on fuel consumption; Establish management program for fuel quality and vehicle maintenance.
Kenya	The country established a reduction goal of 30% of GHG emissions by 2030 relative to the "business-as-usual" scenario. Currently, the transport sector makes a small contribution to national energy consumption. However, this contribution has the potential to grow shortly. GHG emissions will increase until 2030 in all sectors, with transport emissions increasing by a factor of three. Transport-related actions include infrastructure for the mass transit system, non-motorized modes, measures to shift freight from road to rail, improve passenger and freight vehicle efficiency, and adopt bioethanol blending and biodiesel.
India	India aims to cut the GHG emissions intensity of its GDP by 33–35% by 2030 based on the 2005 level. In the transport sector, some of India's commitments are: Increase the rail mode share in total land transport from 36% to 45%; Construct exclusive freight corridors; Promote the expansion of coastal shipping and inland water transport; Construct metro lines; Promote the adoption of hybrid and electric vehicles; Establish a Green Highways Policy; Establish a National Policy on biofuels.

2.3. Hybrid and electric vehicles in Brazil

Electric vehicles are powered by electricity, without a combustion engine, with the main driving force being the electrical energy from batteries. These batteries can be nickel-hydride, lithium-ion, or other materials, each with advantages and disadvantages, costs, safety, and lifetime. The energy is stored in these batteries and converted in motion through the power inverters, transforming the direct current stored in the batteries into alternating current for electric motors (Castro and

Ferreira, 2010; Vaz et al., 2015).

These electric engines, which have a superior energy efficiency compared to combustion engines (electrical is between 60%–85% compared to 20%–25% range of gasoline's Otto-cycle engines and 40%–50% for Diesel-cycle engines, concerning the conversion of energy in motion), can be of several different types. Some of them are the direct current with brushes that demonstrates low efficiency, low cost, and high weight. There is also the induction motor, with low cost and high reliability, but with expensive controllers; the brushless DC motors, more efficient, but more expensive and heavier than those with a brush; and finally, the switched reluctance engines, that are lighter and cooler, but the most expensive (Castro and Ferreira, 2010; Vaz et al., 2015).

Hybrid vehicles combine two energy sources (fuel combustion and electric). It consists of a traditional combustion engine combined with a battery and an electric motor. It can assume different systems arrangements, like the series system, where the combustion engine supplies the battery, the parallel system, where both engines are connected to the vehicle's traction (Castro and Ferreira, 2010; Vaz et al., 2015).

When both engines run and pull the vehicle, the combustion engine also acts as a generator for the electric motor. As well as the purely electric drive, regenerative braking may or may not exist (Castro and Ferreira, 2010; Pistoia, 2010; Vaz et al., 2015). Despite being more found in the national market, Hybrids still have not placed a significant sales pace, even though the growth in recent years (Vaz et al., 2015).

The difference between recharging systems in both vehicles is worth mentioning since electric vehicles depend solely on electricity to move. The batteries need to be charged, usually for hours, until obtaining the desired autonomy. In contrast, in hybrid vehicles, energy can be generated through the combustion engine, although models also allow recharging the battery through an electrical charging input in the car (Castro and Ferreira, 2010; Pistoia, 2010; Vaz et al., 2015).

In numbers, in Brazil, by 2019, of the 2,787,850 new licensed vehicles, only 11,844 had an electric engine (hybrid or purely electric), about 0.43% of the total. Although in 2018, only 3970 electric or hybrid cars were registered in the country, in the available amount, it is noticed that the market more than doubled in a year. Also, in a general comparison between flex-fuel vehicles and electric vehicles' growth concerning 2019, it is possible to conclude that electric vehicle registrations are overgrowing through the years since 2010 (Table 3) (ANFAEVA, 2020). Despite the above, there is potential for them since technological evolution is constant. New components are increasingly being developed, such as regenerative braking and increased capacity and autonomy, which increases the expectation of market growth for these vehicles (Castro and Ferreira, 2010).

When discussing the electric and hybrid market, it is necessary to assess the Brazilian scenario described up to this point. According to data from ANEEL (Brazilian National Electric Energy Agency) of April 2020, the Brazilian electric production is nearly renewable, mainly originated from sources such as hydroelectric (54%), wind (12%), and photovoltaic (6%). It can be said that the recharging potential of electric and hybrid vehicles is practically sustainable since, also, biodiesel and bioethanol are energy sources used in combustion engines, encouraged by the government (ANEEL, 2020b; Castro and Ferreira, 2010; Vaz et al., 2015).

Table 3
Registration of new vehicles Flex Fuel × Electric – 2010/2019. ANFAEVA, 2020.

Year	Flex Fuel	Growth Flex Fuel	Electric	Growth Electric
2010	2,570,578	6.39%	24	14.29%
2011	2,524,402	−1.80%	200	733.33%
2012	2,834,334	12.28%	117	−41.50%
2013	2,833,091	−0.04%	484	313.68%
2014	2,588,367	−8.64%	842	73.97%
2015	1,959,868	−24.28%	843	0.12%
2016	1,572,798	−19.75%	1,085	28.71%
2017	1,739,014	10.57%	3,278	202.12%
2018	1,969,672	13.26%	3,965	20.96%
2019	2,123,841	7.83%	11,844	198.71%

3. PESTEL framework

The PESTEL framework is a strategic analysis tool, an acronym for the defined segments of the macro-environment: P for "political," E for "economic," S for "social," T for "technology," E for "environmental," and L for "legal"; similarly to the segmentations shown previously, the segmentation of the PESTEL analysis allows a structured diagnosis of the macro-environment in which the company operates and on which aspects of this environment corroborate to identify threats and opportunities to create competitiveness in the market highlighted (Barney and Hesterly, 2017; Hitt et al., 2018).

The need to develop more proactive strategies requires the strategist to assess all organizational environments. Thus, for the Macro-environment analysis, the PESTEL framework is the most used in strategic studies. This tool considers the main segments of the Macro-environment, and its principles are flexibility, depth, dynamism and integrability of the analytical process.

It is important to emphasize that the PESTEL framework does not evaluate corporate, competitive, or industrial sector strategies. This analysis tool allows the decision-maker to identify opportunities and threats to their intended strategic actions. The macro-environment is broad, diverse, and constantly influences economic sectors, whether national or global. Thus, the PESTEL framework allows mapping the structure of the macro-environment and the factors of each of its segments (Peng et al., 2008; Hitt et al., 2018; Peng et al., 2009).

In political analysis, public policies that influence the company and its environment is understood. The market's status, prices, rates, correlations, and local and national economic indexes are investigated in the economic segment. In the social segment, the population's demographic issue is observed in the company environment, such as income, economic class, behaviors, culture, working conditions, and health system. For the technological segment, the development and dissemination of technology are evaluated. Communication issues, how often technology changes, and how this can promote advantages or disadvantages for its processes are also considered. In the environmental-ecological segment, the place's environmental policies can be investigated, whether there is a favorable climate for development and climate change relations. Finally, in the legal-regulatory segment, seeking to understand the labor, patent, data protection regulations, or other regulations aimed at a studied sector (Barney and Hesterly, 2017; Hitt et al., 2018; Song et al., 2017).

As it is a qualitative, descriptive analysis with documentary research, to carry out the PESTEL framework, a sequence of steps to be followed in the analysis process was elaborated, namely scanning, forecast, association, and interpretation (Fig. 2).

Identifying the macro-environmental factors to be scanned, predicted, and related was based on documentary research (obtained from government sources, renowned institutions, and associations of sectors and industries) and using bibliographic research (articles and scientific publications). The identified and forecasted factors were evaluated based on their direct or indirect relationship with the automotive sector of electric and hybrid vehicles in Brazil.

The interpretation of factors as a possible threat or opportunity was obtained from a group of academic experts in energy systems planning and business management through a questionnaire developed based on the five-point Likert scale (1932).

The questionnaire aimed to attribute to each macro-environmental factor a type of influence (potential opportunity or threat) and its level of impact in the studied sector. The five answer options for each factor shown in the questionnaire were presented as follows:

(a) Possible opportunity for strong impact
(b) Possible opportunity for moderate impact

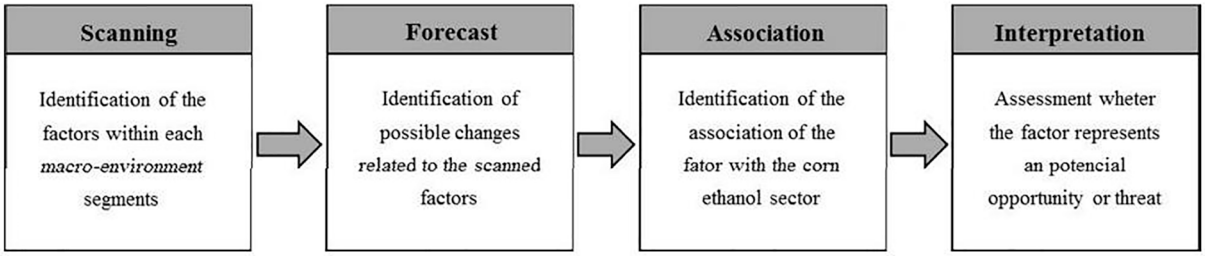

Fig. 2. Flowchart of a PESTEL framework.

(c) Possible neutral impact
(d) Possible threat for moderate impact
(e) Possible threat for strong impact

Although the experts who agreed to collaborate with the research were preserved, Table 4 shows each profile. The interviews were sent and answered by email between the 10th and 20th of September 2021.

4. PESTEL analysis of electric and hybrid vehicles in Brazil

4.1. Political segment

Although they have been around for a long time, electric vehicles gained their importance only in the 21st century, when their potential for reducing environmental impacts was positive for a country's sustainable development (Barros and Pedro, 2012). Thus, to align with the sustainability objectives, the vehicles' electric engines started to gain prominence in Brazilian political discussions.

At the national political level, efforts to determine guidelines for developing the electric vehicles sector in Brazil are feasible (Senado Federal, 2017). Act No. 304/2017 is in an advanced stage of discussion in the Brazilian Senate, which aims to prohibit the sale of vehicles powered by fossil fuels (diesel and gasoline) until 2030 and prohibit the circulation of these until 2040 (Baptista, 2020). For automobiles with engines powered by sustainable powertrains, such as electric energy, it is understood that the ban on the sale and circulation of vehicles moved by fossil fuels provokes a reaction from the national automotive market (producers and consumers) in favor of the development of cleaner options.

Another relevant factor is Act No. 9616/2018 of tax incentives for producing and selling vehicles powered exclusively or partially by an electric motor. Such a project benefits both sides of consuming these products, with the exemption from IPI (tax on industrialized products) for the final consumer of the electric or hybrid vehicle and the deduction of expenses benefiting companies and automakers in research and development in these vehicles. With the incentive, it is understood that these products' consumption will benefit, and in the same way, research and development, which may allow even more efficient products for the public (Câmara dos Deputados, 2018).

The energy sector is indirectly linked to the electric and hybrid vehicles industry because the new electric motion engines depend on energy feasibility and availability. That is why incentives for the energy sector will also be crucial. It is possible to identify, in this way, several policies at national, state, and municipal levels, with all of them encouraging the national electric sector. They mainly concern the own generation of energy through photovoltaic panels, which allows the generation of clean energy for motor vehicles and enables a sustainable alternative for development in conjunction with the electric and hybrid car sector.

There are incentives mainly in the tax area, which aim to reduce taxes on imports of solar energy equipment, the non-taxation of energy generation by residential consumers and development programs to encourage end consumers to generate clean energy in their homes (Manoel et al., 2020; Reuters, 2020; Sena, 2019).

These incentives to the electric sector also present themselves as positive factors for developing the industry of electric and hybrid cars in Brazil, since the "fuel" used in vehicles is renewable electricity and produced by the final consumer who purchases an electric car. All this indicates that the segment's sustainability is increasingly plausible.

Table 4
Profile of interviewed experts.

Participant	Professional activity	Graduated	Academic degree	Years of experience
1	College professor and researcher	Mechanical engineer	PhD	25
2	College professor	Management	PhD	20
3	College professor and researcher	Economist	PhD	15
4	Researcher	Electric engineer	PhD	23
5	College professor and researcher	Chemical engineer	PhD	21

4.2. Economic segment

Factors were identified such as the national indicators released by public institutions in Brazil, such as the Brazilian Institute of Geography and Statistics (IBGE), the Central Bank of Brazil (BCB), in addition to public institutions and agencies that periodically disclose the results of the most diverse sectors of the economy. In 2020, the national economic numbers and indicators suffered from the coronavirus pandemic, having shown negative results until the second half of 2020. The national GDP (Gross Domestic Product) showed a decrease of 9.7%, concerning the previous period in 2019, with shrinkage in the industrial transformation sector about 17.5% and in the energy and sanitation sector, with a 4.4% contraction. These numbers are expected because the results were projected negatively with restricting people's movement and some goods and services (IBGE, 2020b).

However, according to information published in the Focus Report by the Central Bank of Brazil, the Brazilian market's future scenarios are more optimistic despite the negative numbers. The forecast is that the IPCA (Brazil's main inflation index) will accumulate at 1.78% in 2020, with a tendency to increase the accumulated index, directly impacting the price of products in the national market. Despite the low accumulated in 2020, prices tend to increase, with consequent IPCA increase, projected at 3% for 2021, 3.5% in 2022, and 3.25% in 2023. Despite following a downward trend in 2020, the general GDP forecast is at 5.31%; for the coming years, it is estimated the growth by 3.5% in 2021 and 2.5% for the following two years. The dollar should remain above five reais until the end of 2022 when projected at R$ (BRL) 4.90. The IGP-M, the average general price index, is up 11.72%, causing a generalized rise in prices. The projection will remain around 4% in the next three years (Banco Central do Brasil, 2020).

Against the economic scenario, electric and hybrid vehicle sales have grown, even after the pandemic. According to information from the Brazilian Electric Vehicle Association (ABVE) and Brazilian Automotive

Industry Association (ANFAEVA), the first half of 2020 showed positive results in the electric vehicle sector, so it accumulated an increase of 221% over the same period last year, even after the effects of the pandemic. The sales increased from 2356 to 7568 vehicles (including electric and hybrid) in the same period and already made up 65% of sales in the previous year. With the addition of new sales after the results were released in Brazil, more than 30 thousand vehicles of this type (electric and hybrid) became part of the fleet. The expectation is that this number will continue to increase, given the sequence of growth of the data released. According to ANFAVEA, the traditional auto industry had a 50.5% drop in production and 38.2% in sales/new license plates in the first half of 2020, compared to the same period in 2019. Even though the automotive sector's sales trend in 2020 had sharply reduced, the electric and hybrid vehicles (EVs) sector showed contrast and hit a growth trend in 2020 and the coming years (ABVE, 2020).

As in other countries, in Brazil, the sales flow of EVs (Electric and Hybrid Vehicles) follows a different pace from the other segments, proving promising and increasingly counting on more models, including the new Toyota Corolla Hybrid, the first vehicle in the category produced nationally. ABVE's final expectation is that the sector will grow this year, even after the pandemic scenario. ANFAVEA, on the other hand, projects a 40% drop in sales in the automotive industry this year, considering all available engines (ABVE, 2020).

Another economic factor affecting the sector is the changes in the electricity sector. According to information from the National System Operator (ONS), energy consumption fell by 14% during a pandemic in Brazil, according to a study carried out by the Electric Energy Trading Chamber (CCEE). For the captive market consumer, in which the consumer purchases energy directly from the distributors, the reduction was 18%. The survey displays the performance of energy consumption by industry, which shows that the national automotive sector was the most significant drop in consumption analyzed, with a 65% demand declining after the start of quarantine (Agência Canal Energia, 2020; Amato, 2020).

With the pandemic, electricity consumption in Brazil by April 2020 was the lowest for the month in eight years (60,085 average MW), according to data from the National Electric System Operator (ONS). This consumption is the lowest for April since 2012 when demand was 59,354 average MW. According to ONS, of the country's total energy in April, approximately 5.5 thousand average MW were generated by thermoelectric plants. This volume is the lowest for the month since 2011 and is equivalent to 1/3 of that recorded in 2015 (16,097 average MW), the highest value in the ONS series (Agência Canal Energia, 2020; Amato, 2020).

4.3. Social/demographic segment

In the social and demographic sphere, Brazil, according to IBGE data, has the sixth largest population in the world, with approximately 211.7 million inhabitants, according to the last projection made in August 2020. This fact alone indicates a demographic potential for consumption, which is favorable for the industry's development. The most populous states are São Paulo (46 million), Minas Gerais (21 million), and Rio de Janeiro (17 million). Nevertheless, the largest national metropolises in these states are concentrated, including the Brazilian megalopolises (The Rio-São Paulo-Campinas Axis), which also constitute the country's most developed regions (Agência Brasil - EBC, 2020; IBGE, 2020a).

The states mentioned above (São Paulo, Minas Gerais, and Rio de Janeiro) are all contained in the Southeast Region of Brazil. According to IBGE data, this region has the largest population and demographic density in the country, with around 87 million people living in this region. There are also about 60 million Brazilians in the Northeast Region of the country. IBGE projected population growth and concentration in the southeast region. The demographic density of the state of São Paulo, the most populous in the country, is 166.25 inhabitants/km^2, distributing its 46.289 million people in a 248.2 thousand square kilometers area. This high density of people in the large centers and their surroundings, the metropolitan regions, is on a growing projection, maintained at least for the next ten years, mainly in states like São Paulo, where the inhabitants and national income are concentrated (approximately R$ (BRL) 2000 per household). The increase in concentration in large centers allows the electric and hybrid car sector to develop because it facilitates charging stations and finds the highest income population. Besides, in large urban centers, the possibility of getting around with the autonomy already existing in the electric and hybrid vehicles for a daily commute is already plausible (Agência Brasil - EBC, 2020; IBGE, 2020a).

A survey carried out by Quatro Rodas magazine, an influential magazine in the automotive segment in Brazil, asked about the population's opinion regarding electric and hybrid cars to understand if it is prepared this brand-new way of locomotion. Some aspects of the population's behavior and preferences about electric and hybrid vehicles were identified, as well-known brands, in what they believe and declare about this type of automobile. The brands that first come to the respondents' minds are Tesla and Toyota, which lead people's preference when electric and hybrid vehicles are cited (Quatro Rodas, 2020).

The main trends analyzed were: 93% of respondents considered that these vehicles are quieter than those powered by combustion engines; 80% believe that EVs reduce pollutant gas emissions in cities; 78% believe that EVs have the highest embedded technology; 49% believe that these vehicles tend to have lower maintenance costs compared to combustion engines, with fewer maintenance requirements. People's primary concern is the vehicles' autonomy since they believe they were designed for urban centers and not for long trips on highways (79% believe that 300 km is not enough for long trips). Another concern is infrastructure, such as the respondents in Ceará state, where only 16% believe that these vehicles' charging infrastructure and specialized workshops are adequate. The price was another spontaneous factor presented by the interviewees. In the survey, the electric car costing about 60% more than the equivalent of combustion showed that 21% would not buy and 11% would buy for sure. Utterly different scenario from the second proposition, where the electric ones had the same price as the equivalents moved by combustion engines, 46% would buy with certainty, and only 5% would not buy (Quatro Rodas, 2020).

The interviewees were divided into groups, with Low Knowledge, Future, Enthusiasts, and Pessimists, with the first two being the majority and the last two the minority. In short, it is believed that EVs help to reduce environmental impacts and the emission of pollutants. However, as a matter of price and costs, both the product and the sector's investment are still costly. There is no adequate infrastructure for such vehicles, and few people understand that the government is developing the sector. In Brazilian society, the cost of a product is a significant factor in purchasing, especially in the conditions of classes C (family income between R$ (BRL) 1892.65 to 8159.37) D and E (family income between 0 and R$ (BRL) 1892.65). In this way, as there is no forecast for these cars to get cheaper, such as its technology, classes with more significant consumption potential may still be left out of the sector, which does not represent a significant increase in the sale of goods. Another factor is the infrastructure, despite the government's efforts to implement appropriate technology for the industry's development. Many Brazilians believe that they would agree to buy an electric or hybrid car when they increase their autonomy and when the availability of recharging points increases. Such perspectives indicate interest in acquiring these vehicles, but the costs and infrastructure end up repelling people's purchase intentions. Despite the preceding, there is recognition by the population of the benefit that investing in these cars would bring, such as reducing the emission of polluting gases into the atmosphere and contributing to maintaining a cleaner city (Quatro Rodas, 2020; Villas Bôas, 2019).

In another research carried out for a thesis, a counterpoint identified was that current and future generations, the Millennials, tend to drive and like cars more, even though they constitute a generation tending to buy less. The thesis replicates a study on the behavior of the Millennials'

generation concerning their consumption pattern in the automotive sector, previously carried out in the USA, Canada, Australia, and several other countries in Europe. Of the objectives of the study, three resulted in negative points for the development of the sector in Brazil: Millennials are becoming less qualified to drive cars than other generations, not taking their driving licenses; have fewer cars and; add a much lower purchase intention to the industry than the previous generation, mainly due to the cost of obtaining the license, since the low income of this generation. However, two of the goals showed that there are still similarities with the previous generation: Millennials are increasingly using cars (differently than previously thought); they showed a more expressive involvement with the automotive category (Silva, 2019).

There are several distinctions between the age groups of this audience. However, in theory, they are made up of young people between 23 and 38 years old (born between 1981 and 1996), who are the potential consumers of automobiles of the current period. The next generation would be Z (young people aged 7–22). Both generations were born in the "super-connected" period, having already participated since they were children of the technological revolution and present in the internet age. Generation Z is not yet plausible for study, given that only a tiny part of it is legal to obtain a driving license (under 18 in Brazil's legislation). However, the study segregated the Millennials into two categories, one of the youngest and one of the oldest. It was already possible to perceive the trend in reducing direct consumption of vehicles so that individuals were looking for stability and coexistence with consumers the new tendencies like Uber and shared transport and being more concerned with trends in social responsibility and sustainability (Silva, 2019).

Despite individuals' behavior from these generations, it is understood that the income factor has taken on a relevant role in consumers' final decisions. With the emergence of car-sharing apps, transportation apps like Uber and BlaBlaCar, the increase in public transport capacity, and the increase of urban centers concentration, the trend is a reduction in vehicle consumption. However, there is a possibility of purchase as they evolve in their careers. The intention to purchase cars remains but is not carried out due to the more restricted budget (Silva, 2019).

4.4. Technology segment

Although EVs are strongly linked to high technology, electric vehicles' most significant drawbacks are autonomy and recharging time. Technology has been evolving more and more to the point of allowing greater autonomy and shorter recharging time. The new bet for these points' solution is that some lanes for some stretches of highways and avenues through the cities have systems that allow the battery's regeneration while the cars are running them. Copper wires are installed inside the asphalt, and electric currents are transported through them. When the moving vehicle passes through the electrified lane, the current from the wires recharges the battery when a moving part of the car identifies the path and lowers the charging equipment by moving induction. However, this technology's efficiency is still being studied, which revolves around 40–50% (the vehicle absorbs 40–50% of all energy to electrify the copper induction wires). Also, this is a technology understudy, and it is still expensive, as it depends on smart cities and high connectivity to facilitate the charging system for such recharge. Another factor presented is charging stations. Depending on the model, the Brazilian system recharges at 220 V voltage (between 7 kW and 11 kW) for 6 to 12 h (Borges, 2020).

Despite efforts, the benefits of induction charging are still expected to occur in the long term, widely applicable by 2040. The latest vehicle models manage to increase their range, from 250–300 km to more than 400 km. Another effort is a planned launch of a Tesla Car that promises to run 1000 km on a single charge. Although autonomy is still a problem, in Brazil, some stops by the highways allow recharging to 50 kW, and there are projects up to 2023 to implant units of 150 kW and 350 kW (fast recharges). Besides, it is still speculated about the batteries' capacity, currently limited to lithium. However, companies continue their efforts and continue to evolve batteries and increase their capacity (Borges, 2020).

The relationship with the sector is direct, as the technologies being developed by the automakers are a sign of a direct relationship to the electric vehicle sector. Several automakers' simple existence of different kinds of efforts demonstrates that investments in research and development of aggregates for electric vehicles are high and that technology is evolving fast. In terms of infrastructure, the intention is that evolution will take longer. In Brazil, the automakers themselves offer much of the infrastructure, which seeks to retain their customers. Until now, the existing recharge points allow vehicle recharge for free. Therefore, although the technological concern is relevant, its national impact is still small, given that the infrastructure is limited in Brazil (Borges, 2020).

Another factor presented is a study on national "electro-highways," aiming to cover regions such as the Brazilian megalopolis (Rio-São Paulo-Campinas axis) with an extension to Curitiba through the installation of stops with electric charging spots on highways. The study points out the feasibility of these stations being supplied with energy through photovoltaic generation plants, with a power of 75kWp (peak kilowatt – maximum rated power) and a cost of R$ (BRL) 650 thousand each for installation. Each station can charge eight electric vehicles integrally or 40 partially with fast recharges. The study concludes with the advantage of using stations and electric vehicles, despite the high initial investment, given the low operation cost. Also, more studies on the applicability of "electro-highways" and sustainable generation alternatives have been emerging; according to other factors raised, there is already a forecast of cleaning and electrifying the energy used in vehicles shortly in Brazil (Pereira, 2019).

In charging stations, another study was identified to improve the charging infrastructure for electric and hybrid vehicles and be fundamental for their market adoption. In general, the article proposes the implementation and feasibility of improving fast charging at vehicle recharging stations through a station with energy storage elements and the use of a more efficient inverter that allows charging with a power of 60 kW, demonstrating its usefulness (Balen et al., 2019).

Another survey points to many studies on infrastructure, technology, and the automotive sector's development concerning electric and hybrid vehicles. It brings various points of view and analyzes the autonomy, costs, regulations, and even projections on the batteries and the vehicles' autonomy, informing how each of these products influences the sector's development. It also brings several views of companies and associations interested in developing these technologies in the country and the world. It points out several elements that indicate national and international studies on developing technologies to expand and effectively apply electrical energy in the automotive industry. Studies like this demonstrate a great interest in developing technology at national and international levels (Zaneti, 2018).

A study evaluates electric vehicles' adoption in the logistics sector, mainly cargo transportation in large urban centers. It presents the barriers that prevent mass adoption of the electric motor in the energy of movement of the loads and the indication of possible actions that could be taken so that the development of the logistics transport sector can occur in line with the environmental segment and sustainable development. In general, the study pointed out that there is still no economic viability in the sector, given the high costs and the precarious infrastructure for its development, which worries companies and logistics operators (Castro, 2019).

On the other hand, some projects are developed by national agencies and energy companies in Brazil that support electric and hybrid vehicles. The EMOTIVE project, also known as PA0060 (Technical and Commercial electric vehicle insertion in companies' fleet in Campinas Metropolitan Region), aims to establish a Real Electric Mobility Laboratory in the Metropolitan Region of Campinas. This project will analyze the actual impacts of electric vehicles for the electric sector, collect data about applications and implications of technology, and provide a culture for electric vehicles in the region's mobility and the country. EMOTIVE

aims to demystify electric mobility in Brazil, with themes such as energy planning, electric vehicles as a source of distributed generation, economic feasibility study, electric vehicle life cycles and batteries, value chain analysis, pricing and regulation, energy distribution network, new business models in the sector, charging stations, in addition to various adhesion scenarios. Like the National Energy Agency, research in energy efficiency points out study trends for investment in research and development, with themes such as alternative sources of electricity generation, the environment, and energy efficiency, among others (ANEEL, 2020a; CPFL, 2017).

The National Energy Agency has also presented some recent efforts that have generated positive results for investments in research and development in its electric mobility sector. Through R&D Call No. 022/2018, called "Development of Efficient Electric Mobility Solutions," ANEEL managed to encourage 38 projects, which provide for investments in the order of R$ 616 million in the sector, projects with innovative proposals, such as the development of prototypes of electric vehicles with national technology. The call was supported by several companies in the sector, such as CPFL, Elektro, Eletronorte, AES Tietê, COPEL, Light, and CEMIG (ANEEL, 2019).

Although there are several studies in the sector and technology development, most of this is applied to private and small cars' evolution. The cargo and logistics segment is rarely considered in the scope of many studies and analyses. The lack of models is also something that has shown concern for companies in adopting the electric motorization of their vehicles. This lack is a fact that can take years to be resolved by the sector because factors such as battery weight, recharge time, and autonomy and costs, which are directly related, must be taken into account when developing vehicles (Castro, 2019).

4.5. Ecological segment

According to the Energy Planning and Development Secretariat of the Ministry of Mines and Energy, the leading renewable sources present the following percentages in the share of electricity generation: hydroelectric (63.8%), wind (9.3%), biomass and biogas (8.9%) and centralized solar (1.4%). With this, Brazil has been standing out to use more and more renewable resources for electricity generation, contributing to compliance with the environmental protocols that this country is a signatory.

The ministry also predicts that there will be an increase in the generation of energy using these renewable sources since there are government incentives for their development, mainly wind and solar. The ministry itself stated great interest in maintaining incentives for the national development of sustainable electrical energy. 16.6% of the energy sources are from thermal plants (nuclear and natural gas). However, a part of this is composed of the burning of sugarcane bagasse and biogas (Governo do Brasil, 2020).

The national energy system can allow observing the sources with the potential to supply the future electric and hybrid vehicles and whether it is prepared to develop and meet future demand. It will even contribute to the discussion on the sustainability of the sector. This energy condition in Brazil displays that the country is on its path to comply with its international environmental agreements. It is concerned with the nation's sustainable development, which reflects the development of transportation matrices. Furthermore, the sector is prepared to be supplied incentives and investment in this segment's automobiles (Governo do Brasil, 2020).

Other sources also claim that solar energy has the highest growth rates but still represents a small share of global electricity generation. Photovoltaic solar energy was the one that presented the most favorable results; it grew around 31% in 2018 in the world. Despite those favorable numbers, renewable energy still represents only a quarter of all global consumption (Época Negócios, 2019b; IEA, 2019).

Considered by environmentalists to be the most polluting means of generating energy, coal is still responsible for most of the electricity generated, and its use continued to grow in 2018. Altogether solar and wind energy accounted for 7% of all global generation and water, about 16% (Fig. 3). The trend is that renewable energy production continues to grow, especially in Brazil, where wind power has been growing more than 12% per year (Fig. 4). Although there was an increase in energy production from non-renewable sources, this increase was far below the growth levels of renewable sources, which still have much space in the room to grow, both nationally and internationally. With the possible growth in the supply of sustainable energy, the proposal for sustainable development of the electric and hybrid industry becomes increasingly viable. It further reduces greenhouse effect gas emissions (Época Negócios, 2019b; IEA, 2019).

Another factor presented is related to the costs of producing sustainable electric energy that comes from renewable sources. According to data released in a report by the International Renewable Energy Agency, the production costs of clean energies are falling and tend to continue a path of reduction in their costs, driven by the increase in production and the technological development achieved in the year. Concentrated thermal solar energy (CSP) was shown the most significant cost reduction (average fell 26%), followed by bioenergy (14% cost reduction) and the 13% decrease in energy costs generated by photovoltaic panels, the same reduction rate as onshore wind. Hydroelectric plants showed a reduction of 11%, and offshore wind farms only a 1% reduction. The agency predicts that, by 2020, energy from renewable sources such as wind and photovoltaic solar will have a lower cost than non-renewable (fossil) sources, becoming considerably cheaper. The costs of a hydroelectric plant (cheaper) are around 5 cents per kilowatt-hour. In comparison, the wind has reached 10 cents and has been showing significant drops thanks to the sector's technological advancements (Época Negócios, 2019a).

In addition to the electricity factor, other research points to advances in the sustainability of products in the electric and hybrid vehicle sector. For example, a study on implementing electric buses in several major capital cities of Brazilian states shows the ecological benefits, vehicles' high costs, and implementation. However, it is still expected that prices will be reduced. Public policies to encourage development in the sector will be applied, which may benefit the population and transport (Jornal da USP, 2020).

There is a discussion about the conditions and the environmental future of transportation matrices in Brazil made with an analysis of the life cycle, a tool used to evaluate consumer environmental and energy aspects goods from their origin until their final disposition. It has shown that the entire supply chain of fossil fuel vehicles, their production, and maintenance, which involves everything from their manufacture to the transportation of fuel to supply them, also involves fuel consumption. Hybrid vehicles add electricity to this chain. However, despite adding the transmission chain, the electric vehicles exclude the fossil fuel production chain, indicating ecological viability (Souza et al., 2016).

The study considered the batteries for electric and hybrid vehicles and their production and recycling chain (end of life). As a result, the analysis has shown that combustion vehicles are the most impactful and have the most significant potential for global warming, emitting 229 g of CO_2 per km. Hybrid vehicles recorded 184 g of CO_2 per km and electric vehicles 118 g of CO_2 per km, practically half of those cars powered by fossil fuels. Their production comprises 50% of this emission. The downside to electric vehicles resides in many battery components (Souza et al., 2016).

Studies in a product's environmental viability increasingly trigger other studies on the same issue. More research is being done on the environmental impacts of batteries and vehicles' production chain (from extraction of raw materials, production of components, assembly, final product recycling, and how it is returned to nature or the consumer) (Souza et al., 2016).

In general, despite having the benefit to the consumer in its cleanest footprint by not consuming or reducing fossil fuels' consumption, the production chain's impact is still concerning for ecological matters

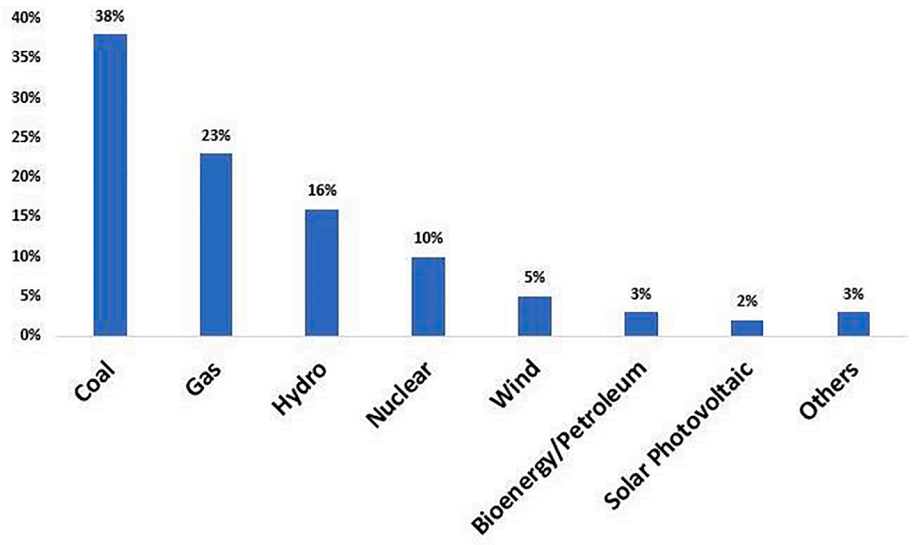

Fig. 3. Power Supply Ranking (2018). Época Negócios, 2019a,b9.

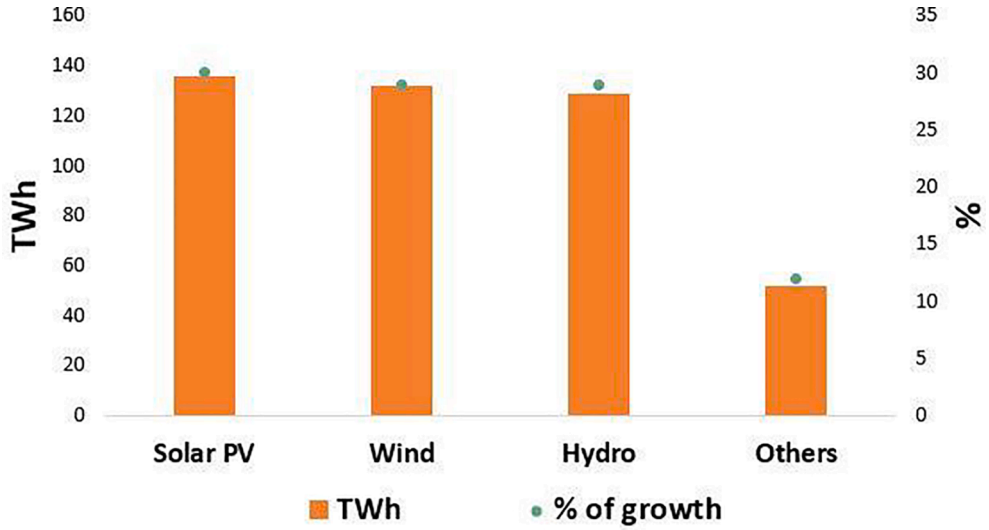

Fig. 4. Growth in renewable electricity generation by technology, 2017–2018. IEA, 2019.

because it continues to depend on fossil sources' function. The post-consumption chain is also a concern, so that some points might be raised and may hinder the option for these vehicles (Souza et al., 2016).

Despite the above, it is still expected to demand time for all this transformation to take place, and the starting point has already been given, hoping that, through a domino effect, the entire downstream and upstream chain will also become sustainable for electric and hybrid vehicles (Souza et al., 2016).

4.6. Legal segment

In 2015, the Chamber of Foreign Trade (CAMEX) approved reducing the import tax rate (II) from 35% to 0% on importing electric vehicles to the national territory. According to CAMEX, in 2015, the measure sought to insert Brazil in developing this technology to allow vehicles with high energy efficiency, low fuel consumption, and pollutant emissions reduction to the consumer. The scope has been extended to hybrid vehicles, so the models between 1000 cm^3 and 3000 cm^3 will also have a reduced rate from 35% to 7% or 0%, depending on each vehicle's energy efficiency and added value. Those legal terms align with the promotion policy for new propulsion technologies and the attraction of new investments for these vehicles' national production (Ministério da Economia, 2015).

As the project is already approved, the use of its benefits is already applicable. The expectation is that the sector's tax changes will continue to benefit the final consumer since there are an incentive and direct assistance in "cleaning" the energy used in the national vehicles. Besides, more laws are expected to come and be implemented to reduce taxes. Some states and cities have promoted a reduction in the Motor Vehicle Property Tax (IPVA) rate for this category of vehicles, giving a discount of 50% in the total payable tax (G1, 2015b, 2015a).

Reducing taxes is a strong incentive for the final consumer since many of these vehicles are foreign, and the import process is necessary. Such reductions expand the number of consumers interested in carrying out the process since they will have a tax benefit upon importation proceeds and during the period in which they own the vehicle (up to 5 years limited to the venal value of R$ (BRL) 150,000 for the IPVA tax basis). Despite being a solid incentive, its impact on the social/demographic tends to be minimal. Very few consumers are aware of the importation process, and, even though it is facilitated, the largest consumers of vehicles that use fossil matrices hardly ever use it. The benefit was established on imports, being limited to economic classes A and B in

Brazilian society. The legal benefits, aligned with the political segment, can promote national production incentives and popularize these vehicles (G1, 2015b, 2015a; Ministério da Economia, 2015).

Another legal concern is associated with the Brazilian taxes system. Electric vehicles may be subject to high taxes, considering that the national tributary system consists of various applicable taxes that could increase the final cost of an electric car in Brazil. Accordingly to the law 5.172/1966, which states the national tax system and new releases and amendments made by the government, the actual taxes applied to an electric car are: (I) 1,65% of contribution to the Social Integration Program (PIS)/Public Servants' Investment Program (PASESP) and 7,6% to the Social Security Financing Contribution (COFINS); (ii) 0% of import tax on electric vehicles or 2% import tax on hybrid vehicles; (iii) an average of 9% for the Tax on Industrialized Products (IPI) and between 12% and 18% contribution to the State Goods and Services Circulation Tax (ICMS). Those taxes added together may raise the price up to 35%. Before 2015 the taxes were higher, without import tax (35%) and IPI (55%) reductions, which doubles the original cost price (Governo do Brasil, 1966).

The legal segment has the fewest factors identified because the electric and hybrid vehicle sector issues are recent. Besides, as identified in item 4.1, many political factors are still occurring, pending approval or becoming laws. Even so, the scanned factors present the existence of laws that benefit the sector.

4.7. Interpretation of identified and analyzed macro-environmental factors

The survey results were divided into two tables, showing the potential opportunities and possible impact levels on the sector (Table 5) and the potential threats and possible impact levels (Table 6).

Table 5 shows that of the eight factors analyzed by specialists, only two were considered a possible opportunity for strong impact by all of them. Two other factors were considered a possible opportunity for moderate impact by the five interviewees, while the other factors showed some differences regarding the level of impact. Only one factor, perceived as a potential opportunity, was assessed as a neutral impact level.

Table 6 shows that of the seven factors analyzed by specialists, three were considered a possible threat for strong impact by all of them. The five interviewees also considered two factors a possible threat for moderate impact. Only one factor had differing perceptions of its impact level, and one factor was rated as a potential threat but with a neutral impact level.

Identifying macro-environmental factors in the segments proposed by the PESTEL framework, the recognition of the type of factor, and the level of impact perception on the sector, can contribute to directing and prioritizing the preparation of strategies by public or private.

The technological and ecological segments present the main macro-environmental factors that can be considered potential opportunities for developing Brazil's electric and hybrid vehicle sector. The economic and social segments present the main factors representing potential threats or barriers for the sector. In the case of the political and legal segments, as shown in the publications cited in Tables 5 and 4, they are essential for the development of any industry related to renewable energy and sustainable development, as they can promote the emergence of influencing factors in all segments of the macro -environment. In Brazil, the political and legal segments still have ample room to be configured as relevant and determinant opportunities for the growth of the electric and hybrid car sector.

5. Discussion of the results

The Brazilian automotive industry has recovered its growth rate since 2015. However, despite some government efforts, the political and legal segments still push down the electric vehicle development. Even at

Table 5
Potential opportunities and their possible impact levels.

Potential opportunities	Survey - choice of options on the scale
(Political) Senate's law project number 304/2017. It forbids fossil fuel commercialization to move vehicles by 2030 and forbids its circulation till 2040 in the whole territory. It shows the potential opportunity to develop sustainable options in the sector, like electric and hybrid cars.	**(a) = 5**
Other possible opportunities were about 15 scannings related to some projects awaiting approval in the National Chamber. Also, some research indicates the sales growth of the electric car and some aspects of the population, like the demography in the big metropolis and the people's perception of the sustainability of electric and hybrid cars. More research was also identified to improve the cars' autonomy and efficiency of the rapid charge stations.	**(a) = 5**
(Technology) As the autonomy (range) and recharging time are among the biggest concerns for the potential users of an electric car, some studies evaluate the possibility of installing an under-pavement wiring system in some highways to recharge the cars while running in those lanes. Also, fast recharge stops in the highways with 350 kW power to be implemented in the main highways.	**(b) = 5**
(Ecologic) The Brazilian electric system is supplied by 83% of renewable energy resources. 63.8% is hydropower, 9.3% is wind, 8.9% is biomass and biogas, 1.4% is solar. This proportion shows a favorable energy scenario for new ventures in economic sectors with high energy consumption, such as the transport sector. The development of the electric and hybrid vehicle sector aligns with the country's energy reality and the prospects for sustainable development.	**(b) = 5**
(Technology) Electric Energy National Agency from Brazil made a Research and Development Public "Call" and promoted almost 40 projects with a total amount of R$ (BRL) 616 million for developing efficient electric mobility solutions. Direct investments show how the country is interested in the sector.	**(a) = 4** **(b) = 1**
(Ecological) Research about the energy costs brings that solar photovoltaic and wind energy reduced by 13% the costs of its production and reduced 11% in hydropower plants. By 2020 it is projected that their costs will be significantly cheaper than the fossil fuel ones. This cost reduction impacts the sector because it indicates a higher availability of a cleaner power source and, consequently, more sustainable development with a reduction in energy production costs.	**(a) = 2** **(b) = 3**
(Social/Demographic) 37.1 thousand photovoltaic residential systems have produced three hundred fifty megawatts, which supply more than 40,000 houses. In 2018, the costs to install and run a system like this were 17% smaller than in 2010. These factors provide more than a 90% reduction in electricity costs in a household. As a result, more people could acquire a system like that to supply their electric vehicles.	**(a) = 2** **(b) = 3**
(Economical) In Brazil, growth in electric vehicle sales went from 2356 in 2019 to 7568 just in the first semester in 2020. However, the entire national industry's sales fell by 40% and the units produced by 50%.	**(b) = 2** **(c) = 3**

Table 6
Potential threats and their possible impact levels.

Potential threats	Survey - choice of options on the scale
(Economic) The country's current economic crisis, deepened by the pandemic caused by Covid-19, has shown, among other indicators, the GDP retraction and the loss of the R$ (BRL) value. Projections for 2021 and 2022 remain negative. This scenario can harm the competitiveness of several links in the production chain of the electric and hybrid car industry.	**(e) = 5**
(Economic) The Brazilian general prices index to consumers (IPCA) has a projected growth for the year by September 2020, when it has accumulated 1,78% growth, the main index for the country's inflation. Another index called IGP-M (average general prices index) has accumulated 11,72% growth in the prices, causing a generalized rise in prices. With the prices improving, the Brazilian's purchasing power reduces significantly, dismaying the general consumers and their will to buy.	**(e) = 5**
(Social/Demographic) After researching Brazilians' knowledge about electric and hybrid vehicles, although most respondents agreed that these cars are quieters, high-tech, and have fewer polluters than combustion, many people replied that they would not buy such vehicles due to high prices. In Brazil, considering that most of the population has a meager income, the slightest change in prices affects their consumption. This elasticity is not an exception for electric and hybrid vehicles. Although the prices were at the same level as the fossil-fueled ones, 46% of the respondents said they would buy an electric or a hybrid car.	**(e) = 5**
(Economic) Brazil's energy consumption has reduced by about 14% due to the coronavirus pandemic. The automotive sector has identified a reduction of 65% of its energy consumption, the most expressive reduction in the county's economy. In April 2020, the country consumed 60,085 MW, the lowest amount for the last eight years. This reduction could affect the concern and attractiveness of investments in the sector, affecting its energy demand.	**(d) = 5**
(Social/Demographic) The next generations have different behavior when the subject is cars. Research showed that the youngest millennials, reaching their adult life through the next ten years, are less interested in vehicles as a consumption product. They are closer to the new transportation platforms like Uber and BlaBlaCar. The latest millennials have a considerably smaller income and job stability, affecting their cars' purchase power.	**(d) = 5**
(Ecologic) An analysis of the life cycle of conventional, hybrid, and electric vehicles, which includes their production, all involved logistics, usage and maintenance, and disposal, revealed that 50% of the CO_2 emissions of electric cars are held in their production. Even though their emissions are almost half of the combustion ones (118 g of CO_2 for each kilometer run against 229 g), their batteries' toxicity was a massive point of concern for science. However, they expect that some development in that area will be soon available.	**(e) = 3** **(d) = 2**
The other possible threats were about four scanning related to economic crisis due to coronavirus pandemic and how that affects the social inequality (which keeps its GINI index about 50 and has not changed its position for a long time). Other research about the high prices of electric and hybrid cars in Brazil corroborates this table's fourth and fifth items. Also, there is fledgling research on the usage of electric engines in logistic vehicles.	**(c) = 5**

a municipal level, the absence of specific sector policies and slow political discussions on existing projects were identified.

However, evaluating the economic data, the projections evaluated by the Brazilian Central Bank and IBGE, the economy of the country has an exciting power to grow in the future, with rates of 3% and above in the yearly GDP, showing that Brazil still has the potential to develop new segments of its economy. As technology continually develops for sustainable purposes worldwide, the sector has benefited from the available technology and its advancement to improve the vehicles' embarked technology, like the batteries and the range. The social segment also influences the evaluated sector because there is a potential demand for electric vehicles that awaits affordable prices or a more attractive cost-benefit relation.

The most substantial segment is the environmental one. The benefits promoted by the technology and the autonomy in electric vehicles have shown how Brazil has an immense potential to absorb electric vehicles in its fleet, mainly because of the green and sustainable power sources available in the country.

Those macro-environmental factors were analyzed to reveal how Brazil's government and industries are interested in developing electric and hybrid vehicles and how much they need to continue working to bring these vehicles to a joint status concerning the combustion ones.

The relevance of the results obtained in this research is highlighted by comparing similarities and differences with results of previous works, which also focused on the hybrid and electric vehicle industry in Brazil (Table 7).

In Table 8, the results obtained in this research using the PESTEL framework contrasted with other research that also used this method to analyze the macro-environment. Thus, one more contribution of the PESTEL framework is highlighted in understanding the macro-environment that influences the development of economic sectors related to energy.

5.1. Limitations

It is essential to mention that the PESTEL framework does not allow analyzing strategies for developing the electric and hybrid vehicle sector in Brazil. However, this tool allowed us to diagnose the structure of the Brazilian macro-environment and the factors that can positively and negatively influence the possibilities of expansion and development of the country's electric and hybrid vehicle industry. Thus, the result of this research may contribute to the proposition of strategies for the sector under study.

Although the PESTEL framework has contributed to analyzing the electric and hybrid vehicle industry's macro-environment, further studies are needed to understand the market's development potential better. Research in the competitive environment (industrial's dynamic and structure, competitiveness, substitutes, strength of suppliers and customers) and at the firm level (resources and capabilities) can be essential.

6. Final considerations

Electric and hybrid vehicles have existed since the end of the 19th century, and nowadays, those vehicles have assumed a potential position to help a country's sustainable development. This research focused on the macro-environment characterization to develop the electric and

Table 7
Comparing PESTEL Framework results with other studies about the electric and hybrid industry.

Macro-environmental factors for the development of electric and hybrid vehicles industry in Brazil	Other studies about the electric and hybrid vehicles industry
It was identified as many developed and under developing projects to implement Electric and Hybrid Cars in the streets, like EMOTIVE and other public investment calls by ANEEL.	Projects like EMOTIVE, VAMO, and Carroleve were some featuring examples of initiatives for developing battery electric vehicles in Brazil (Vargas et al., 2020).
Some research about developing charging stations through the Brazilian highways to permit long trips with the EVs has been developed.	The article presents a general study of the market, with many companies offering recharging stations and other companies in the electric sector providing those stations (Vargas et al., 2020).
This article has presented the general macro-environment influences that affect Brazil's electric and hybrid vehicles industry, presenting political, economic, social, technological, ecologic, and legal factors that define the industry's sustainable development scenario.	The study has shown a table with the main barriers to national development, like the financial, infrastructure, and public demand for battery electric vehicles (Vargas et al., 2020).
It presented the impacts of the Brazilian social segment on the industry, such as its low revenue household income and the refusal of the products' high prices.	It was shown that prices and unemployment are factors that affect the results of battery-electric cars in Brazil. It is projected that the prices and the maintenance costs may reduce (Vargas et al., 2020).
This article has presented how the infrastructure is concerning for developing the Brazilian electric and hybrid sector, mainly because of cost.	This research presented the challenges and opportunities of the Brazilian infrastructure as a challenge for developing these vehicles, including all costs involved (Castro and Ferreira, 2010).
A study about the cars' life cycle was identified, including the combustion engines and the electric and hybrids vehicles. The study presented how each type consumes energy and fossil fuels from the production to its disposal, being the batteries one of the most concerning electrics.	It was presented how the production chain could change with the electric and hybrid vehicles' strong presence in the streets. The batteries are the most challenging because technology is limited to lithium ionic ones, widely used by manufacturers (Castro and Ferreira, 2010).
The political scenario showed itself as favorable to the development of this industry in Brazil. Despite the process being lengthy and bureaucratic, it was presented that the government is worried about the future of transportation in the country, counting on electric and hybrid vehicles as a reasonable solution.	Many investments made by the government are propelling the development of new technology in the industry, such as new vehicles or clean fuel sources for a solution in the transportation system (Castro and Ferreira, 2010).
The results section presented the political and legal environment for the industry's development, including current on-discussion projects and existing laws.	The article presented some policies and laws present in Brazil, which affect the sector, such as vehicle tagging, reduction in pollutants emissions, public financing, and tax reduction in some cases. It has also suggested some policies for developing the sector, such as making the IPI (Industrialized Products Tax) incur under efficiency and not more under engine capacity (Vaz et al., 2015).
At the economic level, the Brazilian automotive industry has grown significantly in the last decades, although there were times of recession.	The study presents a correlation between a country's fleet size and its development, meaning that the automotive industry grows in the same rhythm as the national income and per capita (Baran and Legey, 2011).
Brazil's electric infrastructure is mainly supplied by renewable and sustainable sources such as water, wind, and solar photovoltaic. This infrastructure signifies that electric engines can perform an essential role in cleaning energy consumption with renewable sources.	A general discussion that the electric and hybrid vehicles, as for ecological reasons, are cleaner and more efficient (90% efficient against 40% in combustion engines) and the Brazilian electric system contributes for the ecological purpose as it is clean and mainly renewable (Baran and Legey, 2011).

hybrid cars industry in Brazil.

With an in-depth analysis of the political, economic, social, technological, ecological, and legal macro-environmental segments, it was possible to identify potential opportunities and threats in the Brazilian scenario. Those can potentially support or interfere in the growth and development of the country's electric and hybrid car market. The PESTEL Framework helps to analyze the macro-environment and, consequently, the strategic deliberation from decision-makers. Decision-makers recognize macro-environmental factors, which must be constantly monitored, as potential opportunities and threats.

Brazil has profitable segments that could impulse the electric and hybrid car industry. Technological and ecological segments are the leading positive influencers. Political and legal segments are positive forces for the sector, despite the current crisis faced in the country. However, it is expected that these segments can strengthen their support for the sector and, at the same time, influence the strengthening of factors in other macro-environmental segments.

On the other hand, the economic and social segments present the least amount of potential opportunities and the most significant amount of potential threats for the development of the industry. Considering the current health, economic and social crisis that the country is going through, it is expected that these macro-environmental segments will offer more potential opportunities in the medium and long term.

Generally, in Brazil, the electric and hybrid vehicles industry's future is exhibiting an optimistic scenario. It is a developing country with a growing transport sector and industrial activity sustained by renewable energy sources. Research and innovations are constantly being developed in the country and the world, allowing a rapid improvement in the technical and economic profile of the technologies used by electric and hybrid cars. The Brazilian population is a great potential consumer, as it has signaled its intention to change its shape and source of mobility, motivated by sustainability principles.

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CRediT authorship contribution statement

Gabriel Carvalho de Sousa: Writing – original draft, Methodology, Investigation, Data curation, Formal analysis, Conceptualization. **Juan Arturo Castañeda-Ayarza:** Methodology, Writing – review & editing, Conceptualization, Visualization, Supervision.

Table 8
Comparing the results with other studies that used the PESTEL Framework.

Macro-environmental factors for the development of electric and hybrid vehicles industry in Brazil	Other studies using the PESTEL Framework or macro-environment analysis
The scanned factors' discussions have implied in some data to the companies' decision-makers analyze and take a course of action. It also showed how the results compare to other segments, like energy and other developed studies.	The article presented a historical PESTEL analysis of the macro-environment in Brazil focused on the ethanol fuel sector. The influences of the different macro-environmental segments are identified and compared over decades for forty years (Castañeda-Ayarza and Godoi, 2020).
A PESTEL framework was used to help decision-makers identify potential opportunities and threats for developing electric and hybrid vehicles in Brazil.	The article presented an evaluation of the issues on the development of geothermal energy in China. For that, PESTEL Framework was used to determine the viability of the industry development in the country (Hou et al., 2018).
Some economic aspects have not shown a favorable scenario for the industry's development, mainly because of the current Brazilian economic crisis.	The economic segment was relevant and has shown positive and negative factors for the development of the ethanol industry in the period analyzed (Castañeda-Ayarza and Godoi, 2020).
The discussion and results presented a pessimistic scenario for the economic and social segments. In contrast, the political, technological, ecological, and legal presented an ideal atmosphere for developing electric and hybrid vehicles in Brazil.	The same result was presented in the analysis made for the ethanol fuel sector in Brazil. Social and economic factors were the most negatively shocking for the industry (Castañeda-Ayarza and Godoi, 2020).
An interpretation of the scanned factors and segments was made. It showed how they could affect the industry and the segment's future tendencies in the electric and hybrid vehicles industry.	A general discussion of the scanned factors' impacts showed how each segment supports or requires attention by incipient Brazil's corn ethanol industry (Silva and Castañeda-Ayarza, 2021).
Many policies have been identified in the political segment, showing concern and the difficulty of the Brazilian government in successfully developing the technology application.	China's Geothermal Energy development is in the same situation, with many policies under discussion but with almost no legal or policy mechanism to help develop the sector as a government concern (Hou et al., 2018).
The results of this research categorize the macro-environmental factors identified as potential opportunities and threats, which can contribute to the strategic decision-making process, whether in the public or private sector.	The study showed how Cyprus could acquire a more sustainable energy system in its hydrocarbon industry. The results were compiled in a SWOT analysis, crossing the opportunities and threats scanned with strengths and weaknesses identified in the hydrocarbon industry (Tsangas et al., 2019).

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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