

CURRENT SCENARIO AND FUTURE POTENTIAL OF HYBRID AND ELECTRIC VEHICLES IN THE BRAZILIAN AUTOMOTIVE SECTOR

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Abstract: The present work aims to present an overview that involves the electrification process of the road transport sector for passenger vehicles in Brazil, given the trend of decarbonization of this sector, discussing solutions adopted by some countries to encourage the growth of the fleet. electrified. The electrification of the road transport sector is a global trend and hybrid and electric vehicle sales are increasing every year. In 2022, the Brazilian fleet of hybrid and electric vehicles was approximately 126,000 units, with exponential growth projected to exceed 1 million units by 2030. Current constraints to increasing the fleet include limited charging infrastructure, insufficient government incentives, and the higher upfront costs of hybrid and electric models compared to internal combustion engine vehicles.

Keywords: Hybrid Vehicles; Electric Vehicles; Brazilian Market Potential; Vehicle Fleet Transition; Renewable Electric Matrix.

CENÁRIO ATUAL E POTENCIAL FUTURO DOS VEÍCULOS HÍBRIDOS E ELÉTRICOS NO SETOR AUTOMOTIVO BRASILEIRO

Resumo: Este trabalho tem como objetivo apresentar um panorama geral do processo de eletrificação do setor de transporte rodoviário de veículos de passeio no Brasil, tendo em vista o processo de descarbonização deste setor, discutindo soluções adotadas por alguns países para aumentar sua frota eletrificada. A eletrificação do transporte rodoviário é uma tendência mundial e as vendas de veículos aumentam a cada ano. Em 2022, a frota brasileira de veículos híbridos e elétricos era de aproximadamente 126 mil unidades, com projeção de crescimento exponencial para ultrapassar 1 milhão de unidades até 2030. As restrições atuais para o aumento da frota incluem infraestrutura de carregamento limitada, incentivos governamentais insuficientes e os custos iniciais mais altos dos modelos híbridos e elétricos em comparação com os veículos com motor de combustão interna.

Palavras-chave: Veículos Híbridos; Veículos Elétricos; Potencial do Mercado Brasileiro; Transição Energética; Matriz Elétrica Renovável.

1. INTRODUCTION

Electric and hybrid vehicles are considered a key technology for the decarbonization process of road transport. Since this sector contributed 16% of global pollutant emissions. The importance of electric vehicles for the reduction of GHG emissions and, consequently, lower consumption of oil-based fuels, is indisputable. However, internal combustion engines are still the main form of propulsion in road transportation today and the scenario indicates that they will be used on a large scale for the next decades [1,2].

In 2022, the sale of passenger electric cars reached 10 million units worldwide, which represents about 14% of global vehicle sales this year. In addition, the total number of EVs exceeded 26 million cars around the world. In Brazil, the electrification of the fleet is already happening, but more slowly when compared to developed countries. According to ANFAVEA, in 2022 around 49,000 new hybrid and electric vehicles were licensed, representing 2.5% of light vehicles sold this year [3,4].

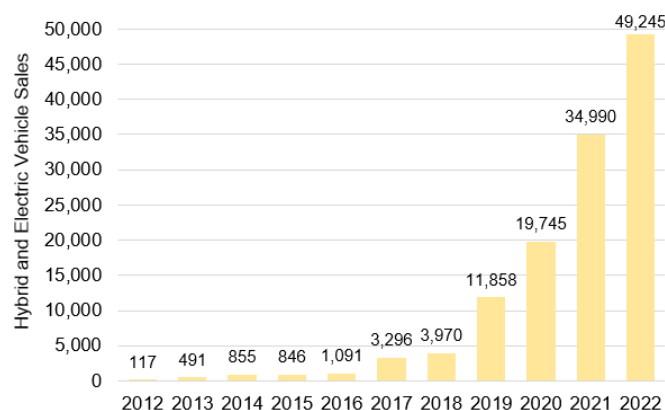
This paper examines the electrification process in Brazil's road transport sector, focusing on passenger vehicles, as part of the ongoing decarbonization trend. The review includes an analysis of the primary barriers hindering the development of the electric fleet in Brazil. Additionally, it explores the future prospects and potential growth of hybrid and electric vehicles in the Brazilian market.

2. BRAZILIAN SCENARIO OF VEHICLE ELECTRIFICATION

In 2021, according to the National Energy Balance (BEN), the transport sector was responsible for consuming 59.4% of all oil derivatives, which represents around 26% of the energy consumed in Brazil. In the same year, the transport subsector was responsible for emitting 47% of the greenhouse gases associated with the Brazilian energy sector. EVs produce low, or even zero, carbon emissions, are quiet, and also represent a possible technological breakthrough in the automotive industry [5,6,7].

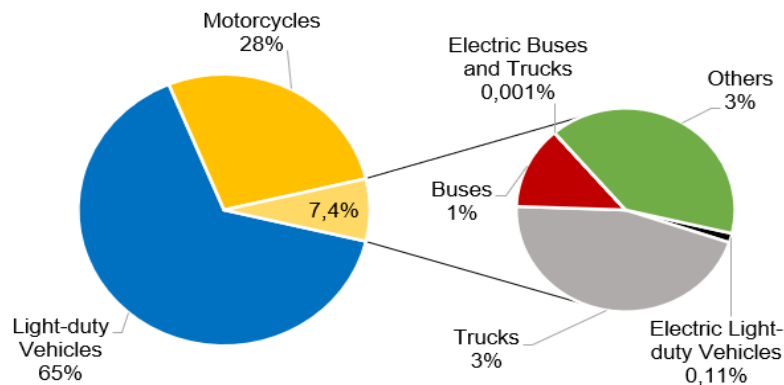
Figure 1 shows the number of EVs sold from 2012 to 2022 in Brazil, it can be seen that the increase was continuous, but it is still far below the number of vehicles powered by fossil fuels marketed in the same period, which only in 2022 reached 1.9 million cars [4].

Figure 1. Historical EV sales in Brazil (2012 to 2022)



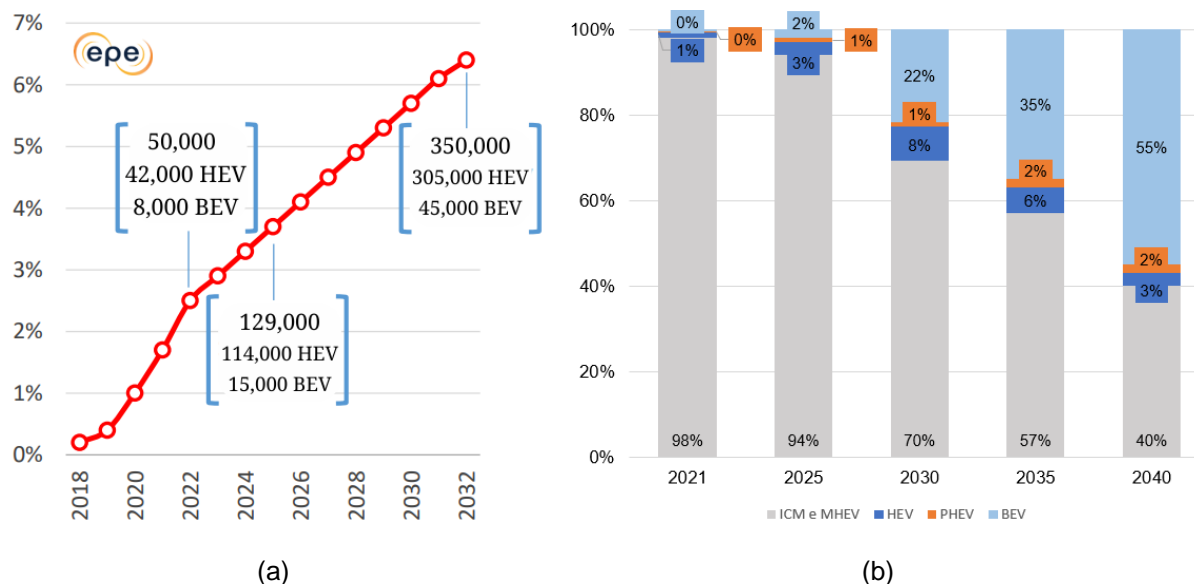
In 2022, Brazil had a total of 126.5 thousand hybrid and electric vehicles, which represents 0.11% of the 115 million cars circulating in the country. Meanwhile, electric buses and trucks represented 0.001% of the Brazilian fleet with 749 units. These data can be seen in Figure 2 [4,8,9].

Figure 2. Percentage of Electric Vehicles in the Brazilian Fleet (2022)



Brazil's electric fleet is still at an early stage of development and needs government incentives to continue growing. According to some projections by the Energy Research Company (EPE), linked to the Ministry of Mines and Energy, the fleet of HEVs and BEVs is expected to exceed one million units by 2030, and by 2032 the annual licensing of EVs will reach 350,000 vehicles, as shown in Figure 3(a). Around 97% of hybrids will be flex-fuel [10].

Figure 3. The projection for Hybrid and Electric Light Vehicle Sales in Brazil by 2032 (a) and 2040 (b)



Another projection by McKinsey & Company goes even further, estimating that by 2040 Brazil will have 11 million BEVs in circulation, which would represent around 55% of car sales, as can be seen in Figure 3(b). This would be an impressive growth in the Brazilian fleet, considering that at the end of 2022, only 8,400 BEVs were running on the country's roads [8,11].

A similar projection was conducted using the FWEMPS (Fleet-Based Well-to-Wheel Model for Policy Support), an advanced life cycle assessment model that

analyzes the system holistically, considering Brazil's unique characteristics. According to this study, the licensing of electric vehicles (EVs) is expected to exceed 1 million units by 2030. The total EV fleet is projected to reach 2.5 million vehicles in 2030, 14 million in 2040 and 17 million in 2050, as shown in Table 1 [12].

Table 1. Projection of Licensing and Total EV Fleet by 2050

Year	Licensed EVs	Total Fleet EVs
2023	76,652	120,406
2025	188,219	315,211
2030	1,064,006	2,587,095
2040	989,968	14,152,045
2050	1,027,912	17,064,586

3. THE CHALLENGES FOR BRAZIL

The main challenges for Brazil can be summarized in three key points: 1) The need for significant investment in charging infrastructure, 2) The need for effective government incentives, and 3) The high cost of electric vehicles. Additionally, there are other barriers to be considered such as the vast expanse of Brazilian territory, the different consumer markets of major cities and small/remote areas, and the income disparity concentrated in a small portion of the population [13].

3.1 DEVELOPMENT OF CHARGING INFRASTRUCTURE

One of the ways to sustain the growth of the electric fleet is the implementation of a reliable charging infrastructure, which will make these systems easily accessible to the entire population. Another reason for implementing a reliable recharging infrastructure is to reduce the phenomenon of range anxiety, which is the anxiety generated by the fear of not being able to recharge the EV before the battery discharges. Therefore, the main role of the government is to provide investments and minimize barriers to charging stations to develop in countries [1,13].

According to ABVE (the Brazilian Electric Vehicle Association), at the end of 2022, there were around 3,000 public and semi-public charging stations in Brazil. Some projections indicate that by 2025 there will be 10,000 charging points. However, according to the International Energy Agency (IEA), a ratio of 10 light electric vehicles per installed charging station is recommended, in addition to a supply of 1 kW per EV.

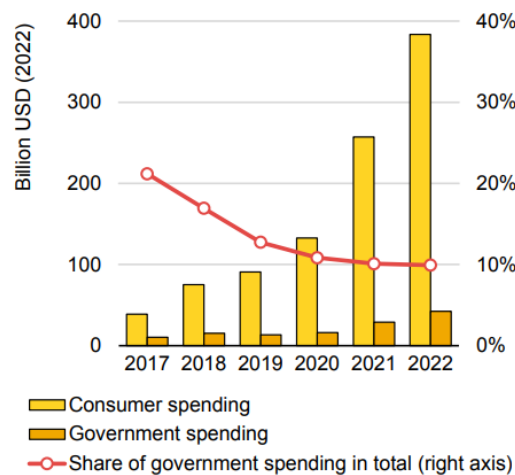
Between 2021 and 2022, around 30,000 BEVs and PHEVs were commercialized in Brazil. To follow the recommendation of 10 cars per charging station, at least 3000 new points need to be installed to serve only the vehicles licensed in that period. This shows that the development of charging infrastructure must grow to keep up with the current growth of the electric fleet. In February 2023, Bill No. 710/2023 was introduced, currently pending approval, with the primary objective of

installing charging points in both private and public parking lots. The proposal mandates that 5% of the spaces in private lots and 2% of the spaces in public lots must be equipped with chargers. The proposed bill aims to provide support to existing electric vehicle owners and promote the growth of a robust recharging infrastructure, thereby encouraging prospective buyers to opt for zero-emission vehicles [8].

3.2 GOVERNMENTAL INCENTIVES

In all major markets, subsidies have been offered for car purchases, and heavy investments have been made in the production of batteries/vehicles and the development of a charging network. Figure 4 shows consumer and government spending on electric vehicles, it can be seen that over time the trend is for the government to invest smaller percentages, while the consumer will spend more, as the market self-regulates and EVs achieve a greater market share in countries [1].

Figure 4. Consumer and Government Spending on Electric Vehicles (2017-2022)



The government has a key role in providing subsidies, investments in charging infrastructure, tax reduction/exemption, and other measures that are important for this new technology to establish itself in the market and overcome certain barriers that exist today. In Brazil, investments and subsidies to help EVs penetrate the market are still almost non-existent, since there are no federal programs. However, there have been some programs such as Inovar-Auto, Inova Energia and Rota 2030, as well as reductions in import taxes, Motor Vehicle Property Tax (IPVA), and other initiatives [7,13].

In 2018, the Rota 2030 - Mobility and Logistics program was launched, which is a direct replacement for Inovar-Auto. Companies that meet the metrics can enjoy a reduction in the IPI rate, import tax exemption on components that are not produced in the country, and incentives for R&D projects. The main objectives of the program are to establish mandatory requirements for vehicles marketed in the country, increase the energy efficiency of vehicle systems, and increase R&D investments, among others.

One measure taken in 2015 was to reduce the import tax on BEVs and hydrogen vehicles from 35% to zero. The only requirement is that the vehicles have a range of at least 80 km. For hybrid models, the tax varies from 0 to 7%, depending on the cylinder capacity of the vehicle and its energy efficiency. Another tax that is

totally/partially exempt is IPVA. However, as the tax is applied differently by each state, some offer a total or partial reduction, while others do not [13].

Several government incentives are being considered in the Brazilian legislature to promote the adoption of electric vehicles (EVs). Bill No. 403/2022 aims to grant Import Tax exemption for hybrid and electric vehicles until December 31, 2025. Additionally, Bill 392/2023 proposes that gas stations should provide charging points for electric vehicles. Currently, Brazil lacks well-established programs specifically designed to support EVs' market penetration, with most efforts focused on improving the efficiency of combustion engines [14,15].

3.3 HIGH PURCHASE COST

The cost of electric vehicles is still very high, compared to traditional cars, and this is one of the factors preventing a greater spread of electrified ones. As about 1/3 of the value is attributed to the battery, decreasing its production cost would also cause the price of the vehicle to be reduced. In the study conducted by the consulting firm McKinsey & Company, where 3,000 Brazilians were interviewed. One of the biggest barriers presented for the acquisition of an EV was the still high price. This has several causes, such as the high production value of electric vehicles and import and logistics values, since most EVs are imported into the country [11,13].

Lithium-ion (Li-ion) batteries are the most widely used in electric vehicles today, mainly due to their lower cost and higher performance. In 2010, this type of battery had a price of USD 1,200/kWh, however, it dropped to around USD 132/kWh in 2021. The trend is that lithium-ion (Li-ion) battery technology evolves and the cost decreases over the years. Consequently, EVs become cheaper, especially those powered by 100% electricity. Additionally, the insertion of new technologies can bring even greater improvements. Electric vehicles still have a high cost, whether in Brazil or around the world and depend on the technological evolution of aspects such as batteries for prices to be reduced. An important point that generates a cheapening of vehicles is the national production of components. In China, where there is a large production of batteries and several national automakers, BEVs cost, on average, 27,000 dollars, while in other markets this value is USD 50,000 [1].

4. CONCLUSION

The study reveals that electric vehicle (EV) technology in Brazil has shown progress in the past decade, but its growth remains slow compared to major markets like China, the United States, and Europe. The limited expansion is attributed to challenges in developing charging infrastructure, lack of government incentives, and high acquisition costs. Brazil can learn from successful projects in these international markets and adapt them to its context. Key actions include government investments in public charging stations, subsidies to facilitate EV purchases, and support for the domestic electric automotive industry to reduce costs. With its renewable energy matrix and biofuel capabilities, Brazil has the potential to emerge as a prominent player in electrified vehicle fleets and compete with homegrown solutions in the automotive market.

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