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OPPORTUNITIES AND THREATS FOR GROWING THE FLEET OF ELECTRIC PASSENGER VEHICLES: AN ANALYSIS UNDER THE PORTER'S FORCES
SDG 13.2

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Abstract
The global automotive industry is experiencing a disruptive transformation driven by the diffusion of battery electric vehicles (BEVs). While electric mobility is frequently presented as a direct route to decarbonization, its large-scale adoption depends on overcoming economic, technical, and infrastructural challenges. This study applies Porter’s Five Forces and SWOT frameworks to assess the opportunities and threats for expanding the fleet of electric passenger vehicles, with explicit reference to the Sustainable Development Goals (SDGs). The analysis is structured around four comparative criteria: (i) cost and economic feasibility, (ii) availability of raw materials and infrastructure, (iii) technical performance and consumer acceptance, and (iv) environmental impact. Recent evidence shows that battery costs have fallen from around USD 1,000/kWh in 2010 to below USD 150/kWh in 2020, approaching the threshold for cost parity with internal combustion engine (ICE) vehicles. Norway illustrates the potential of favorable policy and consumer acceptance, with more than 60% of new cars sold already electric. At the same time, concerns about raw material supply, grid integration, and charging infrastructure highlight ongoing barriers. Smart charging strategies are estimated to reduce peak demand by 30–40%, reinforcing the role of EVs in supporting energy system stability. In temporal terms, hybrid technologies remain relevant in the short term, BEVs are consolidating as the central medium-term pathway, and complementary solutions such as hydrogen fuel cells or advanced biofuels may play a role in the long term, particularly for heavy-duty segments. Overall, the results show that the transition to electric passenger vehicles aligns directly with SDG 7 (Affordable and Clean Energy), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action), but its success depends on coordinated industrial, technological, and regulatory actions.

Keywords: Electric Vehicles; Passenger Vehicle Fleet; SWOT Analysis; Porter’s Five Forces; Energy Transition; Charging Infrastructure; Consumer Behavior; Supply Chain; Battery Technology.

1 Introduction
The transport sector is one of the largest contributors to global greenhouse gas (GHG) emissions, with passenger vehicles representing a significant share of this impact (SACCHI et al., 2022). In response, governments and industries have intensified efforts to promote electrification as a strategy to reduce emissions and accelerate the energy transition. Electric vehicles (EVs) have emerged as a central element in these strategies, supported by technological advances, regulatory incentives, and shifting consumer preferences (AL-HANAHI et al., 2020; RIVERSO; ALTAMURA; LA

BARBERA, 2023). Over the last decade, the global EV market has grown rapidly, driven by subsidies, infrastructure expansion, and innovation in battery technologies (FIGENBAUM, 2022). In Europe, EV adoption has accelerated due to regulatory restrictions on internal combustion vehicles (ICVs) and the development of charging networks (PELEGOV; CHANARON, 2023). Similar patterns are observed in China and North America, where policies such as the Inflation Reduction Act in the United States reinforce industry transformation (MEHLIG et al., 2021).

Despite this progress, significant challenges persist. High acquisition costs, limited charging infrastructure, and dependency on critical raw materials such as lithium, cobalt, and nickel remain major barriers to large-scale adoption (ALI SAYED et al., 2022; KOROMA et al., 2022). Consumer concerns regarding vehicle autonomy, battery durability, and recycling practices further limit diffusion beyond early adopters (FEVANG et al., 2021; RIVERSO; ALTAMURA; LA BARBERA, 2023). Moreover, the coexistence of multiple propulsion technologies—including hybrids, biofuels, and hydrogen—suggests that electrification will not follow a linear trajectory but rather a plural and complex transition shaped by technological, economic, and social factors (STRUNGE KANY et al., 2022; CANDELARESI et al., 2021).

Given this context, a comprehensive framework is required to understand both the structural and competitive dynamics of the automotive industry. This study applies Porter's Five Forces to evaluate the competitive pressures influencing the growth of the electric passenger vehicle market, complemented by a SWOT analysis to identify opportunities and threats for industry stakeholders. Together, these frameworks provide a structured assessment of sectoral dynamics, highlighting how innovation, regulation, and market forces intersect in shaping mobility futures.

The analysis is directly aligned with the Sustainable Development Goals (SDGs), particularly SDG 7 (Affordable and Clean Energy), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action). To ensure clarity and comparability, the study adopts four explicit criteria for evaluation: (i) economic cost and feasibility, (ii) raw material availability and infrastructure readiness, (iii) technical performance and consumer acceptance, and (iv) environmental impacts, especially greenhouse-gas emissions. These dimensions provide a systematic basis for interpreting opportunities and threats in the expansion of electric passenger vehicle fleets.

2 Literature Review

The adoption of electric vehicles (EVs) has been widely discussed in the literature, with studies addressing regulatory frameworks, economic aspects, infrastructure readiness, consumer perspectives, and technological evolution. To provide a structured understanding of these contributions, this review is organized into four main themes: incentives to leverage the EV market, energy infrastructure and costs, consumer perspectives, and technological issues.

2.1 Incentives to Leverage the Electric Vehicle Market

Governmental policies and incentives are consistently identified as decisive factors in promoting EV adoption. Subsidies, tax exemptions, and regulatory restrictions have created favorable conditions for the diffusion of battery electric vehicles (BEVs) in several regions. In Norway, for example, tax exemptions, reduced tolls, and access to bus lanes have made EVs attractive, resulting in more than 60% of new car sales being electric in recent years (FIGENBAUM, 2022). In the United States, California pioneered the implementation of zero-emission vehicle (ZEV) mandates, which stimulated innovation and accelerated adoption (SANTOS; REMBALSKI, 2021). At the federal level, the Inflation Reduction Act reinforced incentives for EVs and domestic battery production, consolidating a supportive industrial policy (MEHLIG et al., 2021). The European Union followed a similar path by approving legislation to ban the sale of new internal combustion vehicles (ICVs) after 2035, further driving electrification (PELEGOV; CHANARON, 2023). While subsidies and regulatory mandates remain effective, some authors highlight risks of dependence on incentives, possible distortions in competition, and fiscal limitations that may affect long-term sustainability (CAULFIELD et al., 2022).

2.2 Energy Infrastructure and Costs

Although social and political pressures to reduce emissions have intensified, EV fleet expansion has not yet met projected targets, compromising environmental goals (POLLÁK et al., 2021). The literature emphasizes that government incentives should address the entire supply chain, from vehicle manufacturers to upstream suppliers of charging infrastructure and related services (VEZA et al., 2022; POLLÁK et al., 2021). Key challenges include building an effective supply chain, managing safety risks, and addressing uncertainties related to emerging technologies (VEZA et al., 2022).

Energy generation capacity and access to charging systems remain central issues (KOROMA et al., 2022). Infrastructure deficiencies, misinformation, and consumer concerns represent significant barriers to electromobility (POLLÁK et al., 2021). The environmental performance of EVs depends not only on battery size and material composition but also on the electricity mix used for charging (KOROMA et al., 2022). High population density further stresses urban electrical networks, increasing the risk of overload (RAMSEBNER et al., 2023). In this context, the use of railway refueling points for energy storage has been suggested as a strategy (KRUEGER; FLETCHER; CRUDEN, 2021). Additional infrastructure in hospitals, shopping centers, and parking facilities may also support charging expansion (BORGE-DIEZ et al., 2021).

Smart charging systems have the potential to reduce peak electricity demand by 30–40% (MANGIPINTO et al., 2022). Replacing 21% of conventional chargers with smart chargers can minimize network expansion costs (FIGENBAUM, 2022). Charging costs are approximately ten times lower at night, when electricity demand is reduced, and GHG emissions per kilowatt-hour are lower (BORGE-DIEZ et al., 2021). In Norway, fast chargers are already widely available, while in Denmark, around 78% of users prefer home charging, where costs are lower (THINGVAD et al., 2021).

The rapid increase in EV adoption also presents risks to electrical grids (ALI SAYED et al., 2022). A balance between EV fleet growth and grid capacity is required to prevent overloads (NOGUEIRA; SOUSA; ALVES, 2022; KRUEGER; FLETCHER; CRUDEN, 2021). Furthermore, grid vulnerability to cyberattacks has been identified as a significant risk (ALI SAYED et al., 2022). Integrating buildings and homes with EV charging systems can help mitigate peak demand (BORGE-DIEZ et al., 2021). In some regions, such as Indonesia, surplus grid capacity is already available to accommodate EV expansion (VEZA et al., 2022).

2.3 Consumer Perspective

Consumer behavior remains a decisive factor for EV diffusion. Studies indicate that cost, autonomy, and charging convenience are the main variables shaping consumer acceptance. In Norway, BEVs reached cost parity with fossil fuel vehicles when fuel, maintenance, and tax incentives were considered, accelerating mass adoption (FIGENBAUM, 2022). In emerging economies such as Malaysia and Indonesia, however, adoption is hindered by higher acquisition costs, lack of subsidies, and insufficient charging infrastructure (VEZA et al., 2022). Psychological factors also play a critical role: intentions to adopt EVs are influenced by uncertainty, environmental awareness, and social norms (RIVERSO; ALTAMURA; LA BARBERA, 2023). Early adopters tend to be wealthier and more environmentally conscious, while mainstream consumers remain cautious until concerns about costs, autonomy, and charging availability are addressed (FEVANG et al., 2021). In addition, circular economy issues such as battery recycling and second-life applications are increasingly important for consumer confidence and long-term acceptance (KOROMA et al., 2022).

2.4 Technological Issues

Technological advances determine not only the efficiency of EVs but also their acceptance in different markets. The SAE J1772 standard defines charging levels from domestic Level 1 systems to high-capacity public Level 3 chargers, illustrating the diversity of charging options and their implications for adoption, as illustrated on Table *1* (AL-HANAHI et al., 2020). Hybrid vehicles are widely available and provide flexibility in regions with limited charging infrastructure, but their greater weight, dual propulsion systems, and continued GHG emissions reduce long-term competitiveness (SANTOS; REMBALSKI, 2021; ZIÓŁKOWSKI et al., 2023).

Table 1 – Charger Classes

Charging Level	Level 1	Level 2	Level 3
Phase	Alternating current (AC), 1-phase	Alternating current (AC), 1 to 3 phases	Direct current (DC)
Tension (V)	120	230-440	≥400
Current (A)	10-16	16, 32, 63	Above 63
Power (kW)	1,4 a 1,9	3,7 a 22	≥44
Installation Type	Domestic	Domestic	Public

		Public	

Source: (Al-Hanahi, et al., 2020).

Biofuels, particularly ethanol in flex-fuel vehicles, are attractive for countries with strong agricultural sectors, offering partial decarbonization while relying on existing infrastructure. However, their scalability is constrained by land-use conflicts, food price volatility, and regulatory pressures in markets such as the European Union (STRUNGE KANY et al., 2022). Hydrogen vehicles, in turn, offer high autonomy and energy density, attracting industry and government support, particularly in Japan and South Korea. Despite these advantages, high costs, low well-to-wheel efficiency, and the lack of refueling infrastructure hinder widespread adoption (CANDELARESI et al., 2021).

3 Method

This study is based on a systematic review of the literature on electric passenger vehicles, focusing on opportunities and threats for their expansion under the framework of Porter's Five Forces. The search was conducted in the Scopus and ScienceDirect databases between March and July 2024, using keywords such as "electric vehicles," "battery electric vehicles," "EV adoption," "charging infrastructure," "Porter's Five Forces," and "SWOT analysis." Only open-access articles in English, published from 2019 onwards, were considered to ensure a focus on the most recent technological, regulatory, and market developments. Earlier works were included only when cited as seminal contributions.

The selection process followed three stages: (i) screening of titles and abstracts, (ii) full-text reading of eligible studies, and (iii) thematic categorization of the final sample. In the second stage, articles were refined by alignment with the research objectives. Papers were ordered by year and citation frequency, resulting in 1,448 citations. To balance distribution across years, a proportional selection rule of 40-30-20% was applied, leading to the inclusion of three papers from 2021, two from 2022, and one from 2023. The final dataset consisted of 36 articles, which were fully read and analyzed, as summarized in Table 2.

Table 2 - Number of articles in each research round

Database	**First Review**	**Second Review**	**Last Review**
Scopus (Elsevier)	1459	175	36

Source: Prepared by the authors (2023).

The results were examined through two complementary analytical frameworks. The SWOT analysis (Strengths, Weaknesses, Opportunities, and Threats) distinguishes between internal factors under firm control and external factors beyond firm control (PUYT et al., 2023; GÜREL; TAT, 2017). Porter's Five Forces evaluates industry competitiveness by analyzing rivalry among competitors, bargaining power of consumers, bargaining power of suppliers, threat of new entrants, and threat of substitutes (RODRIGUES FERREIRA PRATA et al., 2019; PORTER, 2008).

To ensure clarity and comparability across findings, the evidence was consistently structured around four criteria: (i) economic cost and feasibility, (ii) raw material availability and infrastructure readiness, (iii) technical performance and consumer acceptance, and (iv) environmental impacts, with particular emphasis on greenhouse-gas emissions. By combining SWOT and Porter's frameworks with these criteria, the study provides both a snapshot of the EV value chain and a structural assessment of its competitive environment.

4 Discussion

The SWOT analysis provided a comparative view of propulsion technologies in terms of their internal characteristics and external context. Battery electric vehicles (BEVs) emerged as central to the transition due to zero local emissions, lower operating costs, and strong policy incentives. Nevertheless, their competitiveness is limited by high acquisition costs, dependence on critical raw materials, and the fragility of global supply chains (SACCHI et al., 2022; AL-HANAHI et al., 2020; ALI SAYED et al., 2022). Opportunities include integration with smart grids, expansion of charging networks, and the ability to stimulate new industries, while threats involve infrastructure deficits, raw material shortages, and grid vulnerabilities (MANGIPINTO et al., 2022; RAMSEBNER et al., 2023).

Hybrid vehicles occupy a transitional position by combining lower GHG emissions and independence from exclusive charging infrastructure. Their main weaknesses lie in continued emissions, higher weight due to dual systems, and limited battery durability (SANTOS; REMBALSKI, 2021; ZIÓŁKOWSKI et al., 2023). While hybrids facilitate gradual consumer adaptation, their long-term viability is threatened by regulatory restrictions and the expansion of BEV infrastructure (VEZA et al., 2022).

Internal combustion vehicles (ICVs) still maintain strengths such as autonomy, affordability, and a mature infrastructure network. However, they are strongly associated with GHG emissions, noise, and air pollution, which undermine their role in a low-carbon future (LIU et al., 2022). Their opportunities remain linked to global availability of services and supply chains, but growing environmental policies, fuel price volatility, and potential bans after 2025 significantly threaten their competitiveness (MEHLIG et al., 2021; SACCHI et al., 2022).

Biofuel vehicles (Flex-fuel) show advantages in reduced emissions compared to fossil fuels and compatibility with existing distribution systems, especially in agricultural economies. Nonetheless, they face structural weaknesses such as land-use competition with food production, high consumption rates, and price instability (STRUNGE KANY et al., 2022; SACCHI et al., 2022). Opportunities include ethanol fuel cells and transitional policy support, but threats arise from EU restrictions and the volatility of agricultural markets.

Hydrogen vehicles stand out for autonomy, energy density, and strong policy support in countries such as Japan. Still, high production costs, low well-to-wheel efficiency, and safety concerns limit their competitiveness (CANDELARESI et al., 2021; ALI SAYED et al., 2022). Their opportunities lie in long-distance transport and integration into the hydrogen economy, while threats include lack of refueling infrastructure and increasing competition from BEVs (POLLÁK et al., 2021; VEZA et al., 2022). All this represented in Table *3*.

Table 3 - SWOT Comparison of Propulsion Technologies

Vehicle	Strengths (S)	Weaknesses (W)	Opportunities (O)	Threats (T)
Battery (BEV)	- Zero local emissions - Convenience of home charging - Lower operating costs - Supported by strong government incentives	- High cost (battery ≈30% of total) - Battery durability and costly replacement - Long charging times - Need critical raw materials	- Integration with power grid as storage buffer - New policy support/subsidies - Expansion of charging - Stimulate new industries/jobs	- Insufficient charging infrastructure - Electrical grid constraints - Supply chain for batteries and components - Risk of raw material shortages
Hybrid	- Lower GHG emissions than ICV - Independence from exclusive charging networks - Available from different MFG	- Still emits GHGs - Higher weight due to dual motor - Limited battery durability - Higher costs than ICVs	- Transitional technology to BEV - Facilitates consumer adaptation - Allow infrastructure development	- Efficiency improvements in ICVs - Expansion of BEV charging networks reduces competitiveness - Risk of regulatory phase-out
Fossil fuel (ICV)	- High autonomy - Wide range of models available - Lower acquisition cost - Mature global infrastructure	- High GHG emissions - Noise and air pollution - Dependence on fossil fuel - Exposure to carbon taxes/penalties	- Known and established technology - Global availability of services and spare parts - Large existing consumer base	- Energy transition policies/regulations - New cleaner technologies - Fuel price volatility - Regulatory bans (>2035, EU)
Biofuel (Flex-fuel)	- Lower GHG than fossil fuels - Higher engine power - Compatibility with existing engines - Uses established fuel infrastructure	- Still emits GHGs - Competition with food production - High consumption levels - Price volatility	- Integration with ethanol fuel cells - Role in transitional energy policies - Agricultural economies - Synergy with existing Supply Chain	- Fluctuating biofuel costs - Food price impacts - EU energy transition restrictions - Risk of reduced competitiveness versus BEVs
Hydrogen	- High driving autonomy - High energy density - Fast refueling compared to BEVs	- High production and acquisition cost - Limited global availability - Lower well-to-wheel efficiency than BEVs - Safety and handling risks	- Expansion of the hydrogen economy - Policy and industry support (e.g., Japan, Toyota) - Potential role in heavy-duty and long-distance transport	- Lack of refueling infrastructure - High costs compared to BEVs - Uncertain economic viability - Risk of being outpaced by battery technology improvements

Source: Elaborated by the authors (2023).

The Porter's Five Forces analysis highlights the structural challenges influencing the competitiveness of electric passenger vehicles, as illustrated on Table *4*.

Table 4 – Porter's Five Forces Analysis for the EV Market

Force	Key Findings
Rivalry among competitors	- Intense rivalry due to coexistence of BEVs, hybrids, biofuels, hydrogen, and ICVs - BEVs gaining market share with falling battery costs - ICVs still dominant due to infrastructure maturity and lower costs - Competition reinforced by global automakers' diverse strategies
Bargaining power of suppliers	- High concentration of battery suppliers in few countries, mainly China - Dependency on critical raw materials (lithium, cobalt, nickel) - Falling battery prices (from ~USD 1,000/kWh in 2010 to ~USD 100–150/kWh in 2020) reduce costs but not dependency - Supplier dominance poses strategic and geopolitical risks
Bargaining power of consumers	- Early adopters are wealthier and environmentally conscious - Price sensitivity remains a barrier for mass adoption - Concerns about autonomy, charging convenience, and lifecycle costs influence decisions - Increasing demand for sustainability, circular economy, and second-life battery solutions
Threat of new entrants	- High capital intensity of R&D and infrastructure limits new players - Potential for disruption through innovations (solid-state batteries, bidirectional charging, hydrogen fuel cells) - Start-ups face barriers, but partnerships and niche markets create opportunities
Threat of substitutes	- Hybrids, synthetic fuels, and more efficient ICVs act as partial substitutes - Public transport, micromobility, and shared mobility services may reduce car demand - Substitutes can delay or reduce EV adoption in regions with weak charging infrastructure

Source: Prepared by the authors (2023).

Rivalry among competitors is intense due to the coexistence of BEVs, hybrids, biofuels, hydrogen, and ICVs. BEVs have gained momentum with declining battery prices (FIGENBAUM, 2022; MANGIPINTO et al., 2022), while ICVs maintain dominance through mature infrastructure and lower acquisition costs (SACCHI et al., 2022). This dynamic forces manufacturers to pursue diversified strategies to remain competitive (PORTER, 2008).

The bargaining power of suppliers is significant, particularly in the battery segment. Production is highly concentrated in a few countries, mainly China, which increases vulnerability to geopolitical risks (AL-HANAHI et al., 2020). Although lithium-ion battery prices fell from around USD 1,000/kWh in 2010 to near USD 100–150/kWh in 2020 (FIGENBAUM, 2022), dependence on critical raw materials such as lithium, cobalt, and nickel continues to represent a structural risk (ALI SAYED et al., 2022).

Consumers exert growing influence on market dynamics. Early adoption has been concentrated among wealthier and environmentally conscious groups (FEVANG et al., 2021; RIVERSO; ALTAMURA; LA BARBERA, 2023). Wider acceptance, however, remains dependent on affordability, autonomy, and charging convenience. In addition, consumer expectations increasingly extend to sustainability practices, such as battery recycling and second-life applications (KOROMA et al., 2022).

The threat of new entrants is mitigated by the high costs of R&D and infrastructure. Nevertheless, disruptive innovations—such as solid-state batteries, bidirectional charging, and hydrogen fuel cells—create opportunities for specialized firms and partnerships (VEZA et al., 2022; PORTER, 2008). Developing countries barriers to BEV are even stronger (costs, infrastructure) (VEZA et al., 2022).

Finally, the threat of substitutes persists through hybrids, synthetic fuels, and more efficient ICVs, which can delay the full electrification of fleets (SANTOS; REMBALSKI, 2021; ZENG et al., 2021). Broader alternatives such as public transport, micromobility, and shared mobility services also compete with EV adoption by offering non-car mobility solutions (POLLÁK et al., 2021).

Taken together, these findings emphasize that EV adoption is not merely a technological challenge but a systemic transformation involving supply chains, infrastructure readiness, regulatory frameworks, and social acceptance. The analysis also shows that opportunities and threats can be consistently interpreted across four criteria: economic cost and feasibility, raw material and infrastructure availability, technical performance and consumer acceptance, and environmental impacts, particularly GHG emissions. While BEVs lead in the short term, hybrids, hydrogen, and biofuels maintain relevant roles as complementary solutions in specific contexts.

Policymakers and industry leaders must therefore align incentives, infrastructure investment, and innovation strategies to mitigate threats while leveraging opportunities for a balanced and sustainable mobility transition (SACCHI et al., 2022; MANGIPINTO et al., 2022). This staged transition is consistent with SDG 7 (Affordable and Clean Energy), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action), reinforcing that the electrification of fleets requires both immediate actions and long-term systemic solutions.

5 Conclusion

This study applied SWOT and Porter’s Five Forces analyses to evaluate the opportunities and threats for the expansion of electric passenger vehicles. The results indicate that while BEVs have consolidated as the central pathway for fleet decarbonization, the transition is not linear and will involve a combination of technologies shaped by cost, infrastructure, raw materials, and consumer acceptance.

In the short term, hybrid vehicles and biofuels remain relevant as transitional solutions, facilitating consumer adaptation and leveraging existing infrastructure. In the medium term, BEVs emerge as the most robust alternative, supported by rapid battery cost reductions, policy incentives, and growing charging networks. In the long term, complementary technologies such as hydrogen fuel cells and advanced biofuels may play a strategic role, especially in heavy-duty transport and regions where electrification faces structural barriers.

The analysis demonstrates that the trajectory of EV adoption is best understood when assessed across four comparative criteria: (i) economic cost and feasibility, (ii) raw material availability and infrastructure readiness, (iii) technical performance and consumer acceptance, and (iv) environmental impacts, particularly GHG emissions. These dimensions provide a systematic lens for interpreting opportunities and threats, ensuring comparability across studies and contexts.

From a broader perspective, the staged transition of passenger vehicle fleets is directly aligned with the Sustainable Development Goals—SDG 7 (Affordable and Clean Energy), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action). The findings reinforce that the electrification of transport is not only a technological pathway, but also part of a global sustainability agenda requiring coordinated industrial, regulatory, and societal actions.

Final consideration: Policymakers and industry leaders must design incentives, infrastructure investments, and innovation strategies that account for the coexistence of multiple propulsion technologies, while researchers should expand lifecycle and comparative analyses. This combined approach is essential to ensure that the diesel-to-electric transition remains technically feasible, economically viable, and environmentally sustainable in the decades to come.

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