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Growth and Challenges of Electric Vehicles in India: An In-Depth Study

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Abstract: *The future of Electric Vehicles (EVs) in India represents a paradigm shift towards sustainable transportation and reduced carbon emissions. With rising environmental concerns, government initiatives, and technological advancements, India is poised to witness significant growth in the EV sector. This paper highlights the current scenario, government policies, challenges, block diagram representation, and future prospects of electric vehicles in India. Since EVs are roughly three to four times more efficient than comparable internal combustion engine vehicles (ICEV), have zero tailpipe emissions, and are less dependent on petroleum due to their high fuel diversity, vehicle electrification is revolutionizing the transportation sector in terms of energy and the environment. The creation of power is flexible. The power industry and the larger energy system are both significantly impacted by vehicle grid connection. Additionally, the Indian government intends to expand the use of electric vehicles in the automotive sector. This essay discusses the prospects and difficulties facing the Indian market for electric automobiles. This study discusses the various economic, social, technical, and environmental variables influencing the Indian market for electric vehicles.*

I. INTRODUCTION

To promote EVs, the Indian government has launched a number of programs and laws, including the Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) scheme. Electric vehicles (EVs) have a bright future in India, where they have the potential to revolutionize the automotive industry and make a substantial contribution to sustainable development. With the help of government programs like tax breaks and the construction of EV-friendly infrastructure, India's drive for electric Air pollution, energy security, and reliance on fossil fuels are growing issues for India, the world's third-largest vehicle market. Because they promote clean mobility and lower greenhouse gas emissions, electric vehicles (EVs) offer a workable option. mobility has accelerated in recent years.

II. LITERATURE REVIEW

This article is important for comprehending India's EV policy environment and how the industry has been shaped by government incentives. In the larger framework of India's EV transition, it emphasizes the importance of government measures in removing initial cost obstacles. [1] Understanding the technological obstacles to EV adoption in India requires reading this study. It draws attention to the significance of developments in battery technology, which are closely related to the price and functionality of EVs. Given that India's dependence on imported battery components may limit EVs' scalability, this study offers crucial insights into the country's technological prospects and constraints..[2] Understanding the future of battery technology in the Indian EV industry is made much easier by this article. Solid-state batteries are a cutting-edge technology that has the potential to solve many of the present issues with EVs in India, even if lithium-ion batteries now control the majority of the market. The long-term technology developments that will influence the EV market are discussed in this study. [3] Understanding customer behavior and market dynamics in India's quickly expanding electric two-wheeler sector requires reading this article. Since this market category accounts for a sizeable portion of the Indian EV industry, manufacturers and authorities hoping to increase adoption would find the study's data useful. [4] This report is essential to comprehending the infrastructural issues impeding India's EV adoption. Anyone researching EV expansion in the nation should read this paper since it provides practical answers for resolving the pressing problem of charging stations, which continues to be a barrier. [5] An extensive economic analysis of EV adoption in India is presented in this study. It talks about financial incentives and cost dynamics, providing insightful information about how India might lower the cost of EVs for the general public. [6] The improvement of air quality in metropolitan areas, where vehicle emissions are a significant source of pollution, is also included in the research. The study promotes stricter laws and incentives to hasten the switch to electric vehicles, particularly in high-emission industries like logistics and public transit. This report is important for comprehending how India's adoption of EVs affects the environment. It supports India's environmental objectives and offers useful information on how EVs might help lower the nation's carbon footprint. [7]

III. TAXONOMY OF ELECTRIC VEHICLES

In general, EVs they are sorted in five types according to their engine's technology.

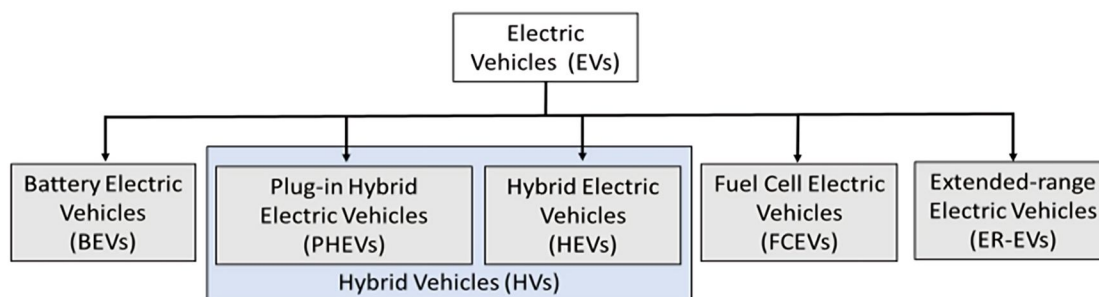


Figure1 Classification of Electric vehicles

Classification of Electric vehicles according to their engine technologies and settings

Battery Electric Vehicles (BEVs): vehicles 100% are propelled by electric power. BEVs do not have an internal combustion engine and they do not use any kind of liquid fuel. In order to give the vehicle an acceptable autonomy, BEVs normally use large packs of batteries. A typical BEV will reach from 160 to 250 km, although some of them can travel as far as 500 km with just one charge. An example of this type of vehicle is the Nissan Leaf [1], which is 100% electric and it currently provides a 62 kWh battery that allows users to have an autonomy of 360 km. **Plug In Hybrid Electric Vehicles (PHEVs):** hybrid vehicles are propelled by a conventional combustible engine and an electric engine charged by a pluggable external electric source. PHEVs can store enough electricity from the grid to significantly reduce their fuel consumption in regular driving conditions. The Mitsubishi Outlander PHEV [2] provides a 12 kWh battery, which allows it to drive around 50 km just with the electric engine. However, it is also noteworthy that PHEVs fuel consumption is higher than indicated by car manufacturers [3].

IV. CURRENT SCENARIO OF EVS IN INDIA

Over the past five years, the Indian EV market has grown remarkably. Industry statistics indicate that while electric automobiles and buses are slowly gaining traction, sales of electric two-wheelers and three-wheelers now dominate the market. Numerous new and well-established automakers are making investments in EV production and infrastructure for charging.

V. GOVERNMENT POLICIES AND INITIATIVES

The Indian government's continued commitment to promoting electric transportation included the announcement of additional EV tax breaks in 2025. The Goods and Services Tax on electric cars will be lowered from 5% to 3% as part of these measures, and batteries for electric vehicles will also be free from extra excise duties. It is anticipated that this tax cut would drastically lower the initial cost of EVs, opening them up to a wider range of Indian consumers. Furthermore, by encouraging local production and drawing in foreign manufacturers, these cutbacks are anticipated to increase domestic EV manufacturing. The Indian government has started a number of programs to encourage the use of EVs. Important programs include state-level subsidies, the FAME-II scheme, and the Production Linked Incentive (PLI) for battery manufacture. Moreover, EV GST has been reduced.

VI. CHALLENGES IN EV ADOPTION

The transition to electric vehicles (EVs) in India presents significant promise in terms of reducing carbon emissions, decreasing dependence on fossil fuels, and fostering sustainable growth in the automotive sector. However, despite the growing momentum and government incentives, the adoption of electric vehicles in India faces several critical challenges. These obstacles, ranging from infrastructure limitations to consumer perceptions, must be addressed to enable the widespread adoption of EVs. This section explores the key challenges hindering EV adoption in India:

A. Limited Charging Infrastructure

One of the most significant barriers to EV adoption in India is the insufficient charging infrastructure. Unlike traditional vehicles that rely on petrol stations, EVs depend on electric charging points. However, India has an inadequate number of public and private charging stations, particularly in smaller cities and rural areas.

The lack of widespread, easily accessible, and fast-charging infrastructure contributes to range anxiety, which remains a primary concern among potential EV buyers. The government's efforts to promote charging infrastructure are ongoing, but the pace of growth is not fast enough to meet the demand for EVs as they become more mainstream.

B. High Initial Purchase Cost

Although the total cost of ownership for electric vehicles is lower in the long term (due to savings on fuel and maintenance), the upfront cost of EVs remains a significant deterrent for Indian consumers. EVs are typically priced higher than their internal combustion engine (ICE) counterparts, mainly due to the high cost of the lithium-ion batteries that power them. While the government offers subsidies and incentives under schemes like FAME-II, the price sensitivity of Indian consumers, especially in the lower and middle-income brackets, remains a considerable challenge. For EVs to gain mass adoption, there is a need for continued price reductions, both through technological advancements and increased production capacity.

C. Limited Battery Technology and Charging Time

The efficiency and range of batteries in electric vehicles are still a concern. Although battery technology has significantly improved over the years, EVs in India are still largely dependent on lithium-ion batteries, which can take hours to fully charge and offer limited range compared to petrol or diesel vehicles. Range anxiety is particularly pronounced in India, where long-distance travel is common, and the availability of charging stations is sparse. Additionally, battery degradation over time remains an issue, as batteries lose capacity, affecting the performance and lifespan of the vehicle.

D. Lack of Consumer Awareness and Perception

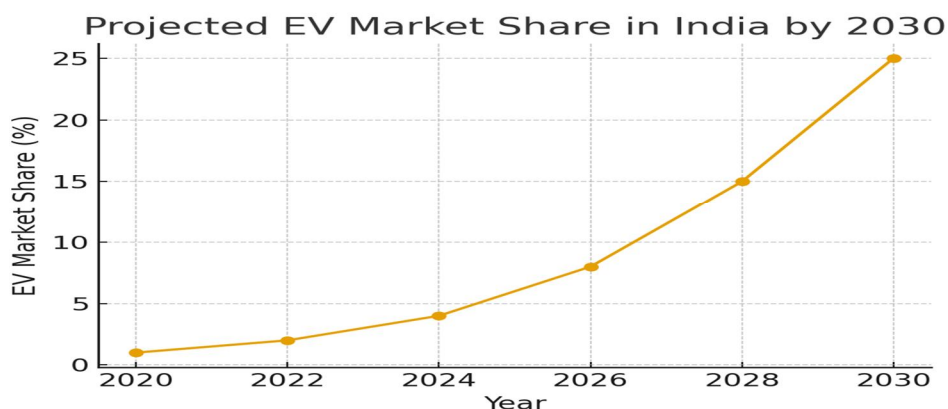
Despite the environmental benefits of EVs, there remains a general lack of awareness among the Indian public regarding the advantages of electric vehicles. Many consumers still view electric cars as niche products and are concerned about their reliability, performance, and maintenance. There is also a perception that EVs are too expensive and not suited to Indian driving conditions, which are often characterized by poor roads and hot climates. As a result, many potential buyers are hesitant to invest in an EV without a clear understanding of its benefits and potential savings.

E. Limited Availability of EV Models

While the market for electric vehicles is expanding, the availability of EV models is still limited compared to traditional vehicles. India's automotive market is predominantly dominated by small, affordable vehicles, and the electric vehicle segment has mostly focused on premium or niche models. Although there are efforts to develop more affordable EV options, limited model variety restricts consumer choice and adoption. Additionally, the absence of affordable **electric** two-wheelers and commercial vehicles further hampers market penetration.

VII. FUTURE PROSPECTS AND OPPORTUNITIES

India's EV industry has immense growth potential due to rising fuel prices, technological advancements, and global climate commitments. By 2030, it is projected that EVs will contribute significantly to the automobile sector. The graph below shows projected EV adoption trends.



VIII. CONCLUSION

The future of Electric Vehicles in India is promising, driven by supportive policies, innovation, and growing awareness about environmental sustainability. However cooperation between the government, business community, and consumers will be necessary to overcome economic and infrastructure obstacles. India has the potential to become a worldwide leader in the EV revolution with careful preparation.

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