Original Article
ISSN (Online): 2582-7472

ShodhKosh: Journal of Visual and Performing Arts
March 2024 5(3), 2078–2086

E-MOBILITY IN INDIA: FROM TRANSITION TO TRANSFORMATION

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DOI
10.29121/shodhkosh.v5.i3.2024.6226

Funding: This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

ABSTRACT

Conventional fuels have been utilised for transportation for more than a century, and throughout that time they have caused major environmental and humanitarian problems. Continuous use of conventional fuels causes air pollution, greenhouse gases and respiratory illnesses in humans resulting in premature deaths. There is a need to transition from convenional fuels and toward cleaner, greener alternative fuels. The purpose of this study is to look into the evolution, current policy scenario and future prospects of electric automobiles in India. This paper is conceptual in nature. Data is gathered from a variety of secondary sources, such as websites and reports. More accessibility to alternative fuels to the public by expanding fuel infrastructure and educating the public about the environmental and financial benefits of alternative fuels, the government can increase the likelihood of alternative fuel adoption.

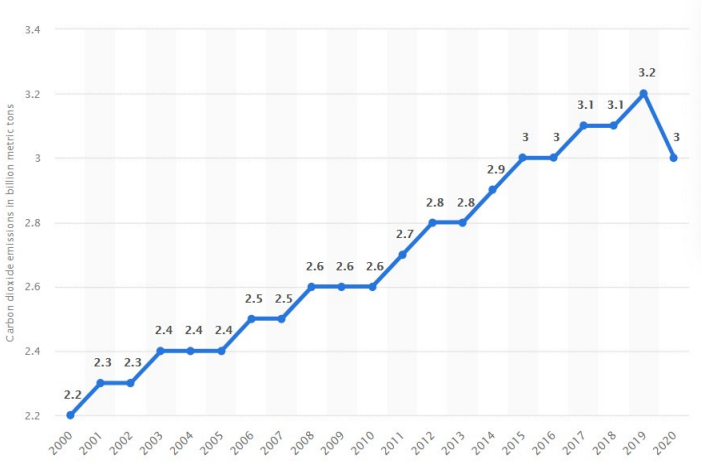
Keywords: Alternative Fuels, Electric Vehicle, Electric Car, E-Mobility, Fame Scheme

1. INTRODUCTION

For more than a century, fossil fuels have met most of the energy needs to power our automobiles. Issues such as global warming, respiratory diseases, air and water pollution, using fossil fuels for energy has had a significant influence on humans and on the environment also.

Because these fuels are made from the fossilised remains of plants and animals that flourished millions of years ago. The terms “fossil fuels” refer to coal, crude oil, and natural gas. Because of their origin, fossil fuels have a very high carbon concentration.

When these fuels are burnt, they release a substantial amount of CO2 (Carbon Dioxide). Carbon emissions cause climate change by trapping heat in the atmosphere. Meanwhile, fossil fuel–powered automobiles are the primary sources of smog-causing carbon monoxide and nitrogen oxide.



Source: Statista 2021, Ian Tiseo, Oct 14, 2021

Figure 1 Carbon dioxide (CO2) (in billion metric tons BMT) emissions from passenger cars globally from year 2000 to year 2020.

From Fig. 1 Passenger automobiles released roughly 3 billion metric tons of CO2 globally in the year 2020, according to estimates. Throughout the last two decades, passenger vehicle emissions have continuously increased, rising from 2.2 BMT (billion metric tons) in 2000 to a high spot of 3.2 BMT. CO2 emissions decreased by around 6% in 2020 due to COVID-19 pandemic, which had caused huge transportation delays.

The fact that traditional fuels such as oil and petroleum will ultimately run out is one of the key reasons why people are turning away from them. Many individuals are concerned about the future of conventional fuels, which are typically non-renewable.

However, we are not doomed to a future based on fossil fuels. Over the last decade, a significant progress has been made in increasing renewable energy and improving energy efficiency.

As a 'green' move, alternative fuels are being adopted as a preferable energy source, mainly in the transportation sector. This movement is gaining traction because alternative fuel cars emit fewer emissions, which is beneficial because emissions contribute to smog, air pollution, and global warming. Alternative fuels are also gaining popularity due to their long-term viability, which allows countries to become energy self-sufficient.

1.1. ALTERNATIVE FUELS

A vehicle which operates on a fuel other than traditional fuels (petrol/diesel) is known as an alternative fuel vehicle; the term also refers to any engine-powering technology that isn't wholly dependent on petroleum (e.g. electric car, hybrid electric vehicles, and solar-powered vehicles). Many administrations and vehicle producers throughout the globe have prioritised the development of cleaner alternative fuels and improved power systems for automobiles due to a variety of factors, including environmental concerns, high oil prices, and the potential of peak oil.

Because conventional fuels are so hazardous, new fuels must be developed if we are to continue driving our automobiles. Alternative-fuel vehicles are more expensive than regular vehicles, but as we find better ways to build them, they will become more inexpensive.

1.1.1. ELECTRIC VEHICLES (EVS)

An electric vehicle (EV) is a car that runs on an electric motor instead of a regular internal combustion engine. The motor may get its power from a number of different places, but the main thing that makes it different is that it uses an electric powertrain to move. People like electric vehicles (EVs) because they are good for the environment as they don't emit much or any exhaust emissions and because they perform better.

There are four main types of electric cars, and each one uses a different way to combine electric and gas power sources:

1) Battery Electric Vehicles (BEVs)

These cars only use an electric motor that gets its power from a large, rechargeable battery pack. Because they don't have an internal combustion engine, fuel tank, or exhaust system, they don't give off any tailpipe emissions. A BEV has to be connected to an external power source, either a house outlet, a specialized home charger, or a public charging station, to recharge.

2) Hybrid Electric Vehicles (HEVs)

A hybrid electric vehicle has both a regular internal combustion engine and an electric motor. Unlike BEVs, HEVs cannot be plugged in to recharge. The gasoline engine charges the battery that drives the electric motor, and regenerative braking does the same thing. This method takes kinetic energy that would ordinarily be wasted when you brake and turns it back into electricity. The electric motor mainly helps the gasoline engine by giving it more power when it speeds up or moving the car at extremely low speeds. This makes the car far more fuel-efficient and less polluting than regular gasoline-only cars.

3) Plug-in Hybrid Electric Vehicles (PHEVs)

Hybrid with a plug Electric vehicles fill the gap between BEVs and regular hybrids. They have an internal combustion engine and an electric motor, just as HEVs. PHEVs, on the other hand, have a bigger battery that can be charged by connecting it into an outside power source. This gives them the option of using either electric or gasoline power. A PHEV can run on electricity alone for a given distance, which is usually enough for a daily commute. Once the battery runs out, the car automatically converts to the gasoline engine, eliminating "range anxiety" on lengthy journeys. Drivers may use less petrol with this dual-power system, or even none at all for short trips.

4) Fuel Cell Electric Vehicles (FCEVs)

Fuel Cell Electric Vehicles are a special kind of electric vehicle that gets its power from a fuel cell. They don't keep power in a big battery. Instead, they keep compressed hydrogen gas in a tank. The fuel cell uses an electrochemical process to mix this hydrogen with oxygen from the air to make electricity, which powers the electric motor. The only thing that comes out of this process is water vapor, which means that FCEVs are vehicles with no emissions. Like gasoline cars, FCEVs can be refuelled in a few minutes, but they still need fuel from an outside source. The biggest problem with this technology is that the infrastructure for hydrogen refuelling is still being built and is not very widespread.

1.2. THE ELECTRIC VEHICLE REVOLUTION TODAY

Increased production and use of electric vehicles appear inevitable in today's period, which is plagued by challenges of global warming and a focus on reducing carbon emissions.

According to a McKinsey study, the electric vehicle sector will explode by 2030, with sales in the United States increasing by 32%, China increasing 7 % to 34%, and Europe increasing by 5 to 6 times. In India, we may anticipate 30 percent of automobiles becoming electrified by 2030.

EVs are now available in two-wheelers, three-wheelers, and four-wheelers, and they have penetrated the car sector. Many of the industry's top electric leaders are setting the pace for the EV revolution.

The electric vehicle (EV) revolution is rapidly transforming the global automotive landscape, moving from a niche market to a significant force in the transportation sector. Driven by a combination of technological innovation, supportive government policies, and growing environmental awareness, EVs are becoming an increasingly common sight on roads worldwide.

The electric vehicle (EV) revolution in India is a dynamic and rapidly evolving phenomenon, marked by significant growth in sales, supported by an expanding ecosystem of manufacturers and technological advancements (ICRA, 2023). As of December 2023, the country has made considerable strides, although challenges remain.

Market Overview and Sales Data

- **Overall Sales Growth:** 2023 marked a significant milestone for electric vehicle sales in India. Approximately 1.53 million electric vehicles were sold, marking an impressive 49% growth compared to 2022 (ICRA, 2023).

The increase in growth has raised the share of electric vehicles in total vehicle sales to 6.4%, a significant jump from only 1.2% in 2019 (ICRA, 2023).

- Segment-wise Dominance: In India, the electric vehicle market is largely shaped by two and three-wheelers, playing a crucial role in connecting people to their destinations and facilitating personal travel.
- Electric Two-Wheelers (E2W): This segment represented the biggest portion of EV sales, comprising 56% of the overall total (Society of Manufacturers of Electric Vehicles, 2023).
- Electric Three-Wheelers (E3W): This segment holds a 38% market share and plays a significant role in the adoption of electric vehicles, particularly through the use of e-rickshaws for passenger transport and cargo solutions for last-mile delivery. (Society of Manufacturers of Electric Vehicles, 2023).

Electric Four-Wheelers (E4W): Electric cars, though a smaller segment, saw remarkable growth, with sales hitting approximately 80,000 units by the end of 2023, marking a 109% increase compared to the previous year. (Society of Indian Automobile Manufacturers, 2023).

2. TECHNOLOGICAL ADVANCEMENTS AND LOCAL MANUFACTURING

India's EV market is moving ahead thanks to important advancements in technology, especially in battery development and the rise of local manufacturing.

- **Advanced Battery Technology:** The typical price of batteries, which play a significant role in the overall cost of an EV, has been gradually going down. In 2023, the average cost of batteries came in at around $139 per kWh, marking a significant decrease compared to earlier years (BloombergNEF, 2023). This drop in cost makes electric vehicles more accessible for everyone. There is an increasing emphasis on creating Advanced Chemistry Cell (ACC) batteries, such as lithium-ion, sodium-ion, and solid-state batteries, aimed at enhancing energy density, range, and safety (NITI Aayog, 2022).
- **Charging Infrastructure Innovations:** As it continues to grow, India's charging infrastructure is adapting and improving through new technological advancements. This involves setting up DC fast chargers that can greatly shorten charging times, along with creating smart charging stations that effectively manage power usage (Bureau of Energy Efficiency, 2023). There is a growing interest in battery swapping technology, especially for two and three-wheelers. This approach provides a fast alternative to conventional charging, helping to minimise vehicle downtime.
- **Indigenous Manufacturing and R&D:** Local manufacturers are really raising the bar. Ola Electric, Ather Energy, and TVS Motors are working on creating their own battery packs and electric powertrains designed specifically for the unique needs of Indian conditions in the two-wheeler market. Tata Motors stands out in the passenger car segment by utilising its own technology and research and development to create models such as the Nexon EV and Tiago EV, which cater effectively to the needs of the Indian market (ICRA, 2023). By concentrating on local manufacturing, we can lessen our reliance on imports, lower costs, and foster a stronger electric vehicle ecosystem.

In summary, as we reach December 2023, India's electric vehicle revolution is thriving, driven by impressive technological progress and an increasing enthusiasm from consumers. The market is experiencing notable growth, especially in the two and three-wheeler segments.

3. GOVERNMENT INITIATIVES

3.1. FAME INDIA SCHEME (PHASES I AND II)

The Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India (FAME) scheme has played a vital role in shaping the government's approach to e-mobility. As January 2024 approached, the second phase, FAME II, was coming to a close, having offered meaningful assistance to the market.

FAME I (2015-2019): The first stage of this initiative was a pilot project with a budget of ₹895 crore, aimed at supporting around 2.8 lakh hybrid and electric vehicles (Ministry of Heavy Industries, 2024).

FAME II (2019-2024): FAME II, with a substantial budget of ₹10,000 crore, aimed to enhance the electrification of public and shared transport. By January 31, 2024, the initiative had helped facilitate the sale of 1,341,459 electric vehicles, with a total subsidy amounting to ₹5,790 crore. The list of vehicles that are supported includes:

Electric Two-Wheelers: 11,85,829

Electric Three-Wheelers: 1,38,639

Electric Four-Wheelers: 16,991

Electric Buses: 6,862 electric buses were sanctioned to various cities for intracity operations (Press Information Bureau, 2024).

3.2. PRODUCTION LINKED INCENTIVE (PLI) SCHEMES

The government has rolled out the PLI schemes to lessen our reliance on imports and enhance local manufacturing.

- **PLI Scheme for Advanced Chemistry Cell (ACC) Battery Storage:** This scheme, with a budget of ₹18,100 crore, is set to create a total ACC manufacturing capacity of 50 GWh in India. As of January 2024, the initial round of bidding wrapped up, resulting in three firms being assigned a combined capacity of 30 GWh (Ministry of Heavy Industries, 2024). On January 24, 2024, the government made an official announcement regarding a new Request for Proposal (RFP) for the remaining 10 GWh capacity, welcoming new bids from those interested (Press Information Bureau, 2024).
- **PLI Scheme for Automobile and Auto Component Industry:** In 2021, a budget of ₹25,938 crore was approved for this initiative aimed at boosting the domestic production of advanced automotive technology (AAT) products, including electric vehicles and their components, through financial incentives (Ministry of Heavy Industries, 2024).

3.3. OTHER SUPPORTING INITIATIVES

- **Green License Plates:** Launched in 2018, this initiative highlights battery-operated vehicles that sport green license plates, allowing them to enjoy exemptions from road taxes and permit requirements in numerous states (Government of India, 2018).
- **Charging Infrastructure:** As of January 2024, FAME II has successfully resulted in the establishment of 2,877 public charging stations in 68 cities throughout 25 states. Moreover, financial support was provided to Oil Marketing Companies to set up an additional 7,432 public charging stations at their retail locations (Press Information Bureau, 2024).

4. CHALLENGES IN E-MOBILITY

India's e-mobility sector is growing quickly, yet it encounters important challenges that need to be tackled for broader acceptance. Even though there's growing support from the government and excitement among consumers, there are still some challenges around costs, infrastructure, and the development of supply chains that are holding back the transition.

4.1. HIGH INITIAL COST AND AFFORDABILITY

The significant initial price of electric vehicles continues to be a substantial hurdle for many consumers in India. An electric vehicle typically costs more than a similar gasoline-powered car. The high cost of the battery pack plays a significant role here, making up about 35% to 45% of the total cost of the vehicle. Although government subsidies through programs like FAME II have provided some assistance, many people still struggle to afford EVs unless there is a significant drop in battery prices.

4.2. INADEQUATE CHARGING INFRASTRUCTURE

The absence of a strong and dependable charging network is a major factor contributing to "range anxiety" among potential buyers. Even though there are more public charging stations appearing, the existing infrastructure still falls short of what's needed for widespread use.

- **Uneven Distribution:** Charging stations are mostly found in Tier-1 cities, which means that Tier-2 and Tier-3 cities often have few or no choices available. This turns long-distance travel into a major concern.
- **Reliability Issues:** Many installed chargers often face issues like poor maintenance, unreliable power supply, and technical glitches, which can lead to a decline in consumer trust.
- **Standardization:** The absence of a consistent charging standard among various EV manufacturers leads to compatibility challenges and a disjointed experience for users.

4.3. SUPPLY CHAIN AND BATTERY MANUFACTURING

India relies significantly on imports for essential EV components, especially battery cells and raw materials.

- **Import Dependency:** India relies heavily on imports for its lithium-ion cells, mainly sourcing them from countries such as China and South Korea. This dependence puts the domestic EV supply chain at risk due to geopolitical tensions and changes in global prices. A study conducted by the International Institute for Sustainable Development (IISD) suggests that by 2030, just 13% of the total battery cell demand in India is anticipated to be fulfilled within the country.
- **Raw Material Scarcity:** India faces challenges with its limited domestic reserves of essential battery minerals such as lithium, cobalt, and nickel, making the aim of localising the battery supply chain more complex.
- **Lack of Localization:** Even with government incentives aimed at boosting local manufacturing, the challenges of finding skilled labour and dealing with a fragmented supply chain for essential high-value components, like semiconductors and power electronics, create substantial obstacles to reaching genuine self-reliance.

4.4. CONSUMER PERCEPTION AND BEHAVIOUR

Even with the clear environmental advantages and reduced operating expenses of electric vehicles, many consumers still feel hesitant.

- **Range Anxiety:** Being anxious about losing battery power while driving can really hold people back. This situation is made worse by the lack of sufficient charging stations and the feeling that charging takes too long.
- **Limited Awareness:** In many smaller towns and rural areas, people often do not realise the long-term economic advantages of owning an electric vehicle, like reduced maintenance and running costs..
- **Safety and Performance Concerns:** People are worried about how batteries perform in different weather conditions, especially in really hot temperatures, and there are also concerns about the risk of vehicle fires. However, it is important to note that battery technology is getting better all the time.

Range anxiety, together with the difficulty of achieving the convenience and ease of use provided by traditional fossil-fuel-based vehicles, continues to be a key impediment to EV adoption. High initial costs, a lack of charging station infrastructure, the absence of an energy grid capable of meeting the needs of charging several EVs at the same period of time, and a lack of public knowledge and awareness about the advantages and benefits of e-mobility might all impede the technology's broad adoption.

Technical, infrastructure, market, and policy constraints the popularisation of electric vehicles. The effective use of technology in the development of power, material science, and the conversion of electrical energy, as well as the proper use of batteries and the supply of suitable charging stations, among other things, may help to minimise these concerns. (Aswani et al., 2018) The adoption of EVs is hampered by challenges such as developing technology and resources to lessen the total cost of ownership (TCO) of EVs, developing sufficient electric power, establishing charging station infrastructure, and sufficient battery production, encouraging EV adoption through government incentives and

subsidies, educating the masses and gaining community support, and incentivizing end customers for faster adoption. (Rezvani et al., 2015).

5. FUTURE OF ELECTRIC VEHICLES (EVS)

5.1. MARKET GROWTH AND PENETRATION

As of January 2024, the Indian EV market has shown impressive growth, with sales in 2023 hitting 1.6 million units (JMK Research, 2024). As we look to the future, the government's goal of reaching a 30% share of electric vehicle sales among all vehicles by 2030 plays a significant role in shaping long-term forecasts (NITI Aayog, 2023).

- **Projected Sales:** A report from Fortune Business Insights highlighted that the Indian EV market, which is valued at USD 8.03 billion in 2023, is expected to expand significantly, reaching USD 117.78 billion by 2032 (Fortune Business Insights, 2024).
- **Segment-wise Growth:** It was anticipated that the future would be shaped by two-wheelers and three-wheelers, which were already at the forefront of the adoption curve. Electric cars, while still a smaller part of the market, were expected to grow steadily, thanks to new models being introduced by leading automakers.

5.2. POLICY AND REGULATORY EVOLUTION

The policy framework was seen to be vital for the market's future. By early 2024, the government was wrapping up the FAME II scheme and was working on a new policy to keep the progress going.

- **FAME II Conclusion:** The FAME II scheme is scheduled to conclude in March 2024. The success in the two-wheeler and e-bus segments has paved the way for a new, potentially more inclusive policy.
- **PLI Schemes:** The Production Linked Incentive (PLI) schemes for Advanced Chemistry Cell (ACC) Batteries and the Automobile and Auto Component Industry are viewed as essential building blocks for what lies ahead. By January 2024, these initiatives had drawn considerable investments aimed at localising battery and component manufacturing. This move was anticipated to lessen reliance on imports and bring down the overall cost of electric vehicles (International Institute for Sustainable Development, 2023).

5.3. ADVANCEMENTS IN TECHNOLOGY AND INFRASTRUCTURE

The future outlook relied significantly on advancements in technology and infrastructure to address consumer concerns.

- **Battery Technology:** The emphasis was on bringing battery production locally at lower costs. This was made possible by the PLI scheme. Exploring next-generation technologies, such as solid-state batteries and alternative chemistries like sodium-ion batteries, is a long-term strategy that holds the promise of enhancing safety, range, and charging times (Capgemini, 2024). Battery swapping was becoming an increasingly popular option, particularly for two-wheelers and three-wheelers, as a way to tackle the challenges of lengthy charging times and the significant initial expenses associated with batteries.
- **Charging Network Expansion:** The future of electric vehicle adoption is closely linked to the expansion of charging infrastructure. By January 2024, although charging stations were not evenly spread out, both government and private entities were dedicated to making a substantial increase in their availability. Organisations such as the International Energy Agency (IEA) have shared insights predicting a significant expansion of charging infrastructure to accommodate the increasing number of electric vehicles on the road. The government set a goal to install charging stations every 25 km along major highways.

5.4. DOMESTIC MANUFACTURING AND SUPPLY CHAIN

The future of electric vehicles is viewed as a significant economic opportunity for India, emphasising the importance of developing a self-sufficient manufacturing base.

- **Manufacturing Hub:** Reports from early 2024 suggested that India is set to become a major player in the global electric vehicle manufacturing scene. Programs such as the PLI schemes aimed to draw in investments

from both local and global participants, enhancing the local supply chain for high-value components (International Institute for Sustainable Development, 2023).

- **Job Creation:** The growth of the EV sector was anticipated to bring about millions of new job opportunities. A report from the Indian Private Equity and Venture Capital Association and EY suggests that the growing electric vehicle industry could generate 10 million direct jobs and 50 million indirect jobs by 2030 (Bolt. Earth, 2023).
- The Indian EV Market was worth 5 bn USD in 2020, and it is predicted to grow to 47 bn USD by 2026, with a compound annual growth rate (CAGR) of more than 44% throughout the forecast period of 2021-2026.

The COVID-19 pandemic has had an influence on the Indian electric vehicle market, causing supply chain disruptions and the closure of production plants as a result of lockdowns and travel restrictions. In India, however, the EV sector is still in its infancy. It is expected to grow at a much quicker pace throughout the projected period as a result of several government initiatives, schemes and policies.

E-commerce companies (such as Amazon) are starting projects to use E-Mobility for last mile deliveries in order to lower their carbon impact. Electric intercity buses have been introduced in several major cities in India, which is experimenting with e-Mobility for public transportation. State governments are also heavily involved in the execution of policies that promote the usage of electric cars. For instance, by 2022, Kerala plans to have 1 Mn electric vehicles on road and 6 thousand E-buses in public transportation and Telangana wants to attain EV sales objectives of 80% 2- wheeler (motorcycles and scooters) and 3-wheelers (auto-rickshaws), 70% commercial automobiles, 40% buses, 30% private cars, and 15% electrification of all vehicles by 2025.

Following the introduction of the FAME India initiative, which intends to transition India to e-mobility as a result of growing international policy obligations and environmental challenges, the EV market in India has gained substantial traction. In addition, India offers the greatest untapped market in the world, notably for electric two-wheelers. Because this industry is open to 100 percent foreign direct investment (FDI), the automatic route market is likely to expand throughout the forecast period.

6. CONCLUSION

The key issues with conventional fuels are their rising pricing, sustainability, and non-renewability. Their continued usage for transportation also has serious consequences for the environment and human health. As a result, a transition from conventional fuels to cleaner, more environmentally friendly alternative fuels is essential. The government should work on policies to make alternative fuels more accessible to the public by expanding fuel infrastructure and educating the public about the environmental and financial benefits of alternative fuels, as increased public awareness increases the likelihood of alternative fuel adoption.

CONFLICT OF INTERESTS

None.

ACKNOWLEDGMENTS

None.

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