



A SHIFT TOWARDS E-MOBILITY IN INDIA: CHALLENGES AND INNOVATIONS

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Abstract

The shift towards electric mobility in India is motivated by the need to reduce the considerable environmental effect on the road sector induced by rapid urbanization and commuter traffic. Which accounts for 80% of total emissions including 60% of greenhouse gas emissions from vehicles. To address this problem the Indian government set up a target for electric vehicle fleets in the country by 2030. The goal is very ambitious but difficult to achieve due to the lack of resources, technology, and infrastructure required for EVs. Hence, different policies, battery technology, charging infrastructure, consumer perception, incentive programs, and local manufacturing for affordability and availability will have to be provided to create an ecosystem for electric vehicles in India. The paper gives an overview of current e-mobility trends, practices, and innovations, and the policy imperatives required to encourage the growth of sustainable e-mobility in India.

Keywords: E-mobility, Policy imperatives, Sustainability, Affordability, Availability

Introduction

The shift towards electric mobility is closely related to the rising global population. As the population continues to grow, especially in urban areas, the demand for transportation is increasing making it a significant trend where normal fuel-based vehicles are being replaced by electric vehicles. This shift is driven majorly by environmental effects, sustainability, technological aspects, government policies, and consumer attitudes. Many different countries are working on this shift with their unique approaches to promote e-mobility based on their resources and priorities. India is not far behind in this shift, being a developing country, it is urbanizing at a very fast pace. As per the census up to 2021, urban areas housed 35% of the country's population, and these numbers can grow up to 52% by 2050 according to United Nations estimates (Rathi, 2016). Originally traditional Indian cities were more dependent on the use of low-carbon and low-energy transport modes like walking and cycling. Rapid urbanization, economic growth, rising household income, and segregated urban planning contributed to the need for mobility and increased the travel demand at a very high rate (Joshi, Joseph, & Chandran, 2016). Usually, big cities tend to have a higher share of public modes of transport and non-motorized transport, which diminishes significantly as the city size decreases making us more dependent on private vehicles. Which results in congestion, pollution, and dependency on fuel-based energy sources resulting in greenhouse gas emissions and threats to sustainability (Sharma, Jain, & Singh, 2011).

The transport sector in India consumes nearly 16.9% of total energy from coal, diesel, petroleum (gasoline), and electricity as per the Bureau of Energy Emergency, which accounts for 80% of total emissions, including 60% of greenhouse gas emissions only from vehicles (TEDDY, 2006, Patankar, 1991). Not only this later in 2009 as per the reports, nearly 80% of passengers and 60% of the freight movement in the country was dependent on road transport (Ramachandra & Shwetmala, 2009). At present, with most of the fuel-based vehicles in India, the situation is getting worse. Hence, the government decided to adopt green mobility producing less or zero emissions in the country. This is a big step for the country as the government has targeted to shift towards electric vehicles by the end of 2030.

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Research Objective and Methodology

The research conducted is exploratory aiming to investigate the shift towards electric mobility in India. Using the comprehensive approach, the study will assess the current trends, practices, innovations, and challenges. The research design involves both qualitative and quantitative methods, including data collection on the EV ecosystem, current policies, air quality measurements, availability of infrastructure, affordability, and consumer behavior. Through a comparative analysis, the research intends to identify the effects of electric mobility in reducing carbon emissions, improving air quality, and cost savings. Later the result of this study will contribute to a deeper understanding of the challenges and obstacles, offering insights for policies and innovations to build a sustainable environment.

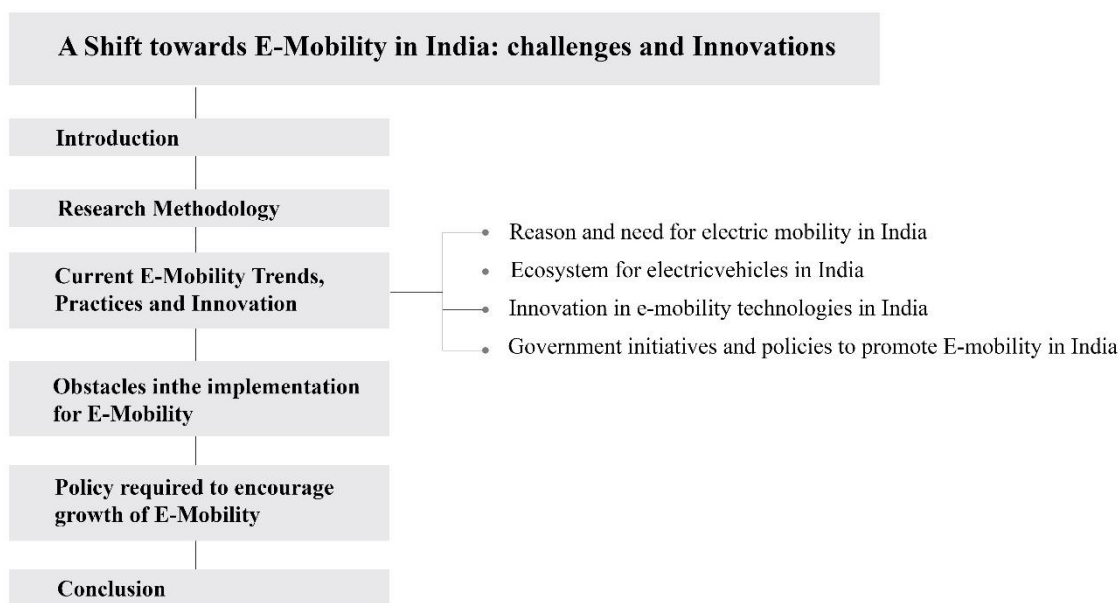


Figure 1. Flowchart for the research

Current E-Mobility Trends, Practices, and Innovation

Reason and Need for electric mobility in India

In India with an increase in population, dependence on motorized vehicles for traveling is increasing at a very fast rate. As per 2022 statistics, India had a population of 1.4 billion with 326.3 million registered vehicles running on the road. This increase in population brings increased money, trade, and economic opportunities, as well as increased demand for motorized transportation to move goods, services, and people. Resulting in a hike in the sales of passenger vehicles by at least 26.7% in the year 2022-23. Most of these vehicles are fuel-based, which on combustion releases toxic pollutants and greenhouse gases indicating that vehicular traffic is a key contributor to urban air quality concerns. Further listed below are several other reasons and needs for electric mobility in India: -

Environmental concerns: According to IQAir's "Global Air Quality" research, India is the eighth most polluted country in the world in 2022, down from fifth in 2017. It is dominating in PM2.5 emissions globally and provides a home to 22 out of 30 most polluted cities in the world (World Bank, 2022). Here cars and two-wheelers generate nearly 11.5% and 77.7% of the total transport-related air pollution. In general, road transport activity accounts for 80% of total emissions, including 60% of greenhouse gas emissions only from vehicles (MoF, 2000).

Table 1. Major polluted cities in India.

No.	State	City	Avg. PM 2.5 in 2022
1.	Rajasthan	Bhiwadi	92.7
2.	Delhi	Delhi	92.6
3.	Bihar	Darbhangha	90.3
4.	Bihar	Asopur	90.2
5.	Delhi	New Delhi	89.1
6.	Bihar	Patna	88.9
7.	Uttar Pradesh	Ghaziabad	88.6

Source: Wikipedia

Dependence on imported oil: Transport is one of India's fastest-growing industries and energy demand associated with it is dramatically increasing, with plans to expand transport infrastructure (World Bank, 2022). Presently the country holds the second largest road network with 5.98 million km, with most of the vehicles running on Petroleum and Diesel (Wing, 2017). In 2016, with only 0.3% of the oil reserves in the country, India consumed 4.8% of the crude oil and became the world's third largest oil consumer (Srikanth, 2018). This consumption is likely to grow to 8.7 million barrels per day by 2040 according to Energy Outlook 2021 by the International Energy Agency due to an increase in population and vehicle dependency (Agency, 2021). Hence, the nation's reliance on imported oil poses a serious threat to its energy security because changes in the price of crude internationally can have a big influence on the trade balance and inflation rate. As per reports in 2018, India spent at least 40% of its oil to power the transportation industry. Oil being used as a primary source of transportation is contributing to degrading air quality, changing climate, and causing other wide range of environmental issues and problems.

Cost savings: Pricing must be prioritized in an economy like India's that is rapidly growing to cover costs for capital renewals, capacity growth, and technical advancement. Additionally, with the recent outbreak of conflict between Ukraine and Russia, oil prices have exploded out of control, setting new highs, and raising transportation costs. Their (users) restricted ability to pay causes a challenge in the market for transportation services for the underprivileged.

Innovation and Technologies: In the year 2017, India sold more than three million cars becoming the fifth-largest market for passenger cars (RAM, 2017). With this pace of growth in cars running with expensive fuel on already overcrowded streets can choke the Indian cities further. Hence, the country needs a revolution in the transport sector. Innovation and technology in the field of mobility in the country are important for sustainable development, economic growth, and improved quality of life. By strengthening technology, India can address the urban challenges, promote inclusive growth, and create a thriving ecosystem for innovation and entrepreneurship. With this, it will be a strong strategy to be at the forefront of the transition to EV and build a strong home market.

International commitments: The country's international commitment to greenhouse gas emissions and climate change is one of the reasons to encourage e-mobility. India has ratified the Paris Agreement, which aims to "reduce the temperature increase to 1.4° C and control the increase in the global temperature certainly below 2 degrees above pre-industrial levels."

UNFCCC has declared that greenhouse gas emissions from transport are growing at a faster rate contributing to around 23% which is estimated to increase nearly by 20% in 2030 and by 50% in 2050 (Srikanth, 2018). Due to The Paris Declaration on Electro-Mobility and Climate Change India is emphasizing the need to convert at least 20% of vehicles into EVs by 2030 to reduce its carbon footprint with the main objective to produce 40% of its electricity from renewable sources by 2030 (UNFCCC, 2015).

Ecosystem for electric vehicles in India

The overall ecosystem for electric vehicles in India is dependent on three parameters- market, technical support, and infrastructure. It is mandatory to assess these parameters in Indian circumstances because the high rating performance of electric vehicles depends on these parameters. The Indian automotive market is quite different from other leading countries for electric vehicles. Firstly, it is mostly dominated by two-wheelers due to market

composition and consumer preferences. Secondly, technical support for this new and less mature technology along with the unavailability of enough infrastructure becomes a big issue. Thirdly, affordability and adaptability by Indian consumers is a matter of concern though the government is working quite deliberately on these issues. Compared to other countries electric mobility is quite new for this country and users are still unaware of its advantages. We Indians normally compare a vehicle based on the mileage and efficiency provided which results in the preference for fuel-based vehicles in the country (Sarode & Sarode, 2020).

According to the Ministry of Road Transport, a total of 1,334,385 Electric Vehicles and 278,169,631 non-electric Vehicles are in use in India, with a concentration in 5 major states. The states namely Uttar Pradesh (255,700), Delhi (125,347), Karnataka (72,544), Bihar (58,014), and Maharashtra (52,506) have the highest electric vehicle registration so far. And with the upcoming wave of the transportation revolution in India, it will establish itself as a global leader in Electric Vehicle manufacturing. And has the potential to become a very large market for electric mobility soon. However, this transition cannot be top-down by the central government but must be driven by the central government for which Pioneering companies and city governments must take initiatives. Today in India we can see a lot of companies and startups coming forward to join hands to work in this field together.

Innovation in E-mobility Technologies in India

In India, electric vehicles being a relatively new idea, need to be accepted in a very open way to advance by replacing fuel-powered ones. With the scale of pollution and alarming projections of worsening climatic conditions in the future, one of the ways to achieve environmental sustainability and clean air is to shift towards electric mobility (Jayadharashini, 2019). However, with time the country has seen a considerable increase in the invention and acceptance due to the rising demand for environmental concerns, zero-emission vehicles, favorable government laws, growth in the desire for energy-efficient commuting, and rising fuel prices. But still, it's not enough, and together with demand, manufacturers, and consumer support we can investigate alternative energy sources and e-mobility solutions, some of which are outlined below:

Government initiatives: The Government of India has initiated a few programs to promote e-mobility, including incentives and subsidies for buying electric vehicles. Some of the popular initiatives include National Electric Mobility Mission Plan 2020 (NEMMP), and FAME which will be further discussed with a timeline later in the research.

Electric two-wheelers: In the early phase of the adoption of electric vehicles in India during 2011-20, nearly 148 million two-wheelers were sold, and these numbers are likely to increase (Kumar, M, & Joseph, 2021). Giving it a market value of USD 893 million in 2022 as per Automotive and Transportation Research, which in 2030 can grow with an average annual rate of 27.30%. But as for the targets for 2030, the Indian government suggest converting at least 30% of all vehicles to electric to reduce air pollution. The low maintenance costs of EVs and the rising ICE vehicle prices brought by the implementation of BS 6 (Bharat Stage Emission Standards 6) are driving this trend toward two-wheelers. Electric scooters and motorbikes have been offered by several businesses, including Hero Electric, Bajaj, and TVS, in the Indian market. These vehicles are incredibly becoming popular in the country.

Electric three-wheelers: Electric three-wheelers, commonly to be known as "e-rickshaws," have become an environmentally friendly mode of last-mile connectivity in India. In 2015, they were given legal status giving it a market value of US\$ 890 million in 2022. And with time this market is expected to grow to reach US\$ 2,156 million by 2028, with an annual growth rate of 15.8% between 2023 and 2028, or almost 300% year-over-year. These passenger-carrying vehicles are powered by battery-based electric motors that reduce additional expenditures associated with fuel usage. These electric vehicles' strong acceptance rate is a result of their low carbon emissions, small size, cost-effectiveness, and noise-free travel.

Electric cars: Electric vehicles are becoming more and more popular in the Indian market thanks to manufacturers like Tata Motors, Mahindra Electric, and Hyundai, among many others. For FY 2022, 17.8 thousand units of four-wheeler passenger vehicles were on the market (team-bhp.com, 2022). These vehicles have already been shown to be less polluting than fuel-based ones, and they are also among the most affordable because of their low maintenance costs. This makes a plus point for them in the market with soaring fuel prices.

Electric buses: Indian public transportation is rising significantly due to rapid urbanization and environmental concerns resulting in electrically powered buses as a favorable option for the government. Last year in 2022, the market was estimated to have a value of \$603.1 million, and it is expected to reach \$2,766.1 million by 2030 (Intelligence, 2022). Different policies and programs have been adopted by the Indian government in this sector such as the National Electric Mobility Mission Plan (NEMMP) 2020 and Bharat Stage (Bs) VI 2020 for concrete emission control measures and catalyst the demand for such vehicles. The bus market has much higher EV penetration than other vehicle segments in all three of the key electric vehicle sales states, with rates of 15% in UP, 12% in Karnataka, and 8% in Maharashtra in the country.

Charging-Infrastructure: For the vast expansion of electric vehicles, the country must have charging infrastructure for both present and future electric vehicles. Today the ecosystem of charging infrastructure isn't strong enough as it is required, even though many governmental and private groups are working on and funding the development across the country. During 2019, a total of 1,827 EV chargers were installed of which 5% were fast chargers (Bank, 2021). Later in January 2020, another 2,636 charging stations were sanctioned across 62 cities in India under the FAME-II scheme. Out of these, 1,633 would be fast charging stations and the remaining 1,003 would be slow charging stations (Bank, 2021). As a result, by the end of 2022, there were 5,500 charging connectors and 2,700 public charging stations. We might also require more infrastructure by the end of 2030, due to a targeted rise in EV sales up to that time. Through programs like FAME1 and FAME 2, the Indian government has been assisting the EV industry with a focus on charging infrastructure.

E-mobility as a service with smart solutions: With firms like BluSmart, Lithium Urban Technologies, and Yulu offering e-vehicles on a subscription or rental basis at cheaper pricing, especially now in metropolitan areas, e-mobility service is an emerging concept and would like to grow more in the future. To provide seamless and effective mobility services, India is also developing smart mobility solutions such as mobile apps, public transportation, intelligent transport systems (ITS), shared mobility, and vehicle-to-grid (V2G) technologies.

Government initiatives and policies to promote E-mobility in India: By providing policymakers with a variety of parameters and tools within the context of the available resources, the Indian government accelerated the manufacture of electric vehicles in the country.

Government initiatives and policies to promote E-mobility in India	
National Council for Electric Mobility (NCEM)	NCEM was established in 2011 to facilitate the creation and execution of laws for the adoption of electric vehicles in India. Some of the major projects undertaken as part of the program are the National Institute of Solar Energy (NISE), the Faster Adoption and Manufacturing of Electric Vehicles (FAME), and the National Electric Mobility Mission Plan (NEMMP)
National Automotive Board (NAB)	Later in October 2012 , NAB was formed as a nodal agency to distribute funds for the FAME India scheme.
National Electric Mobility Mission Plan 2020 (NEMMP)	In 2013 the government of India formed the NEMMP 2020 plan estimating an outlay of US\$6-US\$7 billion (US\$2.7-US\$3 billion by the government and rest US\$4-US\$4.5 billion by the private sector) for the promotion of electric mobility along with investments in R&D infrastructure. The set target was for 2020 to achieve 6 to 7 million electric vehicles on the road enabling fuel savings of 2.2 to 2.5 million tons. Further decreasing the consumption of liquid fossil fuel and carbon dioxide emissions by 1.3%-1.5% making this a highly economical proposition.
FAME-I India	Under NEMMP 2020, the Department of Heavy Industry launched Phase-I of the FAME India scheme in April 2015 , for a two-year long period with an outlay of Rs795 crore (7,950 million). With a focus on developing demand, research, and various pilot projects and charging infrastructures. Along with it various subsidies for 2 and 3-wheelers, passenger and light commercial vehicles, and buses were provided by the government.
FAME-II India	In April 2019 , second phase of FAME was introduced in the country with a budget of Rs 10,000 crore (100,000 million). The implementation period for the scheme was for three years from 2019-2022, with a target of having around 2700 charging stations at different locations in different tier I cities.
Technology Platform for Electric Mobility (TPEM)	Launched in February 2016 to support R&D Consortia Projects, with the objective to develop technology addressing the needs of the Indian market. The aim was to achieve 100% e-mobility by 2030. But in March 2018, the Ministry of Power modified the target to achieve 30% e-mobility by 2030 (FRG, 2021). Further, they also gave a clarification on charging infrastructure concerning the Electricity Act, of 2003 stating that charging EVs is a service and doesn't require any license.

Figure 2. Government initiatives and policies

In the past 10 years, the government has taken several steps to support the nationwide adoption of EVs, including tax incentives and the construction of public EV charging infrastructure, among other projects. Figure 2 shows the chronology and steps that regulators and officials took:

Obstacles in the Implementation for E-Mobility

Despite having the largest population in the world, India's adoption of electric vehicles is extremely low because of lots of obstacles in the process. The main hindrance to this acceptance is the production of the electricity required to power the vehicles, as without electricity it is impossible to envision the future with electric automobiles. Apart from the major cities, India still has a problem with rural electricity. As a result, the distribution network is under more pressure to consistently provide adequate power. Apart from electricity affordability, inadequate infrastructure, consumer preferences, battery technology, and rules and regulations are other major concerns. These challenges and issues are described briefly as follows-

Adequate Electricity Supply: As per research 3% of people in India still lack adequate energy supplies, and the architecture of the current power system will not be sufficient to handle the increased load of EV charging. Fast charging stations for EVs consume a lot of electricity, which might put pressure on regional distribution systems. Also, with an increase in the requirement for electricity India might need more fossil fuels to meet the rising demand for energy since it produces 57.7% of its electricity from fossil fuels, primarily coal (49.3%) resulting in more toxic emissions into the environment causing air pollution (Wikipedia, 2023). The lack of abundance of electricity hinders the development and encouragement of private charging points for users. Hence, this lack of electricity questions the Indian government's amendment to the Electricity Act and how the desired targets will be achieved in a definite time with the basic facilities.

Affordability of e-vehicles: As compared to an ICE vehicle, prices for EVs are quite high in India; for example, the minimum price for an electric vehicle is about 1.3 million (13 Lakh INR), which is significantly more expensive than a car that uses conventional fuel, which is 0.5 million (5 Lakh INR). This is due to the import of lithium used in battery production, accounting for around 50% of the cost of a vehicle (Singh, 2021). Recently with technology development battery costs have dropped over the past several years, but still, EVs cannot match the cost of an ICE vehicle. With different geopolitical events and shortage of raw materials for battery manufacturing price fluctuation and availability become another point of concern making it difficult to determine the EVs' long-term running cost in the country. India has the largest number of motorized two-wheelers in the world, estimating around 37 million motorcycles/mopeds, with an average of 7.5 percent of Indian households (1 in 12) owning a car as per the Ministry of Road Transport. However, affordability is still a question due to high costs, import duties, limited production, and the cost of battery technology.

Charging infrastructure: The lack of charging stations is a key barrier to the adoption of electric vehicles in India as without infrastructure people cannot travel longer distances. Electric vehicles have a limited range of travel and require charging stations on the community level or the option of charging while driving. And these facilities needed to be spread all over the cities for easy access which is at present missing in Indian cities. Currently, an abundance of fuel stations already exists in the country creating difficulty in establishing charging stations (Sarode & Sarode, 2020). Also, the availability of land at subsidized prices and building a charging station requires a significant amount of money which at the current level of utilization hampers the commercial viability of the business (Bank, 2022). Further, limited demand, high installation cost, lack of clear policies and regulations, and technical and infrastructure challenges are some of the other major reasons for the lack of charging infrastructure.

Regulation and encouragement: For the proper efficiency of this new technology in the Indian market clear rules and regulations are required. Through different schemes (already mentioned above) the government is initiating the promotion of electric vehicles by providing subsidies, foreign investments, local manufacturers, etc., but still, as compared to other cities we lack proper regulation. The Indian electric mobility market at present needs regulations to ensure safety, reliability, and sustainability in the industry. Along with the development of standards, guidelines as well as clear policies, incentives, and consumer protection for the success of electric mobility in India.

Range anxiety: Range anxiety can be considered a major roadblock to EV adoption due to the shorter range causing charging fear for the users. Today Tesla's Model S has the longest range of 370 miles per charge but being expensive and not available in the Indian market we don't have access to it. On the other hand, EVs available in the Indian market do not have a range of more than 500km per charge (Singh, 2021). Hence, the problem of range anxiety is closely related to the absence of charging infrastructure in the nation.

Battery technology: For electric vehicles to be successful in India, where many people drive longer distances, battery technology is essential. Customers experience range anxiety due to the short range of electric vehicles compared to gasoline-powered automobiles. The high price and the long-term performance deterioration of batteries due to harsh temperatures are a point of concern. India cannot currently manufacture modern battery technology domestically as a result there is a greater expense and reliance on foreign nations. In addition, India's supplies of essential raw materials (lithium, cobalt, nickel, and graphite) required for battery production, are restricted. Henceforth, import taxes, a lack of scale in home production, and a lack of technological expertise all contribute to the high cost of batteries.

Consumer perception: And in the end, the consumer perception of this technology is all that matters. Here many consumers are unaware and underinformed about electric automobiles. Due to a lack of reliable information, there are many misconceptions and myths regarding EVs, including ones related to their high purchase prices, short range, battery life, maintenance requirements, and performance.

5. Policy Required To Encourage Growth of E-Mobility

To use electric vehicles on a larger scale and to meet all the targets set by different official bodies it is essential to address all the challenges mentioned above. In the coming future, four transformative low-carbon technologies – LEDs, solar energy, wind energy, and EVs will reconfigure several industries in India in parallel to other tech-driven developments like shale gas or e-commerce (Srikanth, 2018). This indicates that although the country is changing noticeably in each of these areas, little significant advancement has been made, particularly in electric vehicles. Although the government is currently working on a variety of plans and initiatives, these are not sufficient to meet the objectives established for 2030. Hence, below are some recommendations that can be adopted in the transition to low-carbon, environmentally friendly, and secure energy future-

Policies and regulations: The Indian government is currently developing NEMMP and FAME, among other policies and programs, to achieve electric mobility targets by 2030. However, there is the need to work in a more precise manner because these projects and policies do not offer a clear road map for their execution. At this point, the government needs to deliberately focus more on the projects and programs in phases over three to five years. Each phase period needs to be supported by the appropriate tools and techniques to be carried out together with the relevant authorities. Additionally, each phase's progress needs to be properly tracked, and insights for the next phase should be provided.

As continuous degrading air quality in India has become a major reason for the adoption of EVs in the Indian market. To be more strategically minded, the Indian government may work on a few pilot projects for some of the most polluted cities (see Table 1), which at least have some fundamental infrastructure, including a steady supply of electricity and a grid distribution system. And these if worked well can be later replicated in other Indian cities.

Provision of electricity in every household through a Grid system: Today the country's 3% of the population barely has any access to electricity, and the other half still suffers from quality and irregularity making it difficult to achieve the desired targets (Agrawal, Mani, Jain, & Ganesan, 2020). The government needs to work parallelly on improving the basic infrastructure requirements of grid-based electricity systems by setting up power plants, the transmission of electricity over high-voltage transmission lines, and distribution of the households and businesses through local networks for the ease of adoption of these vehicles. Hence, the grid infrastructure needs to be upgraded to handle the growing demand and smart grid technologies must be implemented for load management.

Affordability of electric vehicles: With the development of the EV strategy in India battery requirements will rise continuously. Between 2017 and 2020 it was nearly 120 GWh, which can rise to 970 GWh between 2021 and 2025 and can exceed 2410 GWh from 2026 to 60 2030 (Srikanth, 2018). Today most of the parts for EVs and their batteries are being imported to the country leading to an increase in prices. Separate research organizations should be established, and forgiving laws should be implemented for local manufacturers, notably for batteries, as importing cannot be a permanent answer. As a result, the Indian government must take action to design and construct self-made solar cells and modules. Automakers should be able to build batteries at lower costs developing domestic battery production, and in the long run, the nation may start exporting electric batteries. This may also result in economies of scale, which would increase the number of jobs in this sector across the nation. Therefore, the government should work to increase domestic battery production, which will lower the cost of electric vehicles.

Incentives for Encouragement and Promotion: Leading nations in the field of electric mobility have already made a variety of incentives and motives available through various stakeholders to promote electric automobiles. To encourage the usage of EVs among its people, the Indian government must offer incentives for registration and road tax, insurance benefits, free parking, different toll benefits, purchasing subsidies, and land for the construction of public charging facilities for EVs, in addition to enhancements to those that already exist. Currently, the Indian Government has no proposals to support and promote the manufacturers developing Lithium-ion batteries. At least the government should provide some incentives even for a shorter period to encourage the companies to invest in this field so that we can achieve the set 2030 electric mobility goals.

The government should frame proper policies to encourage EVs by PSUs. Especially in the case of EESL (Energy Efficiency Services Limited), it can extend its services to the State Governments for public transportation, which will ensure economies of scale through standardization, and will reduce the need to provide subsidies to separately run electric buses in the States. Further, enabling the escalation of charging stations by the same body will help in the acceptance of electric vehicles by other category users. This way the environment-related problems in our cities can be controlled as the existing petrol and diesel vehicles will slowly be replaced or replenished.

Battery swapping and other charging solutions: Battery swapping technology is the best option for drivers to continue their journey without waiting for their vehicles to recharge, saving a lot of time. However, this technology has not gained much attention due to its high cost and lack of standardized battery sizes. Companies like Tesla have options for battery swapping but this should be made more common for the users for every type of electric vehicle for consumers convenience.

Consumer perception: As already mentioned, consumer perception is a big issue for the Indian electric vehicle market, and consumers are the main game changers for the adoption of these vehicles. The Indian government apart from providing different kinds of subsidies or incentives should also conduct workshops and other group activities or spread knowledge through social media platforms to make people more aware of the benefits these vehicles bring with them.

Research and development: With the need of an hour, the Government of India should focus on research to secure raw materials for the batteries (such as lithium, nickel, and cobalt). Hence, developing research facilities to recycle or reuse Li-ion batteries to reduce the need to import such expensive materials. Different government-controlled and private exploration/mining organizations must be directed to explore cobalt and nickel in India (Srikanth, 2018).

Conclusions

In the study, an effort is made to understand the need, present conditions, obstacles, and policies required for the adoption and promotion of electric vehicles in the Indian market. The implementation of EVs in India majorly aims at reducing greenhouse gas emissions from fossil fuels and cutting oil expenses. The Indian Government's plan to electrify all vehicles by 2030, is going to be a roller coaster ride that will depend on how the entire ecosystem will work and develop from access to electricity, availability of infrastructure, consumers' attitude, market development, growth, and finally how the city and urban planners help in the process to develop policies and norms for it.

With the ongoing scenario of raw materials for automobiles, decline in fossil resources, and increase in fuel prices, India needs an energy transition. Some of the obstacles to achieving the goals can be categorized majorly as a lack of basic infrastructure for charging, affordability, high battery costs, and driving range, of these vehicles. Also, the country needs to think about how to produce an abundance of electricity without the use of fossil fuels. The electric vehicle manufacturers too should have a scheme with a proper timeline and investment strategies to develop a manufacturing ecosystem and scale up the sales and availability of EVs in the country at lower prices. Policymakers and city planning authorities should make planning norms, and byelaws facilitating the development of charging infrastructure at the city, zonal, and neighborhood levels. The government is working efficiently to promote EVs in the market to achieve its 2030 targets, but these efforts are not enough. The government needs to work in a more detailed and time-framed manner with short-term goals. There is a need to work on some pilot projects first and then replicate them throughout the country.

Currently, if the government works on affordability and infrastructure, which are the basic challenges in adoption, then the users will be willing to accept EVs in the future. As a result, along with the expectations of reducing carbon emissions, air pollution, and enhancement of energy security, the country can also become an automotive export market. These transitions will change the business model in the country as well as the usage patterns for the customers.

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