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Energizing The Future: Innovations In Electric Vehicle Technology

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Abstract: Electric vehicles (EVs) in India represent a transformative shift towards sustainable transportation, driven by government initiatives and growing environmental awareness. The Indian government aims for significant EV adoption by 2030, targeting 30% of total vehicle sales.

By 2030, 30 percent of Indian vehicles are expected to be electric. In order to adapt to electric vehicles, the government is working to develop a framework of policies for these vehicles and associated industries, such as the production of batteries, charging stations, and raw materials. This paper aims to compare the operational aspects and environmental implications of battery electric vehicles and internal combustion engine (ICE) vehicles. When developing a policy framework to encourage the adoption of electric vehicles, the paper stands out for emphasizing a few crucial factors. In light of the findings, a few policy recommendations are offered for a more sustainable framework that will enable electric vehicles to be successfully adapted for the future in India. As a solution to the Indian industry and environment, the automotive industry is moving toward electric vehicles. Notwithstanding the implementation of EV policies by governments, the market for electric vehicles is currently quite small. This paper will analyze the compatibility of EVs in India and examine how easy it is to use EVs in the country.

Index Terms- Electric vehicles, Internal-combustion engine, Retrofitting, Convectional vehicles, Challenges in adoption of electric vehicles, Ease of use, Govt policies.

I. INTRODUCTION

India has the largest road network in the world, ranking third. In India, driving is the preferred mode of transportation for nearly 60% of the population (based on fiscal year 2020 statistics). Diesel and gasoline are the main contributors to air pollution and global warming. Sixty-six percent of air pollution-related deaths in India are caused by diesel vehicles. This study has revealed significant health risks associated with India's transportation emissions, especially those from diesel. According to a study conducted by an environmental expert, the Indian government has implemented a number of measures to encourage both the manufacturing sector and the use of electric vehicles. As a result, the number of EVs on the Indian market has increased. India's government wants all of its vehicles to be electric by 2030. It has been suggested that all two-wheelers sold in the nation after March 31, 2025, with engines smaller than 150cc and all three-wheelers sold after March 31, 2023, should be electric vehicles (EVs). The National Electric Mobility Mission Plan includes FAME India as a component (transport policy). FAME's primary objective is to promote electric vehicles through financial assistance. FAME Schemes aim to promote the quicker adoption of hybrid and electric vehicles by providing upfront incentives for the purchase of electric vehicles.

II. LITERATURE REVIEW

Electric Vehicles: A Synthesis of the Current Literature with a Focus on Economic and Environmental Viability: Marcello Contestable, Dr. Gregory Offer, Dr. Robin North, The development of battery technology to reduce costs and boost energy density, as well as the availability of an appropriate recharging infrastructure, will be critical to the longer-term adoption of EVs, according to a study. 2012[1]; Marcello Contestable.

Potential Need for Electric Vehicles, Charging Station Infrastructure and its Challenges for the Indian Market: by Praveen Kumar and Kalyan Dash, In order to address the load issues locally, India should invest in small-scale reinforcements instead of making a significant change. Encouragement of home charging is necessary. The implementation of large-scale charging infrastructure should be preceded by careful planning of the area, population, traffic density, and safety. It is crucial to integrate activities in the transportation and energy sectors. Development objectives through various creative policies and programs, such as providing financial consumer incentives to drivers of electric cars, such as tax credits, purchase subsidies, reduced tolls, free parking, and access to restricted highway lanes, will aid in the market's expansion. Dash P. K. . (2013)[2].

Conventional, Hybrid, or Electric Vehicles: Which Technology for an Urban Distribution Centre?: According to Philippe Lebeau, Cedric De Cauwer, Joeri VanMierlo, and Cathy Macharis, freight transportation significantly affects urban mobility. The researcher investigated how urban logistics operations might incorporate electric vehicles. A fleet with a variety of technologies can potentially lower last-mile expenses. The researcher gave an example of a fleet size and mix vehicle routing problem for EVs with time windows. The authors' primary contribution was taking EV range variability into account. In the small van market, electric vehicles are frequently the most competitive technology. Since electric vehicles would need to travel farther to be cost-competitive, diesel has been viewed as the most intriguing option in the large van market from a financial standpoint. In the truck market, hybrid cars are preferred because they have lower fixed and operating costs than diesel trucks. 2015) [3] (Philippe Lebeau).

Consumer preferences for electric vehicles: by Fanchao Liao, Eric Molin & Bert van Wee, Issues like oil dependence, global warming, and environmental pollution may be lessened if EVs are widely adopted. However, even though governments have put in place robust promotion policies, the penetration of EV is relatively low. They provided a thorough analysis of research on EV consumer preferences with the goal of informing decision-makers and guiding future investigations. The economic and psychological approaches to consumer preference for electric vehicles were compared. The technical and financial characteristics of EVs, such as their driving range, charging time, vehicle performance, and brand diversity on the market, are generally thought to have little bearing on their usefulness. Additionally beneficial to the utility and promotion of EVs is the density of charging stations. The impact of tax reduction and incentive programs is very strong. [4] Fanchao Liao (2017).

International Council on Clean Transportation: Lingzhi Jin, Peter Slowik, Electric vehicles' early market expansion is still ongoing, but a number of obstacles stand in the way of their widespread adoption. These obstacles include the extra expense of the new technology, its relative inconvenience in terms of range and charging times, and consumer awareness regarding its viability and availability. Usually called "consumer awareness," this final point is very important. Jin, Lingzhi (2017) [5].

Study on Electric Vehicles in India Opportunities and Challenges: by Mohamed M, G Tamil Arasan, and G Siva kumar, Electric engines will significantly reduce pollution and benefit consumers when they replace internal combustion engines. Numerous nations have adopted this technology and are helping to improve the environment. The researcher observed India's EV implementation opportunities and challenges. Opportunities have been taken into consideration, including government initiatives, batteries, industries, and the environment. These issues were taken into account, including the demand for EVs, their cost, and their efficiency in India. The main goals of EV adoption in India are to reduce greenhouse gas emissions and oil costs. The government. should take full advantage of the opportunities and identify appropriate strategies for overcoming the obstacles. [6] Mohammed M. (2018).

Electric Vehicles in India: Market Analysis with Consumer Perspective, Policies and Issues: Pritam K. Gujarathi, Varsha A. Shah, Makarand M.Lokhande, The situation in India is different because EV/PHEVs currently hold a 0–1% market share. Nearly all cars today take into account transportation based on fossil fuels. By releasing greenhouse gases into the atmosphere, these contribute to atmospheric pollution and global warming. Domestic petroleum production and consumption are diverging more and more. India imports about 70% of its annual oil needs. Therefore, it is imperative to look into the causes and difficulties of finding cleaner and more sustainable alternatives. (K. Pratam. [7] Gujarathi, 2018).

Perception and Awareness Level of Potential Customers towards Electric Cars: Masurali. A Surya P, In terms of carbon emissions from combustion-engine vehicles, India alone accounts for about 18% of the transportation sector's emissions. One of the most practical alternative solutions to combat crises is the electric vehicle (EV). A number of automakers are diversifying their product lines and launching EVs. Encouraging EVs can benefit the country and its citizens by lowering pollution and fuel dependency. People's awareness of International Journal of Research Publication and Reviews Vol (2) Issue (7) (2021) Page 661-668 663EVs is greatly influenced by their level of education. In addition to manufacturers, the government should work hard to raise awareness and sway prospective buyers' opinions in a positive way. Masurali. A, 2018)[8].

A Study of Consumer Perception and Purchase Intention of Electric Vehicles: Pretty Bhalla, Incas Salamah Ali, Afroze Nazneen, Concerns about the environment, cost, comfort, trust, technology, social acceptance, and the availability of infrastructure all influence the choice of automobile. These claims have been verified for both EVs and regular cars. They believe that these elements directly affect each person's choice of vehicle. According to their findings, EV manufacturers and the government must make greater investments in societal acceptance of the vehicle by building more infrastructure and focusing more on technology to foster trust. The population is well aware of the advantages to the environment, according to the analysis. The government and manufacturers bear the responsibility of investing in people and technology in the production of automobiles. [9] Pretty Bhalla, 2018.

Electric Vehicles for India: Overview and Challenges: by Mr.A. Rakesh Kumar, Dr.Sanjeevi kumar Padmanaban, Global pollution is on the rise and each effort made, is to cut back the CO₂ emissions and save the earth. One such effort is the introduction of EVs. The transport sector is one of the largest emitter of CO₂ and hence it's important to reduce it. The government has come up with ambitious plans of introducing EVs to the Indian market and confine pace with the event of EVs globally. The National Electric Mobility Mission Plan 2020 has included an in-depth report on EVs. Indian compasses a huge challenge in shifting the transportation sector from ICE engines to EVs. This needs lots of planning along with R&D. Charging infrastructure must be adequately built to deal with range anxiety. It's vital to form demand generation by making all government buses electric and offering tax exemptions for personal EV owners. (Mr. A. Rakesh Kumar, 2019)[10]

Opportunities and Scope for Electric Vehicles in India: by Janardan Prasad Kesari, Yash Sharma, Chahat Goel, Developing an aggressive strategy for the adoption of EVs in India and ensuring a well-executed implementation is a challenge but vital for the government. The geography and diversity of India will present problems that require thoughtful solutions. Public procurement is expected to be an important driver of the growth of EVs, with the purchase of four-wheeled vehicles for government offices, three-wheeled vehicles, and buses for public transport. Investments by fleet operators such as Ola and Uber, and operators of food distribution services, are also expected to boost the initial growth of two- and four-wheeled electric vehicles. However, private EVs may take 5-6 years to gain popularity and acceptance. (Janardan Prasad Kesari, 2019)[11]

Indian Electric Vehicles Storm in a teacup: Yogesh Aggarwal, Vivek Gedda, and Kushan Parikh, Users of scooters, who need only to travel short distances, may consider an EV, but those, who need to travel longer distances and already own bikes like a Hero Splendor, may find it difficult to move than e-2W. For cars, it is relatively simple to improve the range with increased battery size. For electric 2Ws though, every increase in kWh may provide an extra 30km in range, but the increase in weight is around 10kg, approximately a 10% increase in the total weight of the bike. This weight issue is even more pronounced in smaller bikes (less than 150cc). (Yogesh Aggarwal, 2019)[12]

III. OBJECTIVES

The objective of this paper is to understand the importance of electrical vehicles with consideration of Environmental factors. It also aims to study the perceptions and expectations of potential, for alternative technologies in automobiles, such as Electric to study the current expectations of consumers concerning Electric/Hybrid Vehicles; this will lead to its potential for the future. As well as changing people's perception of buying electric vehicles and making India a greener place. Furthermore, educating the public about **RETROFITTING** technology and the various technologies adapted by the major players in the industry, their evaluations, and their superior alternatives.

IV. RESEARCH MOTIVATIONS

The following is the fundamental motivation behind this research work:

- Challenges and difficulties in electric vehicle adoption: Adopting electric vehicles has challenges and problems. One of the most significant challenges is infrastructure and electric vehicles' high cost. The price of electric vehicles is often higher than that of their gasoline counterparts, making them less accessible to consumers. Moreover, the scarcity of charging stations is a significant issue that needs to be addressed, especially in regions with low population densities. Additionally, the limited range of electric vehicles, or range anxiety, is a significant obstacle to their widespread adoption.
- The battery issue: The performance of batteries continues to be a major issue for electric vehicles. Batteries are expensive, heavy, and require frequent charging, which makes them less practical for daily use. Scientists are actively developing better battery technology to address these issues, including increasing driving range, weight reduction, cost reduction, and charging time. Battery technology will ultimately determine the success or failure of electric vehicles on the market.
- Integration of electric vehicles into smart cities: Electric vehicles are expected to play a vital role in the transportation systems of smart cities. However, their integration into these cities requires a collaborative effort between governments, industry stakeholders, and citizens. This includes developing charging infrastructure, promoting renewable energy sources, and encouraging public transportation.

A. Research Goal

The primary objective of this study is to shed light on the challenges surrounding the adoption of electric vehicles and suggest effective strategies for their successful implementation. To achieve this goal, we have employed a mixed-methods research approach, which involves gathering and analyzing both qualitative and quantitative data and synthesizing the results to draw meaningful conclusions.

In the context of this work, a mixed-methods approach is particularly advantageous for exploring the intricate and multifaceted issue of electric vehicle adoption and implementation. By combining both qualitative and quantitative data, this approach can provide a more comprehensive and nuanced understanding of the obstacles and opportunities associated with electric vehicle adoption and implementation. The aim is to investigate electric vehicle adoption and implementation by providing evidence-based insights and recommendations. The study represents a significant step towards understanding the challenges and opportunities associated with electric vehicle adoption and implementation. By using a mixed-methods approach, we have been able to provide a more comprehensive and nuanced understanding of this complex issue.

Classification of Electric Vehicles

Vehicles that operate on electricity rather than petrol or diesel fuel are known as electric vehicles (EVs). There are several EV kinds, each with a unique engine and settings [42]. According to their engine technology and settings, electric cars are categorized in the following manner in detail (Figure 1) :

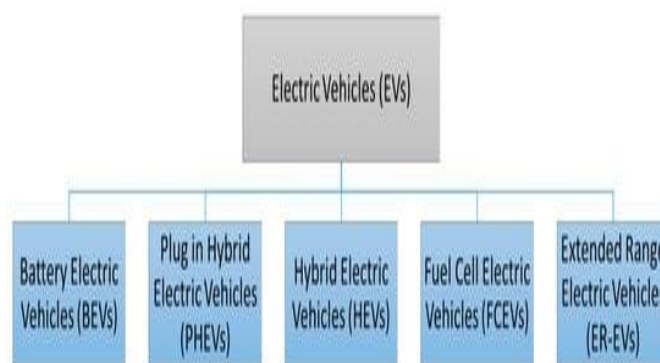


Figure 1 : Classification of Electric Vehicles (EVs)

Battery Electric Vehicles (BEVs)

Battery Electric vehicles (BEVs): Rechargeable batteries are the only power source for BEVs, which are electric automobiles. They don't have a backup generator or a petrol engine. Due to their lack of exhaust emissions, BEVs are regarded as the most ecologically beneficial form of electric car. However, they have a constrained driving range because the battery must be recharged.

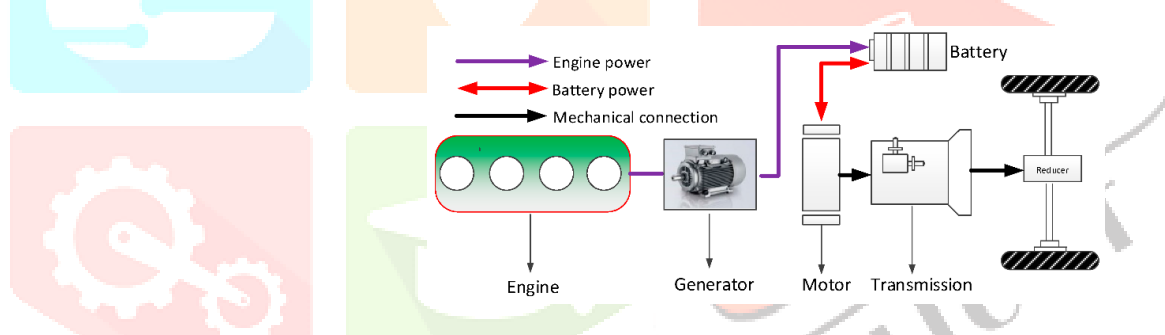


Figure 2 : Hybrid Electric Vehicles

Hybrid Electric Vehicles (HEVs)

Hybrid electric vehicles (HEVs) combine an internal combustion engine with an electric propulsion system, enhancing fuel efficiency and reducing emissions. They utilize regenerative braking and the engine to recharge their batteries, offering a balance of power and eco-friendliness. Definition of Hybrid Electric Vehicles (HEVs) [43]. (Figure 2)

- A hybrid electric vehicle (HEV) integrates a conventional internal combustion engine (ICE) with an electric propulsion system.
- The primary goal is to achieve better fuel economy and lower emissions compared to traditional vehicles.
- HEVs can come in various forms, including cars, trucks, buses, and even aircraft.

Plug in Hybrid Electric Vehicles (PHEVs)

- PHEVs are equipped with a larger battery pack that can be charged from an external electric power source, allowing for extended all-electric driving ranges.[44]

- They combine the benefits of electric driving with the convenience of a gasoline engine, providing flexibility for longer trips.

Key Features of PHEVs

- **Dual Power Sources:** PHEVs utilize both an electric motor and an internal combustion engine (ICE), allowing them to operate in electric-only mode or switch to gasoline when needed.
- **Charging Options:** The battery can be charged via a standard electrical outlet, dedicated charging stations, or through regenerative braking while driving.
- **All-Electric Range:** Most PHEVs can travel between 10 to 50 miles on electric power alone, depending on the model and battery size.

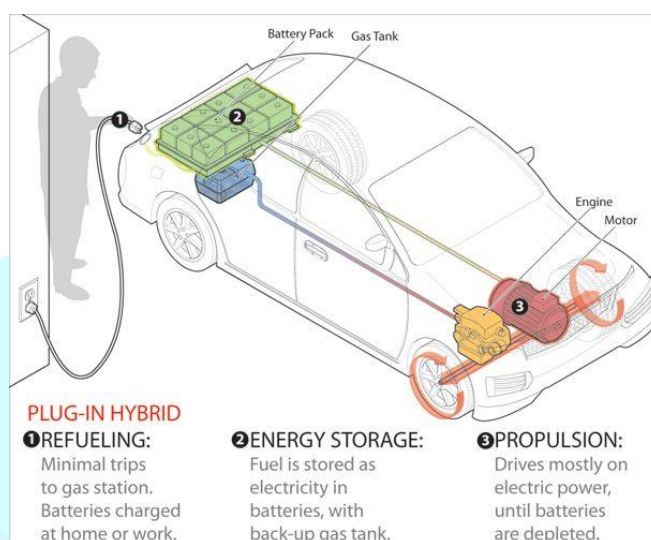


Figure 3 : Plug in Hybrid Electric Vehicles

Fuel cell Electric Vehicles (FCEVs)

Fuel cell electric vehicles (FCEVs): FCEVs react hydrogen gas with oxygen in the air to create power. They don't have a battery, and their sole waste is water vapor. Although FCEVs can be refueled in a few minutes and have a greater driving range than BEVs, there is still a lack of hydrogen refueling infrastructure [42]. (Figure 3) depicts the era of EV research and changes.

Extended Range Electric Vehicles (ER-EVs)

Extended Range Electric Vehicles (ER-EVs) are a type of electric vehicle that combines the features of a Battery Electric Vehicle (BEV) and a Plug-in Hybrid Electric Vehicle (PHEV). ER-EVs have a larger battery pack than PHEVs, which allows them to travel longer distances on electric power alone. However, once the battery is depleted, a small gasoline engine generates electricity to power the electric motor and extend the vehicle's range [46].

ER-EVs- are becoming more popular as they offer the benefits of both BEVs and PHEVs. They can be driven purely on electric power for shorter trips and travel long distances without stopping and recharging the battery. ER-EVs are also more environmentally friendly than traditional gasoline-powered vehicles as they produce fewer emissions.

One example of an **ER-EV** is the Chevrolet Volt, which has a battery range of approximately 53 miles before the gasoline engine kicks in. ER-EVs are a promising option for consumers looking for a more sustainable mode of transportation but needing the flexibility to travel longer distances.

Each type of EV has its advantages and disadvantages. BEVs and FCEVs produce no tailpipe emissions and are considered more environmentally friendly, but their limited range and lack of infrastructure may be a challenge for some users. HEVs and PHEVs offer more flexibility and do not require new infrastructure, but they still produce some emissions and are less environmentally friendly than BEVs and FCEVs

V. CURRENT SITUATION AND DATA ANALYSIS

Descriptive research methodology is used. Primary data of a sample population of 212 is collected using an online questionnaire. The environmental Chi square test is used to test the hypothesis.

1. Based on the desire of Indian people willing to adopt Electrical cars. 37% were in favor of eco-friendly vehicles and 5% are Favored for not adopting the EV. 28% of people are in favor to buy electric vehicles. And 30% of people are still unsure. 664 International Journal of Research Publication and Reviews Vol (2) Issue (7) (2021) Page 661-668

2. Survey based on the choice of fuel

Figure 5: Graph represents the current situation and **data analysis Life cycle GHG emission: 2021 v/s 2030**

3. Survey based on costing issue Cost being an important factor, the customer expects EVs in the 5-10 lakhs range. Some expect to be pricing between 10 to 15 lacks, and some expect to be above 15 lac.,

4. Data based on less or zero Emissions by Electrical Vehicle.

5. Managerial Implications Several implications emerge for not only marketers and manufacturers of EVs but also the government from this study. EV adoption in India is right now in a nascent stage; people are unfamiliar and hence may be skeptical for a move towards EV. Preference for EV will evolve as technology advances, and as familiarity, penetration, and SoC. In improve International Journal of Research Publication and Reviews Vol (2) Issue (7) (2021) Page 661-668 665

The environment is a concern for all, Central and State governments, and every human being, regardless of their stature. The introduction of green license plates on EVs can symbolize concern for the environment, and support with financial incentives such as free or concessional toll, parking, or priority at public places may enhance adoption.

Hence, marketer's communication in addition to the above should highlight the expected features like

Functional information such as range covered per battery charge, battery life, and maximum speed along with Quality specifications.

However, additionally, how the customer can affect the environment positively by adopting EVs.

VI. RETROFITTING

What is Retrofitting?

Electric Vehicle Retro-fitment means to convert existing petrol or diesel run vehicles into an electric vehicle. The process involves changing the original engine and other related components and a new alternative energy source to be transplanted into the existing vehicle body. The retrofitting will allow people to continue to use their costly vehicles rather than getting them scrapped, and will also be beneficial for the environment. However, retrofit kit shall have approval of designated testing agency as specified in rule 12b of CMVR 1989. <https://ev.delhi.gov.in/retro-fitment>

Potential of Retrofitting

A study by Ola Mobility Institute in 2019 said that central government e-mobility targets for 2030 can only be achieved when the incentive provision goes beyond the purchase cost of electric vehicles. The Total Cost of Ownership includes the direct and indirect costs of purchasing, running, and maintaining the electric vehicle. With these overheads, the cost of ownership is significantly higher for electric vehicles at this point, especially since the charging infrastructure is not robust.

Delhi-based startup BharatMobi launched the Bharat Kit , which is designed to convert conventional vehicles into electric. The customized battery, part of the kit, gives an average speed of 80 kilometers per hour after being charged for four to five hours.

In an interview with **News18**, **Akbar Baig, Co-founder of BharatMobi** shared, —With the Bharat Kit, your car becomes a pollution-free, gearless, noiseless vehicle. This kit goes perfectly with a wide range of cars and offers a smooth, efficient, and fuel-free drive. Loop Moto is another startup that provides a compact electric powertrain with Lithium-ion batteries, battery management system (BMS), and other associated accessories as kits for different vehicles to retrofit any conventional vehicle and convert it into an electric vehicle

VII. THE CHALLENGES FOR THE EV MARKET IN INDIA

India only has 650 charging stations as per official reports in 2018. The average on-road price of electric vehicles in India is not attractive enough for consumers. EV startups and auto majors caught between reducing EV costs and spending money to boost infrastructure.

High Price of Electric Vehicles

Further, the average cost of electric cars in India is around INR 13 Lakh, much higher than the average INR 5 Lakh for economical cars run on traditional fuel. Also, the price of electric scooters and motorcycles in India is between the price ranges of INR 70K – INR 1.25 Lakh, as compared to INR 30K – INR 40K cost range of ICE bikes and even lower for scooters.

Range Anxiety

Range anxiety is what consumers suffer from knowing that the electric vehicle might not have sufficient range to take them to their destination. This is deeply linked to the lack of charging infrastructure in the country, and while conventional vehicles can be refueled at petrol stations, such regularized infrastructure is not yet available for EVs. Rudratej Singh, president, and CEO of BMW Group India, also earlier said that the infrastructure for electric vehicles is still ambiguous and uncertain, which would affect the price and acceptability of the vehicle among Indian consumers. Toyota too has recently halted the manufacturing of electric and hybrid cars for the Indian market, citing inadequate charging infrastructure.

Charging infrastructure

India was reported to have 650 charging stations in 2018, whereas China had over 456K charging points in the same year. In addition to charging points, the lack of private parking spaces is also noted as a hindrance for electric vehicles adoption, and the lack of affordable renewable energy means charging EVs is putting a toll on the already stressed coal-powered electricity grid. According to auto giant Maruti Suzuki's research, 60% of Indian customers don't have their own parking space. "There is no way they can charge the vehicle ;therefore, they won't adopt it," said C V Raman, senior executive director (engineering) of Maruti Suzuki India. (Figure 5) represents the total number of Public EV Charging stations in INDIA.

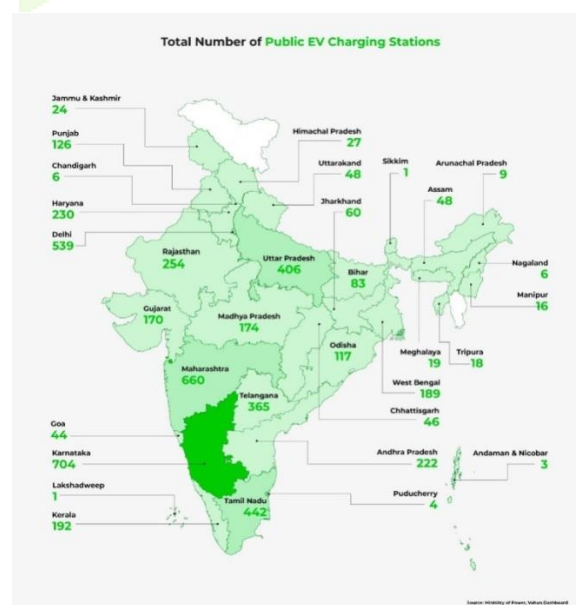


Figure 4: Total number of Public EV Charging stations in INDIA.

FAME policy Flip-Flops

While no one doubts that the Indian government is doing all it can to push EVs, the Faster Adoption and Manufacture Of (Hybrid) And Electric Vehicles (FAME) policy has been criticized by the industry in the past. The government had initially focused on vehicle standardization with FAME, which was sidelined for an emphasis on manufacturing. At the moment, the government is busy drafting an EV charging infrastructure framework.

The government is also planning to tax non-electric vehicles heavier even if the sales of electric vehicles might not justify such a forced transition. And this has put undue pressure on automobile OEMs.

VIII. Future Research Recommendations

Even though there has been a lot of advancement in the evolution and development of electric vehicles, especially in recent years, this section discusses the problems that are still being worked on or that may be worth looking into to find better and more innovative resolutions.

A. EV Batteries: Latest Developments and innovations

As we have previously stated, in electric cars (EVs), batteries are among the most critical components because they account for most of the vehicle's cost and directly affect the EV's performance.

Due to the growth in durability, charging density, and charge and discharge processes, the creation of new technologies that can exceed the current lithium-ion batteries primarily used in vehicles has forced the employment of various resources [45].

Keeping in mind all the parameters, it is seen that there is more work to be done in this area, mainly due to the importance of batteries, which might significantly speed up the development of EVs and the acceptance of these vehicles. New components and technologies are now the subject of investigation. In this regard, new research is underway utilizing pure carbon, which makes up the substance known as graphene, which is very light and has a high thermal conductivity. Graphene-based batteries seldom warm up, which is one of their main advantages, allowing for quick or ultra-quick charges without suffering significant power losses from heat. [45]

A 900 horsepower GTA Spano car with a graphene battery attached has a range of 800 km, according to Graph nano, a Spanish business. This battery can be charged in about 5 min using a high-power outlet. Although graphene batteries are still in the development phase, there are prototypes with a specific energy of 1.0 kWh/kg, and it is projected that they will soon reach 6.4 kWh/kg [45].

According to this theory, the technology that can make EVs more autonomous and significantly shorten the time needed for a full charge will be the one that prevails in the market.

B. Artificial Intelligence in EV

As was already noted, several things will need to come together for electric cars to fully replace other modes of transportation on our roads and in our towns

There is a large research gap in this area as the world moves towards AI. Battery temperature regulation, better and more intelligent charging, and energy-efficient routing are just a few of the artificial intelligence (AI) ideas for EV themes that have been proposed. Ref. [46] offers a unique machine learning-based approach for successful routing. Their method may be used to forecast the energy consumption of the multiple road segments that make up the planned or actual vehicle routes. Ref. [46] addresses the problem of planning the routes for a fleet of electric vehicles. Their approach considers the vehicle's maximum battery capacity and the concurrent use of charging stations along the route and employs a developing genetic algorithm with a learning process.

To improve the thermal management system and lower overall energy consumption, ref. [47] recommends employing Artificial Neural Networks (ANNs) for battery thermal management. The battery temperature may be maintained within acceptable limits under the scheme. Ref. [47] examines the relationship between battery thermal behavior and design factors. Their computational analysis reveals that a cooling method

based on distributed forced convection may result in uniform temperature and voltage distributions across the battery pack at different discharge rates.

Based on that, artificial intelligence (AI) will promote the development of new solutions, which are:

- Streamline the battery charging process (by enabling early booking of the charging point, providing automatic power balancing capabilities, allowing adaptive charges based on context, etc.)
- Improve the power generation process to handle the significant increase in electric demand on the grid (by providing predictions of the required power at every moment, mobility analysis of the E-mobility, etc.).

Thus, the Internet of EVs (IoEVs) is about to become a reality, which will undoubtedly impact how we move about but also offer up a whole new universe of exploration containing new applications and services.

C. Public Policies

As mentioned earlier, government subsidies are a significant element in promoting EV adoption. Few models have been developed to explore how governments may utilize subsidies to stimulate EV adoption among customers with restricted budgets, even though the influence of subsidies on EV production has been studied in previous studies.

Further study is primarily needed to better understand subsidies' objectives and the design of government subsidy programs and policies to maximize EV market demand or consumer surplus while considering the objectives of EV manufacturers, retailers, and consumers. Game models provide a solution to this problem. Some elements will significantly impact the objectives and plans of subsidy programs, including customers' negotiation power when choosing between individually constructed vehicles and electric vehicles.

Government subsidies will impact the transition and expansion of the automotive sector. It's still unclear how governments should balance competing goods (such as BEVs and ICVs) with the goals of various supply chain structures (such as the producer, retailer, or client). Government subsidies, for instance, will impact manufacturer output and price, retailer orders and pricing, and consumer demand if a manufacturer offers battery electric vehicles and individually constructed vehicles and sells them through distinct retailers. Different circumstances can be characterized using game models. It is possible to determine the optimum industrial structure by comparing the outcomes of several situations.

IX. Conclusions

In conclusion, the adoption of electric vehicles (EVs) in India represents a crucial step towards achieving a sustainable and environmentally friendly transportation system. With the country's commitment to reducing carbon emissions and addressing air pollution, the transition to EVs is not only beneficial but necessary. Government initiatives, such as subsidies and incentives, alongside advancements in battery technology and charging infrastructure, are paving the way for a robust EV ecosystem.

Despite the challenges of infrastructure development, consumer awareness, and battery disposal, the opportunities for growth and innovation in the electric vehicle sector are immense. As the market continues to expand, particularly in two-wheelers and public transport, India has the potential to emerge as a global leader in electric mobility.

The collaborative efforts of the government, industry stakeholders, and consumers will be vital in overcoming existing hurdles and fostering a culture of sustainability. As India moves forward, the widespread adoption of electric vehicles can significantly contribute to economic growth, energy security, and a cleaner environment, ultimately enhancing the quality of life for its citizens.

The Role of Government Initiatives in Shaping India's Electric Vehicle Sector

In India, the government has introduced various schemes across the EV value chain to incentivize its production, adoption, and usage. In July 2023, NITI Aayog laid down the roadmap for the growth of electric mobility in India aligning it with the Indian government's vision of achieving net Zero emissions by 2070.

The NITI Aayog has laid specific targets by vehicle type in pursuit of its objective to achieve 30% EV sales penetration by 2030. The targets by specific vehicle type are:

- 30% in Private cars
- 70% in Commercial vehicles
- 40% in Busses
- 80% in two-wheeler
- 80% for three-wheeler
- Further, the government aims for 100% local production of EVs as part of the 'Make in India' initiative.

EV industry in India

The number of electric vehicle registrations in India surged from 1.3 million in 2018 to a 15.29 million by 2023, marking an impressive eleven-fold increase. Figure 6 & Figure 7: depicts the data of State wise highest number of Registered EV in INDIA.

- Total number of EVs registered over time (in millions of units).

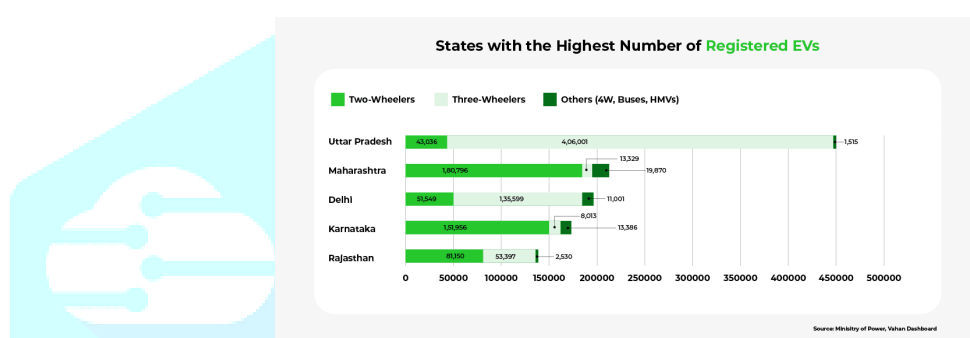


Figure 5: State wise highest number of Registered EV in INDIA.

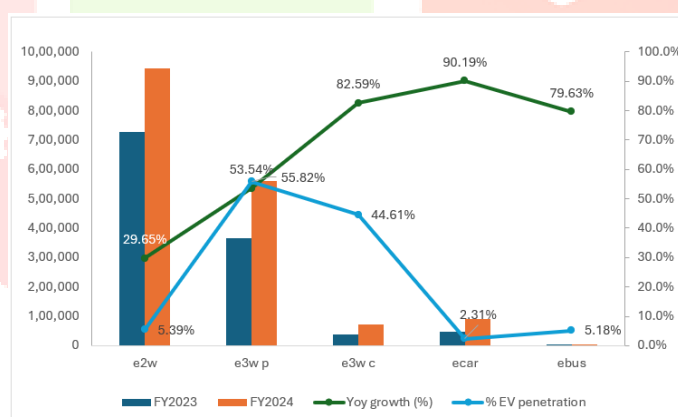


Figure 6 :EV penetration comparison B/W FY2023-24

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