



## Adoption of Electric Vehicles: A Review of Technology, Transformation and Policies

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### ABSTRACT

The adoption of electric vehicles (EVs) is considered a promising solution to address the negative impacts of conventional vehicles on the environment and human health. This paper provides a comprehensive review of the current state of EVs, including their types, technology, adoption, government policies, environmental impact, and future prospects. The review reveals that EVs have the potential to significantly reduce air pollution, greenhouse gas emissions, and noise pollution. However, their adoption has been hindered by various factors such as perceived usefulness, ease of use, and risk, which can be addressed through policy interventions and infrastructure development. The paper highlights the significance of the Faster Adoption and Manufacturing of Electric Vehicles (FAME) scheme in India and other international policies and initiatives to support the adoption of EVs. The review also identifies the technological advances and battery development as promising opportunities for the future of EVs. The paper concludes by providing implications for policy and practice, including the need for incentives and infrastructure development to promote EV adoption and recommends further research on the consumer trends and challenges in the adoption of EVs.

**Keywords:** Electric vehicles, technology acceptance model, FAME, environmental impact, battery development, sustainability.





## INTRODUCTION

India has one of the world's fastest-growing economies, a rapidly expanding population, and rising transportation demand. However, the road transport industry contributes significantly to the nation's greenhouse gas emissions, with over 23% of the total emissions coming from this sector (Agency, 2021). India has been actively encouraging the use of electric vehicles (EVs) as a way to combat this problem and reduce both the nation's reliance on fossil fuels and air pollution (MOEF&CC, 2019). The Faster Adoption and Manufacturing of Electric Vehicles (FAME) scheme, which provides financial incentives to electric vehicle manufacturers and consumers, is one of the policy efforts the Indian government has undertaken in order to accelerate the adoption of EVs (Industries, 2020). As a result, the number of EVs on Indian roads has increased significantly in recent years, with the total number of EVs sold in India in 2021 reaching approximately 6.8 lakh units, a 140% increase from the previous year (Singh & Singh, Aditi Specialist, 2023). Despite this growth, the adoption of EVs in India remains low compared to traditional gasoline-powered vehicles. The Technology Acceptance Model (TAM) states that perceived usefulness, perceived ease of use, and perceived risk are key determinants of the intention of accepting new technologies (Davis, 1989). Therefore, it is crucial to fully understand the factors influencing EV adoption in India and to find strategies for boosting awareness among consumers.

This paper aims to provide a comprehensive review of the technology, transformation, and policies related to the adoption of EVs in India. The paper draws on a range of literature, including academic articles, government reports, and industry publications. The literature review covers both national and international research to provide a comprehensive understanding of the adoption of EVs in India. The paper is structured as follows: Section II provides a summary of different types of EVs and the technology behind them. Section III discusses the adoption of EVs and the factors influencing their adoption, including knowledge about EVs, perceived usefulness, perceived ease of use, and perceived risk. Section IV examines the government policies and incentives in India that support the adoption of EVs, including FAME scheme, rebates, and infrastructure development. Section V discusses the environmental benefits of EVs, including air pollution reduction, greenhouse gas emissions reduction, and noise pollution reduction. Section VI explores the future of EVs in India, including technological advances, battery development, consumer trends, and challenges and opportunities. Finally, Section VII provides a summary of the key findings and implications for policy and practice.

The primary objective of this paper is to offer a comprehensive analysis of the present status of electric vehicle (EV) adoption in India. Through an in-depth review the study aims to add to the existing body of literature by identifying important research gaps and providing viable areas for further investigation in this field.

### Literature Review

The adoption of EVs is influenced by various factors, including technology, consumer behavior, government policies, and infrastructure. In this literature review, we will examine the existing research on these factors and identify the gaps that need to be addressed.

### Technology

The Technology Acceptance Model (TAM) is a widely accepted framework for understanding consumer adoption intention towards new technologies (Davis, 1989), including EVs. Several studies have used TAM to investigate EV adoption intention in various contexts. For instance, a study conducted by (Adu-Gyamfi *et al.*, 2022) found that perceived usefulness, perceived ease of use, and social influence significantly influenced consumer adoption intention towards EVs.

### Consumer Behavior

The inclination towards EVs is also significantly influenced by consumer behaviour. Some studies have investigated the factors that influence consumer behavior towards EVs. For instance, a study conducted by (Karagoz *et al.*, 2020)



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in Iran found that environmental concern, perceived benefits, and social influence significantly influenced consumer behavior towards EVs. Another study conducted by (Yang & Lee, 2022) in China found that perceived value, perceived quality, and brand image significantly influenced consumer behavior towards EVs.

### Government Policies

Regulations by the government are essential in promoting the use of EVs. In order to promote the use of EVs, the number of countries have enacted policies including tax incentives, subsidies, and infrastructure development. For instance, to encourage the use of EVs, the Indian government introduced the Faster Adoption and Manufacturing of Electric Vehicles (FAME) scheme in 2015 (Ministry of Heavy Industries and Public Enterprises, 2019). The scheme provides financial incentives to manufacturers and buyers of EVs. Similarly, several other countries have implemented similar policies to encourage the adoption of EVs.

### Infrastructure

Another significant aspect that affects EV adoption is infrastructure. For EV adoption, the availability of charging stations is essential. One of the biggest obstacles to the adoption of EVs is the absence of charging infrastructure. Several research have looked into the connection between EV adoption and the accessibility of charging infrastructure. For instance, a study conducted in the Netherlands by (Sierchula et al., 2014) discovered that the accessibility of charging infrastructure has a considerable impact on EV adoption.

### Gaps in the Literature

While several studies have investigated the factors that influence EV adoption intention, the literature still has multiple gaps that need to be addressed. One such gap is the absence of research in the Indian context. India is a unique context due to reasons such as lack of charging infrastructure, low awareness among consumers, and costly upfront expenditures. Thus, it is important to conduct research in the Indian context to understand the factors that influence EV adoption intention and develop strategies to overcome the barriers to adoption.

### Significance & Relevance

The adoption of EVs has the potential to address several environmental and economic challenges facing the world. The transition to EVs can dramatically cut greenhouse gas emissions, resulting in a major contribution to the transportation sector. Adoption of EVs can also lessen reliance on fossil fuels and improve energy security. Economic opportunities in the industrial and service sectors may arise as a result of the adoption of EVs. The adoption of EVs is not without obstacles, either. Some of the obstacles to acceptance are the high upfront prices, shorter driving distances, and a lack of charging infrastructure. It takes a thorough grasp of the variables influencing EV adoption intention to get over these obstacles. The existing literature has identified several factors, including technology, consumer behavior, government policies, and infrastructure, that influence EV adoption intention. Nevertheless, there are still gaps in the literature that must be filled, especially in the context of India.

The government of Indian has implemented several policies, including the FAME scheme, to encourage the adoption of EVs. However, the impact of these policies on EV adoption intention is yet to be fully understood. Consequently, conducting research within the Indian context holds significant importance in comprehending the factors impacting EV adoption intention and formulating strategies to address adoption barriers. The adoption of EVs has the potential to address several environmental and economic challenges facing the world. However, the adoption of EVs is not without its challenges, and overcoming these challenges requires a comprehensive understanding of the aspects that impact EV adoption intention. Conducting research in the Indian context is crucial to understand the issues that affect EV adoption intention and develop policies to encourage the adoption of EVs in India.

### Objective

This paper's main goal is to provide a thorough evaluation of the research on the factors that affect EV adoption, with particular focus on the Indian context. The paper aims to identify the factors that influence EV adoption intention and highlight the gaps in the literature that need to be addressed.





## METHODOLOGY

In this paper, we present a literature review on our topic of interest. A comprehensive review of relevant studies was conducted using multiple academic databases, including Scopus, Web of Science, and Google Scholar. We aim to provide an up-to-date analysis and synthesis of current knowledge and findings in the field in this review paper. The search have included articles published between 2010 and 2023. The search terms include a combination of the following keywords: "electric vehicle," "plug-in electric vehicle," "battery electric vehicle," "EV adoption," "technology acceptance model," "consumer behavior," "government policies," "infrastructure," "FAME scheme," "charging station," "range anxiety," and "Indian context." The inclusion criteria for the papers include publication in journals and relevance to the factors influencing EV adoption intention in the Indian context. Papers that are non-English, as well as conference proceedings and presentations are excluded.

## RESULTS AND DISCUSSIONS

Electric vehicles (EVs) have been in advance fame as an alternative to conventional gasoline-powered automobiles due to their potential to decrease greenhouse gas emissions, improve air quality, and promote energy security. In this section, we will provide an outline of the different types of EVs and the technology behind them.

### Overview of Electric Vehicles

#### Types of Electric Vehicles

Plug-in electric vehicles (PEVs), battery electric vehicles (BEVs), and hybrid electric vehicles (HEVs) are the three primary categories of EVs.

#### Plug-in Electric Vehicles (PEVs)

PEVs are vehicles that primarily run on electricity and include an internal rechargeable battery that can be charged by connecting the car to an external power source. Plug-in hybrid electric vehicles (PHEVs) and extended-range electric vehicles (EREVs) are the two categories of PEVs. PHEVs have equally an electric motor and a gasoline-powered engine. They can function in electric-only mode for a limited range, after which the gasoline engine will start to power the vehicle. EREVs, on the other hand, have a larger battery than PHEVs and can operate solely on electric power for a longer range. Once the battery is depleted, a gasoline-powered generator will kick in to power the vehicle (Chakraborty et al., 2022).

#### Battery Electric Vehicles (BEVs)

BEVs are vehicles that rely solely on electricity as their source of power. A rechargeable battery fuels an electric motor that powers them. BEVs don't have internal combustion engines and don't emit any pollution at all. They have a limited range, typically between 100-300 miles, before requiring a recharge (Wicki et al., 2023).

#### Hybrid Electric Vehicles (HEVs)

HEVs combine an internal combustion engine with an electric motor. The engine receives additional power from the electric motor, which lowers pollution and consumption of fuel. HEVs rely on regenerative braking for recharging their batteries because they cannot be plugged in (Karoń, 2022).

### Technology behind Electric Vehicles

#### Charging Stations and Charging Time

Charging stations are essential for EVs, as they provide a place to recharge the battery. There are three levels of charging: Level 1 (120-volt AC), Level 2 (240-volt AC), and Level 3 (DC fast charging). Level 1 and 2 charging can be done at home or at public charging stations and typically take several hours to fully recharge the battery. Level 3 charging can charge the battery up to 80% in 30 minutes, making it ideal for longer trips (Muratori et al., 2021).



**Mudasir Ahmad Tass et al.,****Range and Battery Life**

Range anxiety is a common concern among potential EV buyers, as the range of EVs is typically lower than that of gasoline-powered vehicles. However, advances in battery technology have increased the range of BEVs, with some models having a range of over 300 miles. Battery life is also a concern, as the cost of replacing the battery can be significant. However, the lifespan of EV batteries has been increasing, with many manufacturers offering warranties of up to 8 years (Miao et al., 2019).

**Environmental Benefits**

EVs have the capability to decrease greenhouse gas emissions and enhance air quality. Studies have shown that the total emissions from EVs are lower than those from gasoline-powered vehicles, even when considering the emissions from power plants that generate the electricity used to charge the EVs. Additionally, EVs produce no tailpipe emissions, which can significantly improve air quality in urban areas (Z. Xia et al., 2022). The different types of EVs and the technology behind them provide consumers with a range of options to choose from. Advances in battery technology and charging infrastructure are making EVs a more viable option for consumers. Moreover, the battery life of EVs has also improved significantly with technological advancements. Lithium-ion batteries are the most common type of batteries used in EVs, and they have a lifespan of about 10-15 years, which is equivalent to the lifespan of a typical gasoline-powered car (Miao et al., 2019). Additionally, the cost of lithium-ion batteries has decreased by 85% since 2010, making EVs more affordable for consumers (Colin McKerracher, 2020).

One of the main advantages of EVs is their environmental benefits. EVs emit less greenhouse gases compared to gasoline-powered cars, which makes them a more sustainable alternative to traditional vehicles (Colin McKerracher, 2020). Furthermore, EVs have no tailpipe emissions, which helps to reduce air pollution in urban areas (Gandoman et al., 2019). The widespread adoption of EVs could have significant impacts on reducing air pollution, particularly in densely populated areas.

EVs have derive a long way since their inception, and progressions in technology have made them a more viable alternative to traditional gasoline-powered cars. The different types of EVs available, such as PHEVs, BEVs, and HEVs, offer consumers a range of options depending on their needs. The technology behind EVs, including charging stations, battery life, and environmental benefits, has improved significantly, making EVs more attractive to consumers. As a result, the adoption of EVs has the potential to decrease air pollution and greenhouse gas emissions, making them an important part of the transition towards a more sustainable transportation system.

**Adoption of Electric Vehicles**

An essential step in creating a sustainable transportation system is the adoption of electric vehicles (EVs). However, there are a number of reasons why the adoption of EVs has been so delayed. The Technology Acceptance Model (TAM) is a widely recognized framework employed to comprehend the adoption of new technologies, including EVs. The factors influencing EV adoption within the TAM framework were proposed by (Davis, 1989). Perceived usefulness states the degree to which a technology is believed to be useful in attaining a particular goal or task (Davis, 1989). In the case of EVs, perceived usefulness can be related to factors such as cost savings on fuel and maintenance, reduced environmental impact, and improved performance (Cui et al., 2023). Studies have found that perceived usefulness is positively related to the intention to adopt EVs (Bryła et al., 2023). Therefore, it is important for manufacturers and policymakers to promote the usefulness of EVs to increase their adoption.

Perceived ease of use states the degree to which a technology is supposed to be easy to use (Davis, 1989). In the case of EVs, perceived ease of use can be related to factors such as the availability of charging infrastructure and the ease of charging (Cui et al., 2023). Therefore, it is important for manufacturers and policymakers to make EVs and their charging infrastructure more accessible and user-friendly. Perceived risk refers to the potential negative consequences associated with the adoption of a technology (Davis, 1989). In the case of EVs, perceived risk can be related to aspects such as the range concern, battery life, and the accessibility of charging infrastructure (Cui et al., 2023). Studies have found that perceived risk is negatively associated to the intent to adopt EVs (Bryła et al., 2023). Therefore, it is important for manufacturers and policymakers to address these perceived risks and concerns to



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increase the adoption of EVs. Various factors can affect the adoption of EVs. Studies have identified factors such as demographic characteristics, financial incentives, and government policies as important factors that influence the adoption of EVs (Bryła et al., 2023; Cui et al., 2023; Gandoman et al., 2019). Additionally, the accessibility of charging infrastructure, the choice of EVs, and the cost of EVs also play an important role in the adoption of EVs (Colin McKerracher, 2020). In order to enhance the adoption of EVs, it is crucial for manufacturers and policymakers to take these considerations into account.

### **Government Policies and Incentives**

Government regulations and incentives play a big role in determining whether electric vehicles are adopted. The Indian government has launched a number of programmes to encourage the usage of electric vehicles nationwide. The Faster Adoption and Manufacturing of Electric Vehicles (FAME) scheme, one of the key initiatives, was introduced in 2015 with the goal of encouraging the production and uptake of electric vehicles in India (GOI, 2020). The government offers financial incentives to both consumers and manufacturers of electric vehicles under this scheme.

Governments employ incentives and rebates as essential policy tools to support the adoption of electric vehicles. Incentives offered by the Indian government to consumers of electric vehicles include reduced taxes, lower registration costs, and subsidies for the purchase of electric vehicles (GOI, 2020). Additionally, a number of Indian state governments offer further incentives for the purchase and use of electric vehicles (Aayog, 2023). Building up the infrastructure is essential for the widespread use of electric vehicles. The Indian government has taken a number of actions to encourage the growth of the nation's infrastructure for electric vehicle charging. The government offers financial support to states under the FAME programme for the construction of a charging infrastructure. The government has also set a goal of putting in 2.7 million charging stations nationwide by 2030 (GOI, 2020).

International policies and initiatives also have a significant role in promoting the adoption of electric vehicles. India signed the Paris Agreement in 2016, which aims to limit the increase in global temperature to well below 2 degrees Celsius within pre-industrial levels (United Nations, 2021). To achieve this, India has set a target of achieving 30% electric vehicle adoption by 2030 (GOI, 2020). India has also joined the International Solar Alliance, which intends to encourage the use of solar energy globally (International Solar Alliance (ISA), 2022). The government incentives and policies play an important part in promoting the adoption of electric vehicles. The FAME programme, rebates and government subsidies, as well as infrastructure development, are just a few of the measures that the Indian government has done to promote the production and usage of electric vehicles. International policies and initiatives, such as the Paris Agreement and the International Solar Alliance, also play a significant role in promoting the adoption of electric vehicles.

### **Impact of Electric Vehicles on Pollution and Environment**

Electric vehicles have become an attractive alternative to traditional vehicles due to their potential environmental benefits. The growing concern about air pollution and climate change has led to an increase in research on the impact of electric vehicles on pollution and the environment.

- **Air Pollution Reduction:** Electric vehicles have the potential to reduce air pollution in urban areas. Studies have revealed that as compared to gasoline and diesel cars, electric vehicles produce significantly less nitrogen oxides (NO<sub>x</sub>), particulate matter (PM), and volatile organic compounds (VOCs) into the atmosphere (Palit et al., 2022). Electric vehicles also do not emit greenhouse gases (GHGs) during operation, which further contributes to air quality improvement.
- **Greenhouse Gas Emissions Reduction:** One important technology for reducing GHG emissions in the transportation industry is electric vehicles. According to a study by (Aijaz & Ahmad, 2022), electric vehicles have the capabilities to reduce GHG emissions by up to 90% compared to vehicles using gasoline. However, the extent of the GHG emissions reduction depends on the source of electricity used for charging the vehicles. In regions where electricity generation relies heavily on fossil fuels, the GHG emissions reduction may not be as significant.





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- Noise Pollution Reduction: Another potential advantage of electric vehicles is the decrease of noise pollution. Electric vehicles are significantly quieter than old vehicles, which could lead to a reduction in noise pollution in urban areas (Khreis et al., 2023).

It is important to note that the environmental benefits of electric vehicles depend on the life cycle assessment (LCA) of the vehicles, including the manufacturing, operation, and disposal phases (X. Xia & Li, 2022). A comprehensive LCA is necessary to fully understand the environmental impact of electric vehicles. Overall, the potential environmental benefits of electric vehicles make them an attractive option for addressing air pollution and climate change concerns.

### **Future of Electric Vehicles**

Electric vehicles (EVs) have a bright future ahead of them, with the potential for considerable technology breakthroughs, battery developments, and consumer trends.

### **Technological Advances**

Technological advancements are expected to bring major improvements in EV performance, efficiency, and safety. Advances in power electronics, motors, and control systems have improved the efficiency of EVs (Trinko et al., 2023). Moreover, the integration of artificial intelligence and machine learning technologies is anticipated to enable the development of more efficient EVs, resulting in improved battery performance and increased driving range (Liu et al., 2022).

### **Battery Development**

Battery technology plays a vital role in the development and progress of EVs. Current advancements in battery technologies, such as solid-state batteries, are expected to increase the energy density, reduce the cost, and enhance the safety of EVs (Fan et al., 2021). Furthermore, progresses in battery recycling technologies are expected to reduce the environmental impact of battery production and disposal (Liu et al., 2022).

### **Consumer Trends**

Consumer trends are critical for the growth of EVs. The rising demand for sustainable transportation, coupled with decreasing battery costs and increasing driving range, is expected to boost the adoption of EVs (Palit et al., 2022). In addition, the growing popularity of shared mobility services and electric autonomous vehicles is expected to drive the development of the EV market (Zhu et al., 2022).

### **Challenges and Opportunities**

Despite the numerous benefits, the widespread adoption of EVs faces several challenges. These challenges contain high upfront costs, absence of charging infrastructure, limited driving range, and consumer anxiety about battery life and maintenance (Ke et al., 2022). However, these challenges also present opportunities for further innovation, investment, and policy intervention to address them and accelerate the growth of the EV market. The future of EVs is promising, with significant opportunities for technological advancements, battery developments, and consumer trends. However, the widespread adoption of EVs will require continued investment, innovation, and policy intervention to address the challenges and capitalize on the opportunities.

## **CONCLUSION**

The adoption of electric vehicles is gaining momentum due to advancements in technology and increased awareness of the benefits of electric mobility. Plug-in electric vehicles (PEVs), battery electric vehicles (BEVs), and hybrid electric vehicles (HEVs) are among the several types of electric automobiles; with BEVs are the most environmentally beneficial. Electric vehicle technology, including charging stations, battery capacity, and range, has advanced dramatically over time. The FAME plan in India and other government subsidies and tax credits are only a few





examples of the policies and incentives that have been instrumental in fostering the adoption of electric vehicles. Additionally, electric cars significantly reduce noise pollution, air pollution, and greenhouse gas emissions. The future of electric vehicles is promising due to technological advances, battery development, and changing consumer trends. However, challenges such as infrastructure development, battery cost, and range anxiety need to be addressed. Implications for policy and practice suggest that governments should continue to promote the adoption of electric vehicles by providing incentives, such as rebates and tax credits, and investing in infrastructure development. Companies should also invest in the research and development of electric vehicle technology to improve battery life and range, and provide affordable electric vehicles to the consumers. Recommendations for future research include investigating the impact of electric vehicle adoption on the electricity grid and the potential of vehicle-to-grid (V2G) technology. Additionally, research could be conducted on the impact of electric vehicle adoption on the automotive industry and its supply chain. The adoption of electric vehicles has significant implications for the environment, public health, and the automotive industry. Continued research, policy support, and investment in technology are essential to promote the adoption of electric vehicles and create a sustainable future.

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