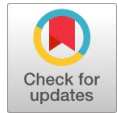


# Enablers of Electric Vehicles Adoption in India: A Review

Deepika Pandita, Vimal Bhatt, V. V. Ravi Kumar, Piyush Gotise



**Abstract:** India is moving towards electric vehicles. However, the road to EV adoption progress does not seem smooth and may require effort from both the people and the government. Regarding the growth of Electric Vehicles in India, there is a need to identify the factors that could accelerate their progress. In this paper, we, based on a review of the relevant literature from scientific databases, suggest a range of factors that require the attention of policymakers and other stakeholders to contribute to improving electric vehicle adoption in India. The factors are explained in detail, along with their implications for the adoption of electric vehicles.

**Keywords:** Electric Vehicles, EV, Electric Cars, Adoption

## I. INTRODUCTION

More than seven and a half lakh electric vehicles are registered in India [1] and with around eighteen hundred charging stations [1] as of now in the country, India is trying to go electric. There are several reasons why electric vehicles should be adopted globally, including in India. Over the past few decades, efforts and interest in protecting the environment and climate have been increasing. The serious consequences of climate change and environmental degradation can be seen as the thinning of the ozone layer [2] and the gradual melting of glaciers [3] that could contribute finally to rising sea water levels [4] and many other natural calamities. Fossil fuel-based transportation across the world is amongst the significant sources of greenhouse gases (GHG) and other harmful toxic emissions that contribute to environmental degradation and climate change [5]. The harmful chemicals like carbon monoxide (CO), sulphur dioxide (SO<sub>2</sub>), ozone (O<sub>3</sub>), and nitrogen oxides (NO<sub>x</sub>) in air pollutants coming from internal combustion engine vehicles (ICVs) are going beyond the level as prescribed by the National Ambient Air Quality Standards (NAAQS) in the cities of India [6]. These pollutants can be detrimental to individuals' health [7].

India is among the world's growing economies and one of its most populous countries, resulting in a significant amount of transportation on the roads to meet the country's needs. The plethora of internal combustion engine-based vehicles (ICVs) that transport people causes a considerable amount of pollution. Moreover, as the prices of fossil fuels are increasing [8] and also due to the limited availability of non-renewable resources, there is a need to find alternative energy resources. The pressure is on the governments of several countries from the masses, the environmentalists, environmental and climate control agencies, and from other agencies and authorities to lessen the reliance on fossil fuel as it is a limited resource [9]. Considering the matter, Electric Vehicles could be an alternate energy transport solution that could check the emissions of GHG and other air pollutants and help in mitigating the harmful effects of it on climate change, the environment, and on people's health [10] [11].

## II. LITERATURE REVIEW

Electric vehicles in India are making progress [9] with the support of the Indian government. Electric vehicle operating costs are considerably cheaper than those of fossil fuel-based internal combustion vehicles (ICVs). Not only are EVs economical, but they also have several other advantages that make them better than ICVs. That is, EVs are tailpipe emissions-free.

They do not cause noise pollution except a slight noise at low speeds [12] and have low maintenance in comparison to internal combustion-based vehicles (ICVs). Furthermore, EVs are simpler in design and comfortable to use.

These days, various types of EVs are available on the market, ranging from fully electric to partially electric. Some electric vehicles (EVs) are combined with internal combustion engine (ICE) vehicles. Typically, they could be categorized as hybrid electric vehicles (HEVs). Battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs), and extended-range battery electric vehicles (E-REVs) [13]. In HEV, both an internal combustion engine (ICE) and an electric motor are present, and the battery is charged by regenerative braking and the ICE [13]. In comparison to hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs) have a higher battery capacity and can be plugged into a charger for recharging the battery [14] [13]. Nevertheless, the range of plug-in hybrid electric vehicles (PHEVs) is limited; that is, these vehicles cannot travel long distances solely on battery power [13]. To address the short range of PHEVs, extended-range electric vehicles (E-REVs) could be a better alternative. An extended-range electric vehicle (E-REV) features a rechargeable battery and a fuel tank, allowing it to operate on both electricity and fossil fuels, and is designed for a more extended range [13].

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\*Correspondence Author (s)

**Dr. Deepika Pandita**, Symbiosis Institute of Business Management, Pune & Symbiosis International (Deemed University), Pune (Maharashtra), India. Email: [deepikapandita@sibmpune.edu.in](mailto:deepikapandita@sibmpune.edu.in)

**Dr. Vimal Bhatt**, Symbiosis Institute of Business Management, Pune & Symbiosis International (Deemed University), Pune (Maharashtra), India. Email: [vimalbhatt@sibmpune.edu.in](mailto:vimalbhatt@sibmpune.edu.in)

**Dr. V V Ravi Kumar**, Symbiosis Institute of Business Management, Pune & Symbiosis International (Deemed University), Pune (Maharashtra), India. Email: [vvkumar@sibmpune.edu.in](mailto:vvkumar@sibmpune.edu.in)

**Dr. Piyush Gotise\***, Symbiosis Institute of Business Management, Pune & Symbiosis International (Deemed University), Pune (Maharashtra), India. Email: [p.gotise@gmail.com](mailto:p.gotise@gmail.com)

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Whereas, in a battery electric vehicle (BEV), there is no fuel tank as it is not fossil fuel-powered and runs entirely on electricity stored in high-capacity recharging batteries that can be plugged in as needed [15] [13].

Regarding the adoption of EVs in India, there are some roadblocks (e.g., lack of charging infrastructure, high battery prices, performance, range, and lack of consumer awareness) that are interfering with its progress in the country [16] [17]. There are psychological barriers also that interfere with the adoption [18]. For instance, after the incidents of fire reported in the news about electric scooters [19] [20] [21], people might feel a bit insecure about buying electric scooters in India. Due to such incidents reported in newspapers and other news media, potential EV buyers are concerned and confused, and have fears about adopting them. Identifying factors or constructs that are related to electric vehicle adoption is of prime importance so that it can be focused upon and dealt with accordingly [22] [21] [20] [23].

Adoption could be defined as a behavioural response that includes purchase as well as the use of an innovation [24] [13]. Several factors contribute to the adoption of electric vehicles, and addressing these factors by stakeholders of electric vehicles (such as governments, policymakers, and manufacturers) could lead to increased adoption. Thus, this research aims to focus on the enablers (factors) that may accelerate adoption and help remove hurdles to the growth of EVs in India.

## III. METHOD

The paper follows a thematic review approach based on the review of relevant literature available from Google Scholar and Scopus. For the literature review, we first searched through two databases (i.e., Scopus and Google Scholar). Sixty papers that seem relevant were chosen. Then, the abstracts of these selected papers were read. Fourteen papers were identified as suitable for the study, which were thoroughly reviewed to extract the significant themes in alignment with the research purpose. Subsequently, all the major themes were developed conceptually and built upon some past literature.

## IV. FINDINGS ENABLERS OF EV

### 4.1 The Government Policies

The Indian government at the central and state levels are making policies and regulatory frameworks that could promote EV adoption [25]. The government is also attempting to ease adoption by focusing on bringing schemes and initiatives that could bring the cost down for consumers and make it more affordable [26]. The government, through subsidies, rebates on taxes, and through other such incentives, are trying to motivate buyers to purchase an EV [27]. Furthermore, the government is putting effort into making way for better fast-charging infrastructure [27] so as to reduce range anxiety, to instil confidence in EV drivers regarding the availability of charging stations in exigencies and to ensure that they could reach their destination certainly and hassle-free.

### 4.2 Financial Incentives and Tax Benefits

For earlier and faster adoption of EVs, the Indian government is providing subsidies and tax benefits for buyers [27]. However, the subsidies are applicable only up to a specific

price range of EVs, not for all vehicles. Similarly, an individual buyer could avail of tax benefits by opting for an EV on loan [28]. Additionally, in some of the states like Madhya Pradesh, Uttar Pradesh, and Punjab, EV owners are exempted from paying road taxes [28]. Research suggests that financial incentives could impact the attitude of buyers [29] and these financial incentive policies and practices subsequently could act as a motivator for buyers to adopt EVs, as Indian consumers are more focused on the economic aspect [30].

### 4.3 Fast Charging Time

One of the most significant issues with EVs is that they take too much time to charge [31] [32]. The AC charging for a typical electric vehicle (EV) with a 200-300 mile range usually takes around 6-8 hours for a full charge, whereas DC fast charging typically takes 1.5 to 2 hours for a full charge. In long-distance travel and in rural areas where a person is away from their house, overnight charging is not possible, and charging stations are the only options where an EV could be recharged [32]. The charging stations with high kilowatt output take less time compared to those with low kilowatt chargers. That is, the charging kilowatt should be increased to promote adoption. Otherwise, buyers may feel insecure and concerned about going long distances in an EV.

### 4.4 Affordability

The price of electric vehicles is an important determinant and motivating factor for automobile buyers [29]. India is a developing economy and is not a wealthy nation; that is, the purchasing power of a typical person in India is not very high [33]. EVs these days are coming at a premium cost in the market as compared to ICVs [32]. The price gap is quite significant, which could prompt a buyer to reconsider their decision. The price gap should be reduced, and electric vehicles (EVs) should be made more affordable to increase their adoption.

### 4.5 Fast Charging Infrastructure

The charging infrastructure in India is still in its nascent stage. It is a vital factor in the adoption of electric vehicles [34]. EVs can be charged at home; however, concerns arise when people travel long distances in an electric vehicle (EV). In metro cities, within urban boundaries, it is comparatively easier to find charging stations than on highways and in rural areas. Even if the charging stations are there, sometimes, they are not in working condition or are not compatible with all types of vehicles [35]. There should be compatible chargers which are high in kilowatts so that they could lessen the recharging time to a minimum, and the number of charging stations should be more along the highways, in rural and far-off places [25].

### 4.6 Increased Battery Capacity

People require a high range, and for that, EVs should have a high battery capacity [36] [37]. The battery pack should be smaller and lighter. The range promised by car manufacturers fluctuates according to the driving style of drivers and decreases at higher speeds. The EV should deliver the promised range with minimal fluctuations. The range is related to the cost per kilometre; a higher range could make travel more economical and reduce worry, which could eventually lead to adoption [37].



#### 4.7 Increased EV Awareness and Education on EV

EV might have several benefits; however, if it is not adequately communicated and known by the masses, it is of no use. To increase adoption, the government and other bodies should educate people about the benefits of EVs [32]. There is also a need to educate people on how to acquire an EV at affordable prices by highlighting subsidies and tax benefits. There is a necessity to generate awareness of EVs for encouraging adoption [17] [39]. Education also plays an integral part in adoption [38]. Past research has found that customers who are highly educated are more aware of the benefits of Electric Vehicles, which could increase the possibility of quick adoption of electric vehicles [29].

#### 4.8 Availability of Skilled Labour

India has the added advantage of having skilled labour [40] at economical prices [32]. A well-designed government scheme for the development of EV charging infrastructure and research and development, leveraging the human capital from the Indian market, could help facilitate the adoption of electric vehicles (EVs) in India.

### V.CONCLUSION

Electric vehicles in India are gaining ground [9] with the support of the Indian government. These vehicles, in the long run, are considerably cheaper than fossil fuel-based ICVs. They are not only economical, but they also offer several additional benefits that make them superior to ICVs. That is, EVs have zero emissions- they do not cause noise pollution except a slight noise at low speeds [12] and have low maintenance in comparison to internal combustion-based vehicles (ICVs). Furthermore, EVs are simpler in design and comfortable to use.

Nevertheless, the growth of EV adoption is not as expected and is relatively slow, with several hurdles. For adoption, it may need effort from the individuals and the government. Regarding the promotion of electric vehicles in India, there is a need to identify the enablers that can accelerate their progress. In this paper, we, based on a review of the relevant literature from scientific databases, have suggested a range of factors that require the attention of policymakers and other stakeholders to contribute to improving electric vehicle adoption in India. The factors are: (i) the government policies; (ii) financial incentives and tax benefits; (iii) fast charging time; (iv) affordability; (v) fast charging infrastructure; (vi) increased battery capacity; (vii) increased EV awareness and education on EV, and (viii) availability of skilled labour. These enablers are not exhaustive, but they could contribute to an increase in adoption if the public, EV stakeholders, and the government put in the effort, most importantly.

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### COMPETING INTERESTS

The authors have declared that no competing interests exist.

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**Dr. Vimal Bhatt** is an Associate Professor of Marketing at Symbiosis Institute of Business Management, Pune. He has over 17 years of total academic experience. His teaching interests focus on Integrated Marketing Management, Business Analytics, and Marketing Research. He currently teaches the core marketing subjects. His research interests focus on customer experience management and customer engagement. He has to his credit several journal publications, including those in Scopus and the ABDC.



**Dr. V.V. Ravi Kumar**, formerly a Banker and now a Professor at Symbiosis Institute of Business Management, Pune, Symbiosis International (Deemed University), Pune, India. Dr. Ravi Kumar has authored several research papers in Scopus-indexed, peer-reviewed journals and presented papers at various conferences. Currently, his research interests include Electric Vehicles, Self-Service Technologies, MOOCs, Internet/Mobile Banking, Green Advertising, Advertising Puffery, and Financial Services. He can be contacted at email: [chalamravi@gmail.com](mailto:chalamravi@gmail.com)



**Dr. Piyush Gotise** is presently working as a Research Assistant for an ICSSR-funded Minor Project at Symbiosis Institute of Business Management (SIBM), Pune, Symbiosis International (Deemed University), Pune, India. He is an experienced researcher and does both qualitative and quantitative research. His current research interests include sustainability, electric vehicles, well-being, human resource development, positive organizational behaviour and other related areas. His research works have been published in ABDC, ABS, SSCI, and Scopus Journals.

## AUTHORS PROFILE



**Dr. Deepika Pandita** is an Associate Professor at Symbiosis Institute of Business Management, Pune. She has been honoured as the "Hall of Fame" Faculty under the Teaching Category for Symbiosis International (Deemed University), Pune, for her contribution to academics, research, and administration. Dr. Pandita's research focuses on talent management, Generation Z, women entrepreneurship, leadership, electric vehicles, qualitative research, and research writing. Her research achievements have been exemplary, with over 900 Google citations and 25 research papers published in various international journals indexed in Scopus, Web of Science (WOS), and the ABDC. She is an avid contributor to leading HR magazines like People Matters and Human Capital.

