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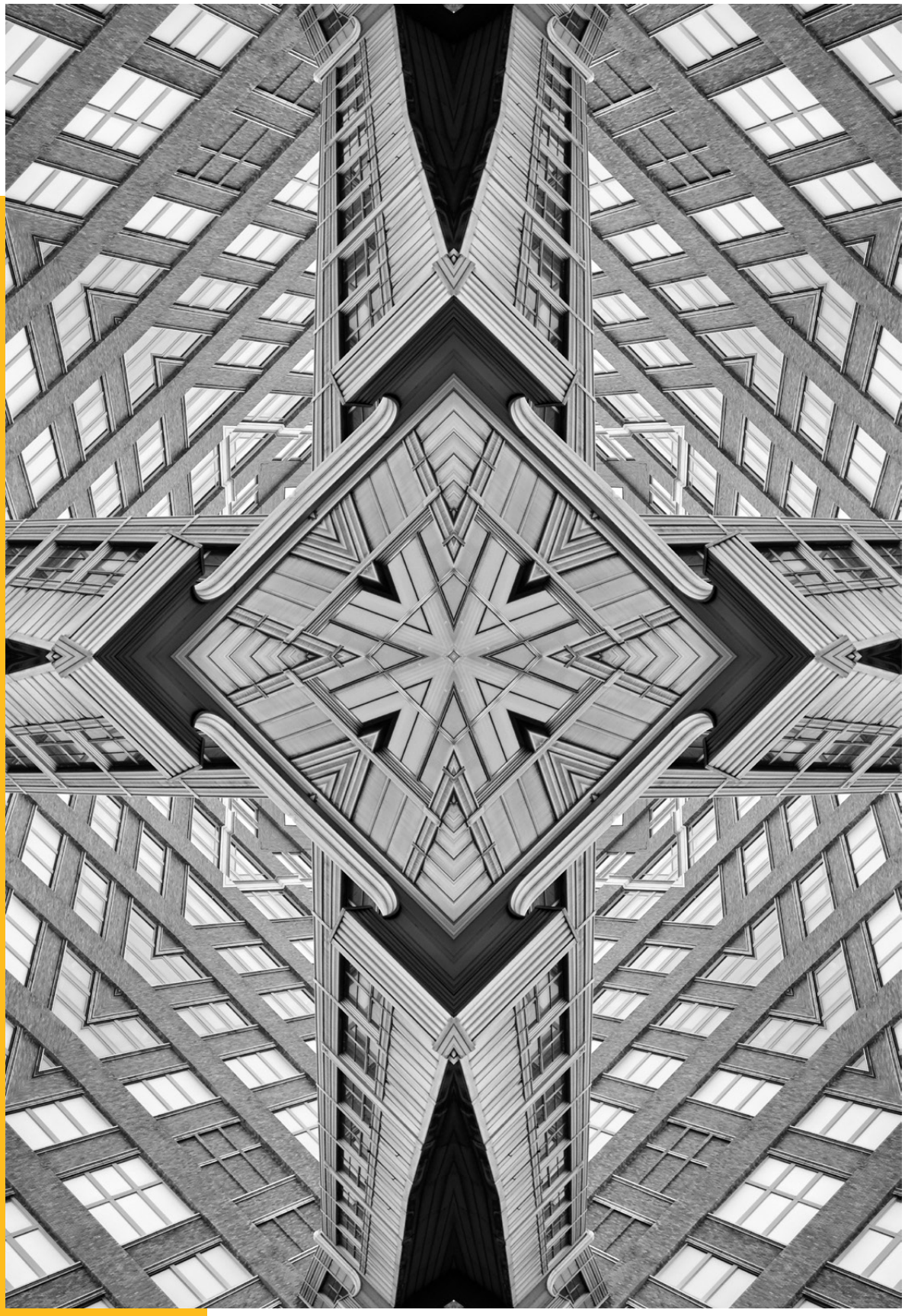

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Electric Vehicles in India: Filling the Gaps in Awareness and Policy

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Abstract

In recent years, more governments have been giving greater attention to developing their countries' electric vehicles (EV) sector as a strategy for minimising the harm that mass transportation can cause to human health and the environment. This paper tells the story of India's EV initiative. It offers an overview of the national mission to push the manufacture and adoption of EVs; appraises the policies introduced by governments of select states and union territories (UTs) to address their EV needs; and analyses the current state of EV penetration across the country. The study finds that while over one million EVs have been sold in India so far, the pace of transition is impeded by multiple problems including lack of public awareness, the lag in manufacturing and sale of EVs, and the unavailability of financing.

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Introduction

The use of fossil fuels such as petrol, diesel, and natural gas for transport releases carbon dioxide (CO_2) in the air that is harmful to human and environmental health. Along with other greenhouse gases (GHG) emitted through human activities, rising CO_2 concentrations are responsible for global warming. The other consequences of using fossil fuels to meet the energy requirement of human activities are depletion of this valuable resource and frequent fluctuations in international crude oil prices. In many countries across the world, governments are mitigating these challenges by reducing dependence on fossil fuel-based vehicles and shifting to cleaner modes of transportation.

The manufacture and promotion of hybrid and electric vehicles (EVs) are important steps in this direction. They result in fuel savings, improved air quality, and reduced noise pollution. EV owners too, gain in many ways. In India, for example, they bear lower costs for vehicle maintenance and operation, and receive government incentives for purchasing EVs and scrapping their conventional vehicles, including income tax deductions.

Travelling a distance of 100 km in a conventional vehicle costs about INR 435, whereas in an EV, INR 97.[1] Thus, during the lifetime of an EV, the total cost of (vehicle) ownership (TCO) is considerably less than that of a conventional vehicle. In the context of air quality, the Ministry of Environment, Forest and Climate Change in India has reported that GHGs are reduced by about 82 percent over the lifetime of an EV.[2]

Scope and Purpose of Paper

Motorists in India have yet to adopt EVs on a large scale. This paper attempts to explain the challenges confronting the EV sector.

This study is relevant in the context of India's global commitment to reducing the emissions intensity of its GDP by 45 percent by 2030, thereby achieving the goal of net-zero by 2070.[3] These targets are included in India's updated Nationally Determined Contributions (NDCs) for the United Nations Framework Convention on Climate Change (UNFCCC). Through such measures, India aims to enhance its contribution towards global response to threats posed by climate change, as agreed in the 21st session of the Conference of the Parties (COP 21) or the Paris Agreement.

India's EV Mission and Plan

In India, the imperative of shifting to electric mobility was recognised amidst the manifold problems created by fossil fuel use: their fast depletion, rising energy costs, impact of motor vehicles on the environment, and concerns over climate change. It is estimated that in 2022, India's transport sector will be responsible for about 375 million tonnes of direct CO_2 emissions, which is about 10 percent of the country's total GHG emissions.[4]

A number of EVs were assembled and sold in the country beginning in the mid-1990s, but their use remained low due to demand and supply-related issues. These include lack of domestic manufacturing ecosystem and component supply chains, limited EV options, high vehicle costs, vehicle and battery performance issues, and inadequate battery charging infrastructure. At that time, the government was undertaking short-term and isolated initiatives to promote EVs, without the guidance of a vision document or roadmap for the EV sector's holistic development.

In response to escalating environmental problems, and to remove barriers to greater adoption of EVs, the Indian government's Department of Heavy Industry[5] launched the National Mission for Electric Mobility (NMEM) in 2012. Its aim was to promote domestic manufacturing and build the necessary conditions for widespread adoption of hybrid and electric vehicles (xEVs). The initiative set a target of total xEV sale of 6-7 million units by 2020.[6] The National Electric Mobility Mission Plan (NEMMP) 2020 offered the following proposals to achieve the goal:

(i) Create demand for xEVs by making these mandatory in government fleet and public transportation, and offer incentives of reduced price, tax exemptions to buyers of various types of vehicles.[7]

(ii) Strengthen the xEV manufacturing ecosystem in the country by offering tax exemptions to domestic manufacturers, thus reducing dependence on imported oil and xEV parts.[8]

(iii) Support xEV research and development (R&D), including international collaboration for designing cost-effective solutions, and lowering vehicle costs.[9]

(iv) Augment existing infrastructure of power generation and transmission, and set up EV charging stations/points at public places, workplaces, bus depots, and homes, in partnership with the private sector.

(v) Inform the public about the benefits of xEV technologies.

To take the NEMMP forward, a scheme named 'Faster Adoption and Manufacturing of Electric and Hybrid Vehicles in India' (FAME India) was formulated and implemented by the Department of Heavy Industry in two phases beginning 2015 for a period of nine years (until 2024). As the name indicates, the scheme aims to address the issue of vehicle emissions by encouraging use of non-polluting motor vehicles. This aim is being achieved through technology development, demand creation, and provision of charging infrastructure (See Table 1). An amount (outlay) of INR 108.95 billion has been allocated for completion of work proposed under the two phases.[10] Majority of the outlay is allocated as purchase incentive to buyers of EVs. The scheme is promoted through discussion forums on e-mobility that allow an exchange of ideas between national/state government representatives and industry leaders.

Table 1
Salient Features of FAME India Scheme

Category	FAME I 2015-2019	FAME II 2019-2024
Aim	Reduce dependency on fossil fuel and address issues of vehicular emissions	Encourage faster adoption of electric and hybrid vehicles
Emphasis	Provide affordable and environment-friendly public and private transportation for masses	Electrify public transportation, including shared transport
Focus Areas	Technology development, demand creation through incentives, pilot projects, charging infrastructure	Upfront incentive on EV purchase, charging infrastructure in selected cities and along major highways

Source: Ministry of Heavy Industries, Annual Report 2021-22, New Delhi: Government of India.

The government has also taken the following measures: keeping goods and services tax (GST) rates on EVs in the lower bracket of 5 percent as against 28 percent for conventional vehicles;[11] allowing the sale of electricity for EV charging as an incentive to attract private investments in development of charging

infrastructure; issuing notification for exemption of permits in case of battery-operated vehicles;[12] and establishing battery-swapping stations considering the scarcity of land in urban areas.[13]

To be eligible for incentive, vehicles should be manufactured in India and be registered as a motor vehicle with the road transport authority. They should be fitted with advanced chemistry cell (ACC) battery,[a] and their ex-factory price at less than threshold value.[14] To be sure, vehicles that do not meet all of these conditions are still sold in the market; in this case, buyers/sellers/manufacturers do not receive any government incentives, and their purchase price is thus far higher than those sold under the FAME scheme.

> "In 2022, India's transport sector will be responsible for about 375M tonnes of direct CO_2 emissions, around 10 percent of the country's total GHG emissions."

a ACC batteries can store electric energy as electrochemical/chemical energy and convert it back to electric energy.

EV Policies of Select States and UTs

A number of India's state/UT governments[b] have formulated their own policies for the successful implementation of the national EV mission and FAME scheme. The idea is to ensure the planned development of the EV sector in their respective jurisdictions and address state/UT-specific needs.

This paper works along the assumption that the maximum uptick of EV use will occur in India's four most populous cities—i.e., Mumbai, Delhi, Kolkata, and Chennai. Therefore, this paper reviews the EV policies of three states and one UT where the four cities are—Maharashtra, Delhi, West Bengal, and Tamil Nadu—to understand their proposed measures. Table 2 describes the key features of the EV policies of the four.

Table 2
EV Goals and Strategies

State/UT	Goal	Strategies
Maharashtra	10 percent of all new vehicle registrations should be EVs by 2025	• EV purchase price reduction • Reimbursement for scrapping old vehicle • Waiver of road tax and registration fees • Incentives to manufacturers on extended battery warranty and EV buyback • Incentives to service providers for setting up charging stations • Incentives to entities/start-ups for EV manufacturing, R&D
Delhi	25 percent of all new vehicle registrations should be EVs by 2024	• EV purchase price reduction • Reimbursement for scrapping old vehicle • Interest subvention on loans • Waiver of road tax and registration fees
West Bengal	To be the top state in electric mobility penetration by 2030	• 100 percent net state GST (SGST) reimbursement to private companies for development of hydrogen generation and refuelling stations

b These are: Andhra Pradesh, Assam, Bihar, Chandigarh, Delhi, Goa, Gujarat, Haryana, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Meghalaya, Odisha, Punjab, Tamil Nadu, Telangana, Uttar Pradesh, Uttarakhand, and West Bengal.

Tamil Nadu	To attract investment and create a comprehensive EV ecosystem over the next 10 years	• Waiver of road tax and registration fees • Waiver of permit fees on auto rickshaws and taxis • Exemption on electricity tax and stamp duty • Capital subsidy to private operators/ units for setting up charging stations and making EV components • Reimbursement of SGST to manufacturing units • Reimbursement of employer's contribution to EPF

Sources: EV policies of Maharashtra, Delhi, West Bengal, and Tamil Nadu.

Maharashtra

The state government of Maharashtra is aiming to accelerate the adoption of EVs so that these contribute to 10 percent of all new vehicle registrations by 2025.[15] The EV transition plan applies to all types of vehicles.[16]

In this endeavour, focus will be given to five urban agglomerations[17] with high rates of particulate matter ($PM_{2.5}$). In these urban regions, efforts will be made to achieve 25-percent electrification of public transport by 2025. They will be required to create low-emission zones served primarily by zero tailpipe-emission vehicles. At the state level, 15 percent of the state government's existing bus fleet will be replaced with electric buses. The policy also proposes the replacement of all conventional vehicles used by government functionaries.

For charging EVs, the policy proposes provision of one public charging station in a 3 km-by-3 km grid or a minimum of 50 charging stations per million population in cities. Development plans will earmark locations for provision of EV charging stations. In addition, building codes and town planning rules of Ministry of Housing and Urban Affairs (MoHUA) for provisioning of EV stations will be applied. Major state highways will also be made EV-ready by provision of stations every 25 km.

Further, the state government aims to establish factories for manufacturing EVs and ACC batteries. Research and development (R&D), innovation, and skill development will be encouraged and supported for the creation of a strong EV ecosystem. Entities/start-ups interested in EV manufacturing, battery assembly and recycling, and R&D will be supported by the state government. Steps will be taken for training workers in repairing and servicing of EVs and charging stations.

To attract buyers, incentives will be offered on various types of EVs. For example, buyers of electric two wheelers (e-2Ws) will receive a maximum incentive of INR 10,000 per vehicle; for electric three wheelers (e-3Ws, i.e. autos and goods carriers) the incentive will be INR 30,000; in case of electric four wheelers (e-4Ws, i.e. cars and goods carriers), between INR 100,000 and INR 150,000; and for state transport undertaking (STU) e-buses, up to INR 2 million. Road tax and registration fee exemptions will be provided, and buyers will be eligible for scrapping incentive on their old vehicles: INR 7,000 for e-2Ws, INR 15,000 for e-3Ws, and INR 25,000 for e-4Ws.

In view of EV buyers' concerns regarding battery life, manufacturers will be given incentives for offering battery warranty[18] of at least five years, and for assuring buyback[19] of EVs that are five years old. Incentives will be provided to charging infrastructure service providers/electricity distribution companies/utilities (DISCOMS)[20] undertaking work of establishing public[21] and semi-public[22] charging stations. For efficient operation and parking of EVs, municipalities will be required to create proper lanes and parking spaces; EV-ready parking spaces will be created in new buildings and residential projects, institutional and commercial complexes, government office complexes, and in future public parking areas.

The state government proposes to create a state EV fund with the support of income generated from green tax and green cess. The money collected will be used for promoting EV adoption, providing infrastructure, and incentives. For policy implementation, an apex steering committee and EV secretariat will be constituted.

Delhi

Delhi's electric vehicles policy aims to ensure that EVs contribute to 25 percent of all new vehicle registrations by 2024.[23] In this regard, the policy proposes various incentives for buyers and other requirements for proper functioning of the EV sector.

On e-2Ws, maximum purchase incentive of INR 30,000 per vehicle is provided to buyers;[24] they are also offered a scrapping incentive up to INR 5,000 for old 2Ws that run on internal combustion engine (ICE).[c] It is expected that incentives will encourage people, particularly those engaged in goods delivery, to switch to electric 2Ws. The purchase incentive for e-3W auto rickshaws and

c Vehicles with internal combustion engines that are powered by petrol, diesel, or natural gas.

light commercial vehicles (including goods carriers) is the same as e-2Ws, but the scrapping incentive is higher (i.e. up to INR 7,500). Further, buyers of e-3Ws and goods carriers are entitled to interest subvention of 5 percent on loans, and are eligible for permits at no additional cost. For e-4Ws, i.e. cars, maximum purchase incentive of INR 150,000 per car is provided to registered owners of first 1,000 cars.

Another incentive that applies to all types of EVs is the waiver of road tax and registration fees. The above-mentioned fiscal incentives offered are in addition to those available under FAME.

Other policy proposals include constitution of state EV board and dedicated EV cell, creation of state EV fund,[25] setting up of skill training centres, development of an intensive public outreach programme, introduction of electric buses for public transportation, establishment of battery charging/swappable battery stations/points at public places,[26] workplaces and homes,[27] and recycling ecosystem for end-of-life batteries. Necessary changes in building by-laws will be made to make places EV-ready.

West Bengal

The state government of West Bengal has set a target of having one million EVs, and 100,000 public and semi-public charging stations over a five-year period beginning 2021.[28] To enable EV adoption and achieve targets, the state EV policy recommends the constitution of an EV Accelerator Cell. This entity will be tasked to facilitate inter-departmental coordination and faster decision-making.

Further, the policy calls for awareness campaigns that will familiarise people with the benefits of adopting EVs. There is also scope for exploring new ideas to boost innovation in the EV sector. For this purpose, research grants will be made available to research laboratories, incubators, and start-ups. An EV Innovation Centre is also proposed for undertaking research on battery technology development, its recycle and reuse, and charging infrastructure.

Among the main infrastructure components proposed in the policy are battery charging/swapping stations with smart charging features to be set up through concessional means (at minimum lease rentals) in public/private areas (such as malls, commercial buildings, parking areas, homes, workplaces). They also include adequate power supply by electricity distribution utilities (DISCOMS),

and development of digital database powered by Big Data to keep motorists informed about precise locations of public charging stations. An electricity tariff of INR 6 per kilowatt hour is proposed for charging EVs at public charging stations established by DISCOMS.

The state government also aims to create model e-mobility cities that will have green zones where fossil fuel-based vehicles will not be allowed entry. In addition, inter-city electrified green routes having rapid chargers will be deployed every 25 km.

The West Bengal EV policy document does not provide details of incentives offered to various categories of EV buyers, unlike those of Maharashtra and Delhi. However, there is mention of 100 percent net state GST accrued to the state on purchase of machinery as reimbursement to developers of private hydrogen generation and refuelling infrastructure.

Tamil Nadu

Like a number of other Indian states, Tamil Nadu has committed to attracting investment and creating a comprehensive EV ecosystem in the state over the next 10 years.[29] Its proposals address a wide range of aspects, including promotion of innovation, creating an environment for industry and research, component manufacturing and skill building, ensuring adequate supply of power and charging points[30] with favourable tariff, and safe handling, re-use and recycling of batteries.

Demand creation for various types of EVs is based on a set of incentives. Buyers of e-2Ws, e-3Ws, and e-4Ws will not be required to pay road tax and vehicle registration fees. Further, permit fees for EVs in the category of auto rickshaws and taxis will be waived, whereas owners of light goods carriers will not be required to obtain a permit. For setting up EV charging stations, government will extend support to both public sector units and private operators.

The Tamil Nadu government will offer an 'EV special manufacturing package' to units engaged in manufacture of EVs, its components, batteries, and charging infrastructure. The package includes the following incentives:

- SGST paid on sale of EVs will be reimbursed to manufacturing units.
- Capital subsidy of 15 percent will be given to units making intermediate products for EVs and charging infrastructure; capital subsidy of 20 percent will be provided to battery making units.

- An additional 20 percent capital subsidy to micro, small and medium enterprise (MSME) units and 6 percent interest subvention to medium industries will be provided.
- Manufacturing units will be provided 100-percent exemption on electricity tax and stamp duty, and 15-percent subsidy on cost of land.
- Employer's contribution to employees' provident fund (EPF) (up to INR 48,000 per employee) will be reimbursed for a period of one year.
- For attracting investments, government will develop EV parks, promote logistic parks and free trade warehousing zones.

The implementation of policy proposals will be carried out by the departments of industries, energy, and transport. In addition, working groups, centres of excellence and incubation centres will be set up for technology development and market research. For the support of EV start-ups, an EV venture capital fund will be formed. Capacity building and skill development are equally important strategy components, and the Tamil Nadu Skill Development Corporation will be offering EV-related courses. Regarding town planning provisions, building and construction laws will be amended to create spaces for setting up of charging infrastructure and for creating parking spaces for EVs at various places in cities. The monitoring work will be overseen by a representative EV steering committee.

This author's appraisal of the work undertaken so far for the development of the country's EV sector under FAME reveals the following key achievements:

- 61 original equipment manufacturers (OEMs)[d] registered 235 EV models[31] for availing benefits.[32]
- Incentives amounting to INR 26.16 billion given by the government.[33]
- 627,511 EVs sold/supported under FAME.[34]
- 1,447 electric buses deployed/supported.[35]
- 532 charging stations installed.[36]
- 3,448 retail outlets offering EV charging facility.[37]
- 167.77 million litres of fuel savings.[38]
- 381.79 million kg of CO_2 reduction.[39]

Data on every EV registered in various states and UTs are yet to be made available on a single digital platform. For this study, therefore, data were obtained from multiple sources:

- *Vahan* (vehicle) website: Information on all vehicles registered in India, including EVs, is uploaded on this website.[40] Three states and one UT, namely Andhra Pradesh, Madhya Pradesh, Telangana, and Lakshadweep, are yet to digitise their vehicle records. Thus, data for these administrative units were obtained from other sources as mentioned in the following points.
- Ministry of Heavy Industries (MHI) website: MHI promotes the development of automobile sector and is responsible for implementing FAME. Buyers purchasing EVs in any vehicle segment—such as 2Ws (scooter), 3Ws (cart, rickshaw), 4Ws (passenger cars, light commercial vehicles, buses) under FAME—are entitled to benefits like reduced purchase price of EV and waiver of road tax. On its website, data are available only for those EVs that are sold under FAME:[41] 627,511 as of 9 October 2022.

d OEM is a public/private firm engaged in manufacturing of vehicles and has achieved a certain percentage of localisation in production.

- Other secondary sources of data include road transport yearbook of the Ministry of Road Transport and Highways, state/UT transport departments, and media reports. Data for Andhra Pradesh, Madhya Pradesh, Telangana, and Lakshadweep are obtained from these sources and MHI website.

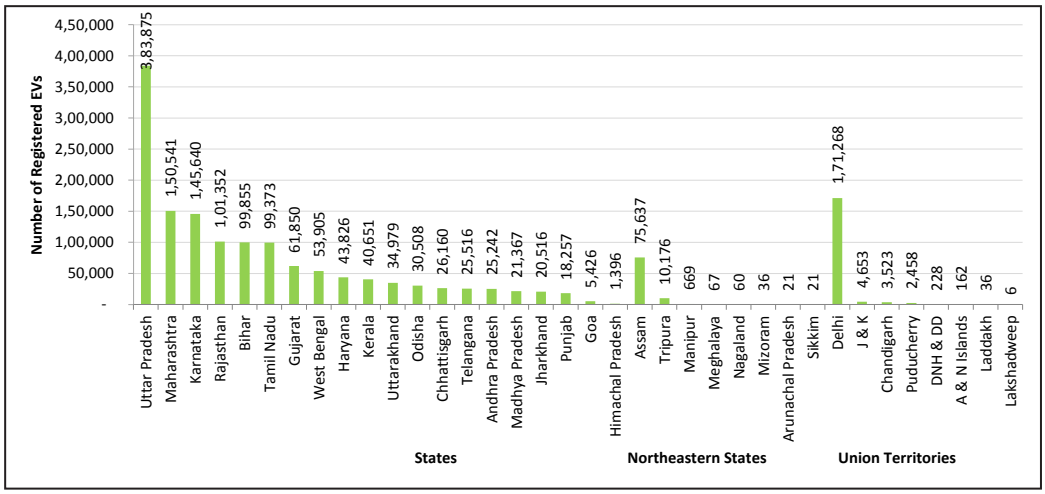
Sale of EVs

At the time of writing this paper, a total of 1.66 million EVs have been sold/registered in India.[42] The *Vahan*/MHI websites are updated multiple times in a day, which indicates a growing number of EVs. According to data, the sale of 2Ws and 3Ws is higher than 4Ws. A media report published in August 2022 says that 793,370 e-3Ws (57 percent), 544,643 e-2Ws (39 percent), and 54, 252 e-4Ws and above (4 percent) have been sold, and sale of EVs has increased by over three times between 2020-21 and 2021-22.[43] The exorbitant price of 4W EVs is an important reason for their low sale.

Of the total number of registered motor vehicles in India (over 338 million), the share of EVs is less than one percent. In the total vehicle sales during 2021, EVs accounted for 1.1 percent.[44] There are only three states and one UT, namely Tripura, Assam, Uttarakhand, and Delhi, where EV share in total registered motor vehicles is slightly more than one percent. This shows that people still prefer buying motor vehicles that are powered by petrol, diesel, or natural gas, instead of electric (battery-operated) vehicles.

EVs are in use in every Indian state and UT. In populous states of India, the highest number of EVs (above 300,000) was registered in Uttar Pradesh; Maharashtra and Karnataka then follow. At the other end are Himachal Pradesh and Goa, with less than 5,500 EVs (see Figure 1).

Figure 1
Number of EVs Registered in States and UTs



Sources: State/UT data obtained from Vahan website on 9 October 2022: https://vahan.parivahan.gov.in/vahan4dashboard/; Data for Andhra Pradesh, Madhya Pradesh, Telangana, and Lakshadweep obtained on 9 October 2022 from FAME: https://fame2.heavyindustries.gov.in/dashboard.aspx.

Among north-eastern (NE) states, Assam stands out with over 75,000 registered EVs. Data shows that Assam has a higher number of EVs than many populous states of India, such as Gujarat, West Bengal, and Haryana. Tripura is the other state recording over 10,000 registered EVs. In the remaining NE states, the number of EVs is less than 700. Among the UTs, highest number of EVs (171,268) is recorded in Delhi. When compared with states/UTs, Delhi stands second after Uttar Pradesh. In the remaining UTs, combined, the number of EVs is around 11,000.

Regarding electric buses, the Ministry of Heavy Industries has sanctioned 6,315 e-buses, of which 1,447 are deployed in various Indian cities.[45]

Charging Stations

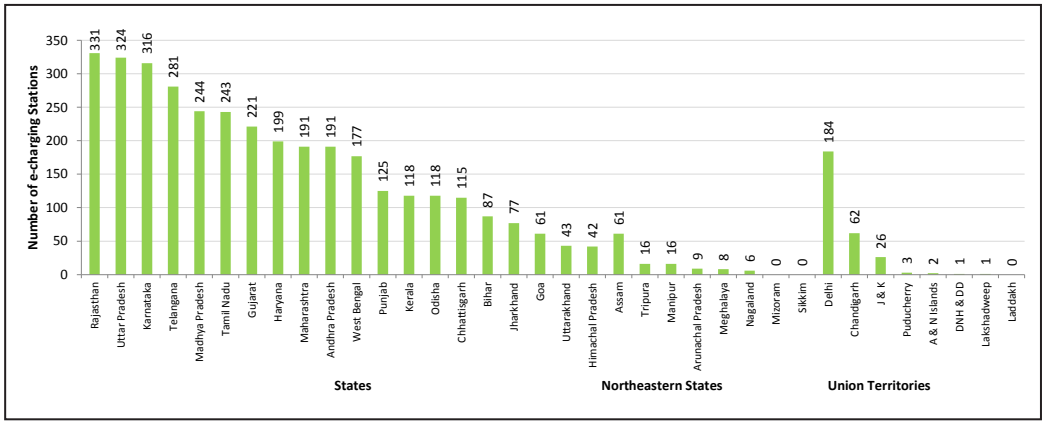
EV batteries require charging from an external source after several kilometres of use.[46] The government has taken steps to provide charging stations at public places in cities, and along expressways and highways. Companies that sell EVs also make arrangements for installation of battery charging points at the homes of the buyers.

As of 15 July 2022, 451 public charging stations have been installed in different Indian states/UTs and 81 were established along road highways[47] under the two phases of FAME. There are 3,448 retail outlets in different Indian states/UTs where EV charging facilities are available. Thus, a total of 3,980 charging stations are available to EV users across India.[48] Many more stations have been sanctioned for states/UTs under FAME[49] and the number is expected to increase significantly in the future.

Figure 2 shows the distribution of charging stations in Indian states and UTs: Rajasthan, Uttar Pradesh, and Karnataka have the highest numbers, each having over 300 stations. The number is lowest (below 45) in the hill states of Himachal Pradesh and Uttarakhand. Among NE states, Assam tops the list with 61 stations, followed by Tripura and Manipur with 16 stations each. Among the UTs, Delhi and Chandigarh have the most number of stations. Overall, the number of stations is less in most NE states and UTs.

Data provided by the Press Information Bureau shows that there are no public charging stations in Mizoram, Sikkim, and Ladakh.[50] Media reports, however, say there are seven in Ladakh, established in 2021.[51]

Figure 2
EV Charging Stations in States and UTs



Source: Press Information Bureau, "Ministry of Heavy Industries installed 532 charging stations/infrastructure under Phase I & II of FAME India scheme," July 26, 2022, https://pib.gov.in/PressReleseDetailm.aspx?PRID=1844982.

Reference may be made to some initiatives being undertaken to establish charging facilities. In Sector 86 of Gurugram city in the National Capital Region, for example, an EV charging station with 121 chargers has been established by a private company named Alektrify. At this facility, up to 1,000 cars can be charged within 24 hours.[52] Further, in some commercial buildings of Gurugram, EV charging points have been installed, which allow office staff to charge their vehicles during work hours. Another significant development is the establishment of 18 charging points along the Manali-Leh highway by a joint venture company named Shuchi Anant Virya.[53]

The provision of charging stations on highways and expressways is also helping bus operators in starting inter-city electric passenger bus services. The Mumbai-Pune and Kanpur-Lucknow road corridors are examples of such routes where e-buses are plying.

> "Of the total number of registered motor vehicles in India (over 338M), the share of EVs is less than 1%."

Key Challenges in India's EV Sector

Even as the number of EV users in India has grown in the recent few years, the shift from ICE vehicles to EVs remains slow. At current rates, it will be difficult to achieve the national target of achieving 30 percent EV sales penetration for cars, 70 percent for commercial vehicles, 40 percent for buses, and 80 percent for two- and three-wheelers by 2030.[54] Secondary sources, and this author's interactions with EV sellers and users, reveal a number of reasons responsible for the slow adoption of EVs in the country.

Availability: Since the beginning of 2022, certain companies that sell vehicles[55] have begun to launch hybrid and EV models in various vehicle segments—2Ws, 3Ws, and 4Ws—and it is now possible for buyers to purchase these models. Further, a number of private companies are providing e-2Ws/3Ws to goods delivery workers. On city roads, a small proportion of e-2Ws and e-3Ws can be seen; e-4Ws are rare. Market trends indicate plans of more auto companies entering the EV sector. In this respect, India can be said to be in the take-off stage.

At present, however, the variety of EV models available for purchase is limited compared to ICE vehicles. This reduces the chance of buyers considering EVs as their next vehicle.

Price: ICE vehicles are available in abundance for purchase at a price generally cheaper than EVs. The higher price of EVs is due to the machinery, materials, and high-end technology required to make the EVs and their batteries. Indeed, the rechargeable lithium-ion battery of an electric car is its most expensive component. A shortage of metals such as cobalt and lithium—the main elements in making these batteries—has forced India to import from other countries, pushing the price of EVs up. For example, the price of electric scooters (e-2Ws) is between INR 37,000 and INR 120,000,[56] e-3Ws cost between INR 150,000 and 300,000,[57] and electric cars are over INR one million.[58]

Buyers are also concerned about battery replacement costs. Electric scooter batteries last for about two to four years, whereas the life of an electric car battery is about eight years. The cost of a new electric car battery is around INR 600,000—[59] a price point where a buyer can purchase a brand-new ICE car.

As discussed earlier, incentives are given to buyers under FAME, helping bring down the cost of EV.[60] For example, the incentive amount on electric cars manufactured by Tata Motors and Mahindra Electric is about INR 160,000.[61] However, such offers are available to a select number of buyers, i.e. the first 1,000 buyers in the case of some vehicles. Thereafter, the offer expires, which means that EVs are sold at their actual price.

Key Challenges in India's EV Sector

Safety: The occurrence of some incidents involving EVs catching fire has raised doubts about its safety. In June 2022, an electric car caught fire in suburban Mumbai.[62] Another incident in the same month was reported from Patan, a city in north Gujarat, where an electric scooter that was connected to a charger, caught fire.[63]

Taking note of these incidents, the national government ordered a probe that revealed errors on the part of some manufacturing companies, such as production of deficient battery management systems, absence of proper heat release venting mechanisms, and use of poor quality battery cells.[64] Another assessment points to problems with lithium-ion batteries. These pertain to overheating, flammability, short life spans, underperformance, as well as toxicity and logistics challenges.[65]

As a response, a new set of EV battery safety standards to be followed by EV manufacturers have been developed by the Ministry of Road Transport and Highways. These relate to battery cells, battery management system, on-board charger, design of battery pack, and thermal propagation due to internal cell short circuit.[66] The standards will come into effect from 1 December 2022.[67]

Driving range: The distance that can be covered by an EV running on a fully charged battery depends on a number of factors such as battery capacity, driving speed, load in EV, and weather conditions.[68] Higher-capacity batteries can store more energy and thus offer longer driving range. For example, some e-scooters with battery capacity of 3.97 kilowatt-hours (kWh) can cover a distance of up to 181 km on a single charge.[69] Meanwhile, some e-cars with battery capacity of 39.2 kWh offer a range of up to 452 km.[70]

Motorists, particularly those covering long distances, are uncomfortable with the idea of frequently charging EV batteries for two reasons: there are few battery charging stations at public places in the country, and it takes more time to charge the EV battery than to fill up an ICE vehicle tank with petrol or diesel.[71]

As an e-scooter driver engaged in household delivery of goods said to this author, "the battery discharges completely after 6-7 hours of use, and is to be replaced by the end of the day." The private company for whom the driver works bears the cost of replacement. In this arrangement, known as battery swapping, the discharged batteries are exchanged for charged ones, which saves time and money.[72] An EV taxi driver noted the low engine power derived from battery: "the e-car is difficult to restart after the engine is switched off, and the air-conditioning is weak." He thinks the EV sector will still take around five years to mature, "and this is probably not a good time to buy an EV."

Key Challenges in India's EV Sector

Charging: EVs are usually charged in two ways: by plugging into a wall socket or an AC wall box charger installed at home, or by plugging into a DC charger installed at public places. The time taken in charging through either of these methods differs and depends on the amount of power supplied by the charger. Home chargers take a longer time (six to 19 hrs) compared to those available at public places (over one hour) for a full charge.

Two issues compound the cost of time spent in charging. First, although India produces sufficient power to meet the demand, there is a problem in efficient transmission and distribution. This causes power outages, which are common across India and can create difficulties for EV owners. Second, there are fewer public charging stations in cities and along highways, making buyers hesitant to buy EVs.

Battery disposal: The lithium-ion batteries used in EVs contain toxic substances, such as manganese, nickel, lithium, and cobalt. With the expected growth in the number of EVs, proper infrastructure and procedures would be required for safe disposal of end-of-life batteries. Besides catering to the requirement of the EV sector, such battery disposal facilities would be useful for other electronic goods powered by lithium-ion batteries.

Electricity production: As India pushes for faster adoption of EVs, the demand for electricity for charging EV batteries will increase. At present, coal is the largest energy source for electricity generation in India. The burning of coal for producing electricity results in release of harmful emissions that have consequences on environmental and human health. The ensuing problems include acid rain, smog, haze, respiratory illnesses, lung diseases, and neurological and developmental damage in humans and animals.[73] Therefore, to meet future electricity demand, it will be necessary to tap safer and cleaner sources.

A study conducted by TERI describes how load on electricity caused by increasing demand from EV sector can be managed.[74] It is reported that while there will not be a substantial increase in demand in the near future, there is a possibility of imbalanced distribution of EVs within a city. This pattern of uneven growth in the number of EVs would lead to overloading of some section of the power distribution network. Shubham Thakare, et al. suggest that adoption of "dynamic pricing for EV charging based on real-time network loading" would be a useful measure.[75] This would ensure that a large number of EV users do not charge their vehicles at around the same time, as charging prices would be high during periods of local electricity network congestion. This paper argues that while this approach may be beneficial for power utilities, it could restrict the mobility of many EV users.

Key Challenges in India's EV Sector

Financing: Despite increasing public and private sector investments in EV sector, the sale of EVs is still lower than expected. One of the problems observed in this regard is the slow pick-up of retail lending to support consumers and institutions in financing EVs. A 2022 study by Niti Aayog, RMI, and RMI India notes that financial institutions are hesitant in lending due to risks involved, such as product quality, and uncertainty of resale value.[76]

Manufacturing: The proper development and growth of India's EV industry is affected by a number of challenges related to technical expertise of workers, R&D capabilities, ancillary auto components, backward linkages (with metal industries, capital equipment, trucking, warehousing and logistics), linkages with dealership, retail, credit and financing, repair and maintenance.

Public awareness: There is still very little understanding of EVs among the public, in terms of its benefits, risks, subsidies available, charging methods and tariff, battery life, maintenance costs, and resale value. The most common media such as radio, television, newspapers and magazines do not disseminate adequate information and most buyers continue to prefer ICE vehicles. A significant development in this regard is the launch of e-*Amrit* web portal by Niti Aayog in November 2021. The portal provides extensive information on EVs and aims to create awareness among various stakeholders, including citizens, manufacturers, and service providers.[e]

> "The cost of a new e-car battery alone is around INR600,000—the same price of certain brand-new conventional cars."

e The available information includes types of EVs by different manufacturing companies along with price, financing and insurance options, incentives offered by government, charging calculator, and charging station locator.

Key Findings

The government of India is implementing a plan to push for the faster manufacture and adoption of electric (and hybrid) vehicles. The plan aims to achieve 30 percent EV sales penetration for cars, 70 percent for commercial vehicles, 40 percent for buses, and 80 percent for two- and three-wheelers by 2030. Under this initiative, incentives are being offered to attract buyers and manufacturers, and steps have been taken for holistic development of the EV sector. These include tax exemptions for domestic manufacturers, capital subsidies for private operators interested in installation of EV charging stations, reduction in price of EVs, and waiver of road tax and registration fees. As of October 2022, incentives amounting to INR 26.16 billion have been given by the government.

At the state-/UT-level, policies are being implemented to guide the development of the EV sector and address state-specific needs:

- In Maharashtra, five urban agglomerations recording inferior air quality have been chosen for faster transition to EVs.
- The focus in Delhi is to accelerate EV adoption in the mass category of two-wheelers, public/shared transport vehicles, and goods carriers.
- The government of West Bengal plans to create model e-mobility cities with green zones for EVs.
- In Tamil Nadu, an EV special manufacturing package is developed to attract investment.

The impact of policy measures is seen in the growth of EVs and charging stations. Until October 2022, over 1.6 million EVs were sold and nearly 4,000 EV battery charging stations were set up in various Indian states and UTs. The majority of the EVs sold are two- and three-wheelers. The share of four-wheelers sold is only about four percent, which is primarily due to their high price. In the total number of motor vehicles registered in India until October 2022, the share of EVs is less than one percent. Uttar Pradesh, Delhi, Maharashtra, Karnataka, and Rajasthan have the highest number of EVs (over 100,000). Generally, number of EVs is lowest in north-eastern states and UTs.

Necessary amendments in city development plans (or master plans) and building by-laws are being made to accommodate requirements of EV sector, such as provision of low-emission/green zones, earmarking locations of proposed EV battery charging stations, reserving lanes and parking spaces for EVs. So far, the highest number of charging stations (over 300) is in Rajasthan, Uttar Pradesh, and Karnataka. The numbers are low in most north-eastern states and UTs.

Key Findings

A large proportion of the Indian population remains inclined towards ICE vehicles and the shift to EVs is occurring at a slow pace. This present analysis finds the following reasons for the slow adoption of EVs:

- The variety of EV models available to buyers, particularly in the four-wheeler segment, is extremely limited.
- Generally, EVs cost more than ICE vehicles due to machinery, materials, and technology used.
- Metals, such as lithium and cobalt, used in making batteries for EVs are imported from abroad, which raises the cost of EVs.
- Government incentives on EVs are available only to a select number of buyers.
- There are unaddressed concerns over manufacturers' compliance with safety norms.
- There are only a few EV battery charging stations in cities and along highways; at existing stations it takes a few hours for a full charge.
- Proper arrangements for safe disposal of end-of-life EV batteries are yet to be made.
- Dependence on coal for producing electricity to meet growing demand of EV and other sectors is causing harm to the environment.
- Financial institutions avoid lending to consumers and institutions in view of the risks involved, such as product quality, and uncertainty of resale value.
- Most people are purchasing ICE vehicles as they are unfamiliar with EV technology, its benefits, and risks.

Conclusion

The government of India is offering financial and technical support for the holistic development of the electric vehicle sector. Many state and UT governments have also introduced measures to complement the national initiative. Indeed, eco-friendly motor vehicles, such as hybrid and electric, are being manufactured in the country and over a million people are driving such vehicles. Its benefits are seen in the form of fuel savings and reduced air pollution.

The transition from conventional (ICE) to electric vehicles, however, continues to lag. The government recognises the problems that impede the growth of the EV sector and is taking steps to address these by strengthening the manufacturing ecosystem and providing EV charging facilities. However, a lot of ground is needing to be covered: manufacture more EV models, particularly in the four-wheeler segment, and at an affordable price; ensure the safety of e-vehicles; set up adequate charging infrastructure at public places; provide a steady flow of incentives to manufacturers and consumers; equip workforce with advanced skills; improve forward and backward industrial linkages; facilitate shift to renewable sources of energy for electricity production; and scale up EV awareness campaigns. Considering the present limitations, it will likely still take a long time before India sees more electric vehicles on its roads.

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18 4 percent of total vehicle cost capped at INR 6,000.

19 6 percent of total vehicle cost capped at INR 10,000.

20 For slow charging stations, incentive amount will be 60 percent of the cost of charging station with maximum limit of INR 10,000. For moderate/fast charging stations, this will be 50 percent of the cost with maximum limit of INR 500,000. The incentive amount is not meant for land and any ancillary costs.

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