Energy and Economic Growth
Applied Research Programme

Bottlenecks in India's Transition to Electric Mobility

Energy Insight

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March 2020

Oxford Policy Management

UKaid
from the British people

Introduction

The Indian automobile industry is the fourth largest in the world. Over 210 million cars, two-wheelers, three-wheelers, and other vehicles currently ply the country's roads. India has demonstrated its commitment to transition to electric vehicles and is part of the Electric Vehicle Initiative under the global Clean Energy Ministerial. Member countries of the Initiative have endorsed the global 'EV30@30' campaign, which sets the objective to reach a 30% sales share for electric vehicles by 2030. India aims for electric vehicle sales penetration of 30% for private cars, 70% for commercial cars, 40% for buses, and 80% for two- and three-wheelers by 2030. Transitioning to electric vehicles could potentially reduce India's annual crude oil import bill by $7 billion per year by 2030, and by $100 billion per year by 2050 (Abhyankar, Gopal, Sheppar, Park, & Phadke, 2017).[1] It could also translate into savings of 846 million tonnes of net CO_2 emissions over the sold vehicles' lifetimes (Rocky Mountain Institute; Niti Ayog, 2019).[2]

Electric vehicle sales in India

Type	2018	2019
Two-wheelers	54,800	126,000
Three-wheelers	250,000	630,000
Four-wheelers (cars)	1,200	3,600

Source: Emerging Technology News, 2019

India's mobility transformation so far has been skewed towards two-wheelers. Electric vehicle market penetration is only 1% of total vehicle sales in India, out of which 95% can be attributed to two-wheelers (Sahay, 2019). While the growth in electric vehicle sales has been promising, electric four-wheelers only constitute 0.1% of total car sales. Significant supply-side issues need to be addressed to ensure that the capital and total cost of ownership are reduced significantly enough to make electric vehicles competitive with fuel-based vehicles. The enabling environment for electric vehicles also needs to be strengthened to ensure a smooth transition and to meet the Government's ambitious targets. This paper throws a spotlight on existing institutional and policy arrangements, infrastructure gaps, and local manufacturing constraints relating to electric vehicles, and on the impact of rapid electric vehicle uptake on the power grid.

Institutional arrangement and key electric mobility schemes in place

There are multiple actors involved in the policymaking and implementation process at the national level (Figure 1). NITI Ayog, a policy think-tank of the Government of India, has anchored the national policy roadmap in consultation with key ministries. In addition to the ministries shown in

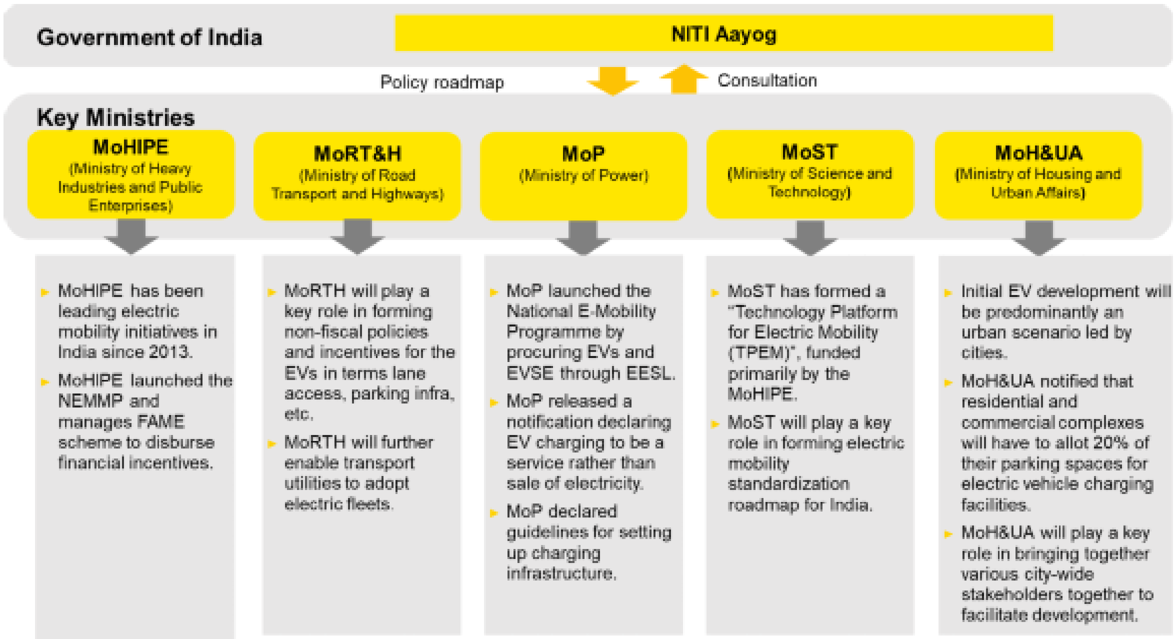
Figure 1, the Ministry of New and Renewable Energy has been involved in research and development around alternative fuels for surface transportation,[3] and the Ministry of Finance has provided tax incentives.[4] The National Mission for Electric Mobility Plan, which lays out the roadmap for electric vehicle adoption and domestic manufacturing, was launched in 2013 by the Ministry of Heavy Industries and Public Enterprises (MoHIPE). This was followed by the flagship Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) schemes (Phase I in 2015, Phase II in 2019).

FAME Phase II is a three-year long scheme that has allocated $1.4 billion towards increasing the uptake of electric vehicles, with a specific focus on public and shared transportation. 85% of the scheme's outlay is earmarked as a demand incentive applicable to buses, passenger vehicles, and three-wheelers registered for commercial usage or public transport, along with privately owned two-wheelers. The scheme aims to support 1,000,000 two-wheelers, 500,000 three-

[1] Assuming a constant oil price of $40/barrel, more than 80% of the crude oil consumed in India by 2030 is imported, and if all vehicle sales by 2030 and beyond are electric vehicles, all ICE vehicles purchased before 2030 retire by the mid-2040s.
[2] Assuming electric vehicle sales penetration of 30% for private cars, 70% for commercial cars, 40% for buses, and 80% for two and three wheelers by 2030.
[3] Supports research projects on hydrogen production, hydrogen storage and applications; fuel cell technologies; and alternative fuels for surface transportation
[4] Announced reduction of Gross Services Tax on electric vehicles from 12% to 5% (2019); Income tax deduction of INR 1.5 lakh on the interest paid on the loans taken to purchase electric vehicles (2019)

wheelers, 55,000 four-wheelers, and 7,000 buses that operate on lithium ion batteries or other electric powertrains.

Figure 1: Key government actors (Source: Bureau of Energy Efficiency and EY, 2019)



While FAME Phase II serves as the key national electric mobility scheme, several states have developed their own electric vehicle policies, setting specific investment, employment, and electric vehicle sales targets, as well as demand and supply incentives:

State	Policies	Snapshot of key targets
Karnataka	Karnataka Electric and Energy Storage Policy- 2017	Investment target of $4.07 billion by 2022; 55,000 jobs by 2022
Telangana	Electric Vehicle Policy 2018	Investment target of $3 billion by 2022; 50,000 jobs by 2022; Innovation fund supported by the Government to support electric vehicles; 100% electric buses by 2030 for intra-city, intercity, and interstate transport, with 25% targeted by 2022 and 50% by 2025
Delhi	Electric Vehicle Policy 2018	50% electric buses in public transport by 2023; 'pollution cess' on petrol/diesel vehicles starting 2019; electric vehicles to constitute 25% of all new vehicle registrations by 2023
Andhra Pradesh	Electric Mobility Policy 2018	Investment target of $3.9 billion by 2030; 60,000 jobs by 2030; government buses, commercial vehicles to go electric by 2024
Maharashtra	Electric Vehicle Policy 2018	Investment target of $3.2 billion; electric vehicles to go up by 500,000; 100,000 jobs (policy duration of five years)
Kerala	Electric Vehicle Policy 2018	1 million electric vehicles by 2022; over 6,000 electric public transport buses by 2025
Uttar Pradesh	Electric Vehicle Policy 2018	1,000 electric vehicles by 2030; set up electric vehicle incubation centres at IIT-Kanpur/other educational institutions
Uttarakhand	Electric Vehicle Policy 2018	Investors to have 100% electricity duty exemption; term loans of Indian rupees (INR) 10-15 crore to micro, small and medium-sized enterprises, to manufacture electric vehicles; 100% electrification of public transport (e-buses), shared mobility, including e-bike-taxis and goods transport using electric 2 watt (W), 3W, and 4W and other mini goods transport vehicles in five priority cities by 2030
Tamil Nadu	Electric Vehicle Policy 2019	Investment target of $6.5 billion; 15,000,000,000 lakh new jobs (policy to lapse by 2029 unless renewed earlier)

Bihar	Electric Vehicle Policy 2019	Investment target of $329 million; 10,000 direct employment opportunities

The FAME schemes have also set city specific targets. FAME Phase I provided funding support for 390 buses, across 11 cities (with a population over 1 million). Domestic manufacturers such as Tata Motors, Goldstone-BYD, and Ashok Leyland were selected for this purpose. Kolkata and Indore both now have electric buses in operation (40 buses each). As part of FAME Phase II, the Department of Heavy Industry has already approved the sanction of 5,595 electric buses to 64 cities, state government entities, and state transport undertakings for intra-city, intercity, and last-mile operations.

Infrastructure gaps that may affect the ease of transition

Range anxiety is a major factor that results in the low uptake of electric vehicles. The Government has specified targets for charging infrastructure through FAME Phase II:

- at least one charging station within a grid of 4km by 4km, leading to a total of 2,700 charging stations in a set of shortlisted cities;[5]
- fast charging stations along major highways at an interval of about 25 km each; and
- ultra-fast charging stations every 100 km.

However, given the fact that India's charging infrastructure is currently in its infancy, the quantum of charging stations that FAME Phase II aims to set up amounts to only 1% of what is required to meet the demand generated if the targets for 2030 are met (ORF, 2019). The onus would then be on the private sector to invest in and operationalise charging stations. The Government has deemed public electric vehicle charging a de-licensed activity, allowing the private sector to set up charging stations as per prescribed standards.

Consolidated data on existing or upcoming private charging stations does not exist yet, but some private actors have already announced their intention to set up private charging stations based on the standards prescribed by the Government. Panasonic, for example, aims to set up approximately 100,000 charging stations for two- and three-wheelers by 2024 across the top 25 Indian cities.[6] However, private players continue to remain reluctant to invest heavily in charging stations given the uncertainty around revenue generation. Companies cite access to land, electricity load connection, and access to capital as significant barriers to scaling up charging infrastructure (Bureau of Energy Efficiency and EY, 2019).

There has also been confusion in the market as a result of charging standards. Box 1 provides further details on the types of charging modalities in use in the country. India made significant updates to its charging infrastructure guidelines in 2018 to keep up with international standards. Existing norms require charging stations (with a minimum of six charging points) to install a combination of Japanese CHAdeMO, European Combined Charging System (CCS), Type 2 AC, or the Indian Bharat Standard (Government of India, 2018a). The Bharat Standard is a low voltage charging technology and is the most economical, making it more appropriate for two- and three-wheelers. Companies looking to set up charging infrastructure are required to get licences for these standards, which translates into high capital costs, especially if they choose a combination of two or more charger types. The Bureau of Indian Standards and Department of Science and Technology is looking into standardisation of fast charging infrastructure, with the goal of reducing costs. The Bureau's delays in issuing the full set of standards for charging infrastructure have led to some confusion in the sector over which way to move forward in order to ensure relevant supply chain alignment (EY and Bureau of Energy Efficiency, 2019).

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[5] The cities identified for an initial roll-out of charging infrastructure are Mumbai, Delhi, Bengaluru, Hyderabad, Ahmedabad, Chennai, Kolkata, Surat, and Pune

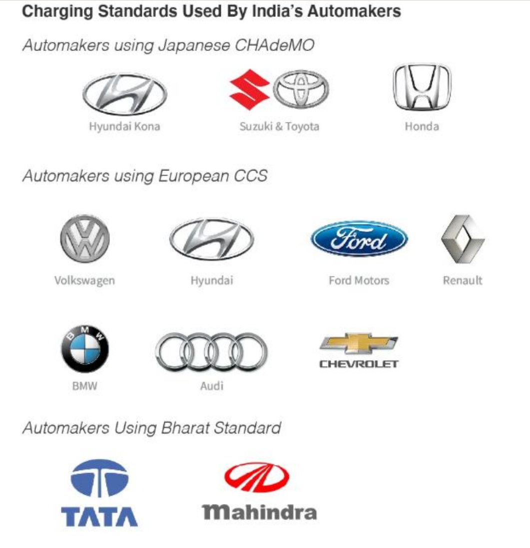
[6] See https://timesofindia.indiatimes.com/business/india-business/panasonic-to-set-up-a-1-lakh-strong-charging-grid-to-power-electric-vehicles-in-india/articleshow/69347132.cms

Box 1: Types of charging modalities

Three types of charging mechanism are used in India:

Charger type	Charger connectors	Rated voltage (V)
Fast	CCS (min 50 kW)	200–1,000
	CHAdeMO (min 50 kW)	200–1,000
	Type-2 AC (min 22 kW)	380–480
Slow/ moderate	Bharat DC-001 (15 kW)	72–200
	Bharat AC-001 (10kW)	230

While these specifications cater to four-wheelers, there are not any prescribed charging standards for two- and three-wheelers, with the market being full of competing charging ports.



Source: Arya, 2019; Naik, 2020

Local manufacturing constraints

Local manufacturing limitations translate into higher costs for electric vehicles. Electric cars still remain at least 30% costlier than internal combustion engine vehicles in terms of upfront prices, mainly due to the cost of imported batteries (Philip, 2020). High capital and lifetime costs of electric vehicles remain a major barrier to adoption. In India, two- and three-wheelers are expected to become capital cost competitive long before four-wheelers (Rocky Mountain Institute, 2019). A majority of two- and three-wheelers use lead batteries, which are both locally built and cheaper than the lithium ion batteries commonly used in four-wheelers.

The National Mission on Transformative Mobility and Battery Storage and the 'Make in India' initiative aim to promote domestic manufacturing and localisation of the entire value chain for electric vehicles. The Government has issued detailed draft localisation guidelines, but their adoption may initially lead to higher costs while manufacturers adapt to the local sourcing requirements. So far, local manufacturing of battery packs has yet to take off. Battery packs continue to be imported from Japan and China (Emerging Technology News, 2019). Given that there is limited movement towards alternative storage technologies (such as hydrogen fuel cells), and that 65% of lithium reserves are located in Bolivia and Chile, and 60% of cobalt reserves are located in Congo, India will continue to rely heavily on metal imports. Indian companies have made limited attempts to localise lithium processing, and have been unsuccessful at acquiring a stake in lithium and cobalt mines overseas.[7] Lithium ion battery costs, in the short run at least, will remain a function of import duties and local manufacturing capabilities. Higher battery costs will likely translate into a slow transition towards four-wheeler electric vehicle uptake, possibly undermining the Government's targets for 2030.

[7] See https://economictimes.indiatimes.com/industry/auto/auto-news/indias-electric-car-ambitions-could-stumble-on-lack-of-lithium/articleshow/73467372.cms?from=mdr

Implications of electric vehicle uptake on the power grid

Energy demand will not increase substantially as a result of electric vehicle uptake, but a study by Brookings India (2018) suggests the need to address the potential load capacity implications of meeting the electric vehicle targets by 2030. Existing research indicates that the additional energy consumption of electric vehicles in 2030 will amount to approximately 4% of total energy demand, which could be managed without significantly affecting the power system. However, India's power system must prepare to address load capacity constraints in the face of the anticipated transition to electric vehicles (Ali and Tongia, 2018). In terms of aggregate loads, electric vehicles might constitute the most significant share – even higher than industrial sectors (Ali and Tongia, 2018). Studies suggest that uncontrolled charging of electric vehicles could contribute as much as 20–50% to peak load by 2030, depending on the level of electric vehicle penetration (Ali and Tongia, 2018; Sharma et al., 2019). Much of electric vehicles' contribution to peak load will depend on substation and feeder-level modalities, indicating that utilities should urgently conduct distribution capacity assessments at these levels. Simulation studies conducted for feeders in New Delhi, for example, demonstrate the need for distribution companies (DISCOMs) to undertake distribution transformer-level interventions and splitting of feeders (Reddy et al., 2019). The Time of Use (ToU) facets of electric vehicle charging demand also need to be reviewed. Figures 2 and 3 project load profiles with and without ToU in place. It is likely that charging demand will coincide with peak demand. Peak load profiles will also vary based on the location of substations, and will depend on the distribution of residential and commercial areas. Reports of overloaded transformers breaking down due to load constraints imposed by newly installed charging stations have already started to trickle in.[8]

Figure 2: Projected load profile on a typical day with uniform electric vehicle load in 2030 (Source: Shakti Foundation, 2017)

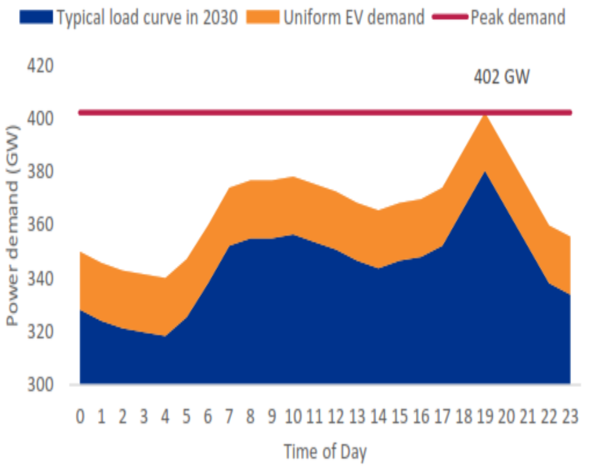
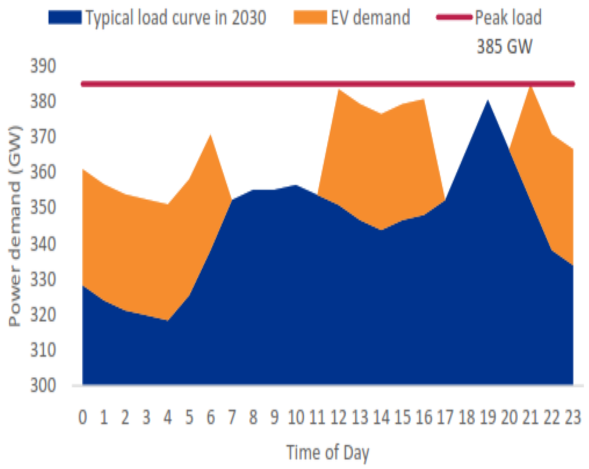


Figure 2: Projected load profile on a typical day with ToU in place (Source: Shakti Foundation, 2017)



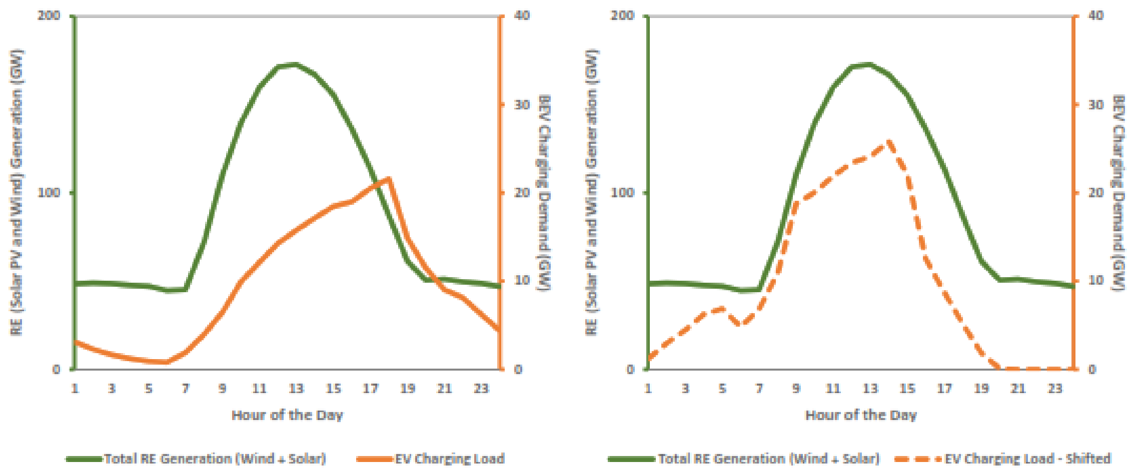
Designing effective rate structures (such as ToU tariffs) to shift electric vehicle charging times: ToU tariffs can offer the benefit of load flattening for DISCOMs. Electric vehicles constitute a 'flexible load' that can be shifted to a different time of the day through incentives (Figure 3), allowing DISCOMs to address technical losses and reduce instability in the grid. For instance, the simulated impact of 23% electric vehicle penetration in the fleet in 2030 in California (USA) showed a big difference in peak load between controlled and ToU charging modes. In this case, electric vehicles in uncontrolled charging and ToU charging modes were found to increase the peak load by 11.14% and 1.33%, respectively (Rocky Mountain Institute, 2016). In India, Delhi was the first state to

[8] See https://indianexpress.com/article/cities/pune/at-bhekrai-nagar-depot-45-e-buses-stop-plying-after-high-capacity-transformer-breaks-down-5952966/

introduce a distinct electricity tariff for electric vehicle charging. Twelve states have now issued similar tariffs in the range of $0.085–0.10/kilowatts per hour (kWh) (India Smart Grid Forum, 2019). So far, only four states[9] have applied ToU rebates and surcharges to influence electric vehicle charging behaviour (India Smart Grid Forum, 2019).

ToU tariffs can also be used to promote cost-effective renewable energy grid integration. Figure 4 forecasts battery electric vehicle charging demand profiles in 2030, with and without ToU tariffs, against hourly solar and wind generation. Renewable energy curtailment and the inefficient operation of thermal power points during high renewable energy periods can be avoided if the electric vehicle charging load is shifted entirely to the daytime to match solar and wind generation (Abhyankar and Gopal, 2017). To understand overall load impacts, however, it is crucial to further understand whether the renewable energy generation curve (particularly of solar) would also coincide with peak demand. There is evidence of demand management interventions leading to a reduction in oversupply of renewable energy. A study modelling the impact of demand management through ToU tariffs for a 2030 scenario in California (USA) concluded that demand management through ToU tariffs could reduce oversupply of renewable energy by up to 72.6% (Forum of Regulators, 2017). A similar impact was also found by a study in Germany, which predicted that ToU tariffs could reduce oversupply by 64% (Forum of Regulators, 2017). However, this evidence is derived from modelling studies, since little empirical evidence is available to corroborate the effectiveness of ToU tariffs in shifting electric vehicle charging loads throughout the day.

Figure 3: Average hourly renewable energy generation and electric vehicle charging load – May 2030 (Source: Abhyankar and Gopal, 2017)



Grid interactive charging: **Vehicle-to-grid (V2G)** allows electric vehicles to supply power back to the grid from their storage during peak hours and to be charged back from the grid during off-peak hours (TERI, 2018). Vehicular requirements for such a setup include: (a) a power connection to the grid for electrical energy flow; (b) control or logical connection necessary for communication with grid operators; and (c) precision metering on-board the vehicle (Kumar, 2019).

Vehicle-grid integration technologies (Figure 5) have been tested through research and are already being piloted in some countries. Assuming 100% electric vehicle penetration by 2050, a study found the peak of the net load curve to increase by 20% in Scandinavia and Germany, while this increase was only 7% when V2G technology was applied (Taljegard, 2017). Companies such as Nuvve (United Kingdom) and Nissan (Japan) have been working on developing V2G chargers and compatible vehicles, respectively. Grid interactive smart charging for electric vehicles is in its nascent stage in India. Only one state (Andhra Pradesh) has indicated that it will issue regulations, defining tariffs as well as terms and conditions for V2G sale

[9] Delhi, Maharashtra, Uttar Pradesh, and Telangana.

of power to meet the requirements of real-time and ancillary services for DISCOMs; the sale of power from battery swapping stations to the grid will also be considered as V2G sale of power (Andhra Pradesh Electricity Regulatory Commission, 2018).

Figure 4: Vehicle-grid integration technologies (Source: International Renewable Energy Agency (IRENA), 2019b)

Conclusion

The Government of India has demonstrated its commitment to a swift transition to electric mobility by introducing both supply- and demand-side interventions. Many state governments have followed with their own electric vehicle policy frameworks. The national government has also focused on promoting the domestic manufacturing of electric vehicle components (including lithium batteries) to reduce electric vehicle costs. Given the nascent stage of local manufacturing, it will become critical for the Government to set realistic deadlines for domestic manufacturers to indigenise electric vehicle components and provide clarity on charging standards, especially for the four-wheeler segment. The Government has also taken the first step in developing a skeletal network of charging infrastructure across the country to ease consumer range anxiety. The Government will be able to meet its ambitious electric mobility targets only if the transport and power sectors work together to assess the implications of charging demand for power supply, and to develop viable options for grid augmentation.

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