Powering Progress: Assessment of India's EV Charging Infrastructure Policy Landscape

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By

Snigdha

Reg. No.- HP21PPOL0100043

Under the supervision of

Dr. Amarendra Pandey

Associate Professor

KSPP, GITAM

KAUTILYA SCHOOL OF PUBLIC POLICY

GANDHI INSTITUTE OF TECHNOLOGY AND MANAGEMENT

(DEEMED TO BE UNIVERSITY), HYDERABAD

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DECLARATION

I declare that the research work contained in the thesis entitled "Powering Progress: Assessment of India's EV Charging Infrastructure Policy Landscape" is original and it has been done by me under the supervision of Dr. Amarendra Pandey, Associate Professor, Kautilya School of Public Policy. The work has not been submitted to any other University for the award of any degree or diploma.

Date

Signature of the Scholar

Snigdha

CERTIFICATE

This is to certify that the thesis entitled “Powering Progress: Assessment of India’s EV Charging Infrastructure Policy Landscape”, submitted by Ms. Snigdha in the Kautilya School of Public Policy, GITAM (Deemed to be University) for the award of the degree of Masters in Public Policy is a record of bonafide research work carried out under my (our) guidance and supervision.

Date:

Signature of the Supervisor(s)

(Dr. Amarendra Pandey)

Associate Professor

Kautilya School of Public Policy

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DEDICATION

Dedicated to all the women in the world.

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ABBREVIATIONS

Abbreviations	Meaning
BSS	Battery Swapping Station
BEE	Bureau of Energy Efficiency
BIS	Bureau of Indian Standards
CI	Charging Infrastructure
CS	Charging Station
DISCOM	Distribution Companies
EV	Electric Vehicles
FAME	Faster Adoption and Manufacture of Electric and Hybrid Vehicles in India
ICE	Internal Combustion Engines
LEV	Light Electric Vehicles
MNRA	Ministry of New And Renewable Energy
NEMMP	National Electric Mobility Mission Plan
NITI Aayog	National Institution for Transforming India
PCS	Public Charging Station

ABSTRACT

Electric Vehicles are a sustainable alternative to conventional fossil fuels-based vehicles and a viable source of reducing the carbon footprint of the transport industry. India has adopted the goal of electrifying the transport sector and achieving 30% EV penetration in the country by 2030. One of the biggest factors that impacts EV adoption is the availability of Charging Infrastructure. For the promotion of EV and its rapid adoption, a robust charging infrastructure must be set up across the nation, so that issues such as range anxiety can be addressed.

This capstone project, undertaken in association with Ather Energy, assesses the present state of EV Charging Infrastructure Policy in India to understand the gap in policies and find a way ahead for future development of EV charging infrastructure, that would bolster the progression of E- mobility in India. The findings of the study show that India's central and state charging infrastructure policies offer incentives for the CI installers and consumers and have boosted the sales of EVs but they fail to address certain issues of standardisation effectively. The study also revealed that due to the presence of different nodal agencies in different states, there is a lack of coordination among the states on the issue of CI. Further, the study highlights the need for more two-wheeler EV compatible CI to meet the requirements of this rapidly developing segment of the EV industry.

Keywords: EV Charging Infrastructure, EV Policy, E-mobility, public policy, public charging stations, sustainable transport

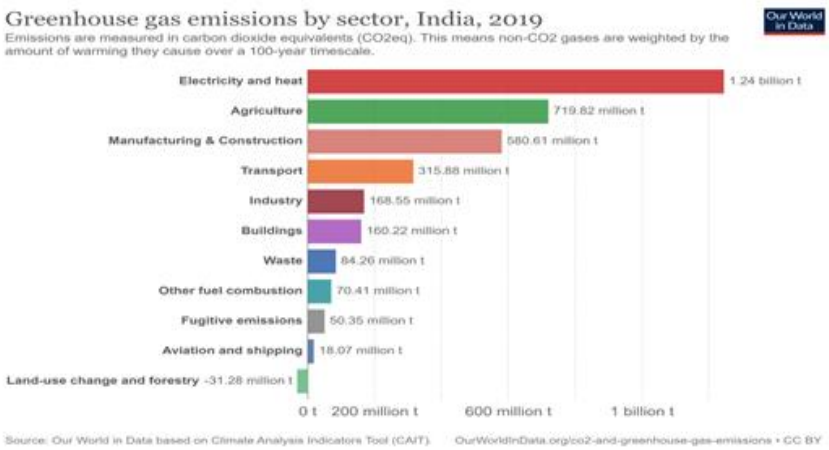
1. INTRODUCTION

1.1 Background

The unprecedented rise in global temperatures and the fast-paced climate change has necessitated the world to look at more sustainable ways of living and find alternate sources of energy which would reduce the burden on exhaustible resources and at the same time be efficient and eco-centric (Khosla et al., 2021). Due to the gravity of the threat posed by climate change and global warming, governments throughout the world have voluntarily committed to reducing their carbon footprint and greening their growth routes. To combat global warming, India has pledged to integrate 175 GW of energy derived from renewable sources into its power system by 2022 (MNRA, 2018; Kumar et al., 2021), and by the end of 2022, 95% of this target has been achieved. Over the course of the past few years, there has been a meteoric rise in the utilisation of renewables with capacities ranging from small to extremely large, and it is anticipated that this upward trajectory is going to persist into the subsequent phase of economic and industrial expansion. As one of the biggest contributors to pollution and global warming (Figure 1), the transport sector is now facing some serious questions which need to be addressed. Vehicles running on Internal Combustion Engines use fossil fuels which are a major source of pollution.

Figure 1.

Greenhouse Gas emissions by sector, India, 2019.



In such a scenario, Electric Vehicles (EVs), have proven to be a welcome change. It is environmentally beneficial and has low maintenance and operating costs. Electric vehicles powered by energy generated from renewable sources present a possibility for reducing our transportation dependency on the use of fossil fuels. Policymakers all over the world have acknowledged this distinct benefit of EVs and established vigorous transformation objectives for electric modes of transport.

In India, the EV rate of adoption is approximately 4.7%, and 1.05 million EVs were sold by the end of the year 2022. One of the primary forces that will enable further adoption of electric mobility is the universal accessibility of facilities designed for charging electric vehicles. In both industrialised and developing nations, the establishment of CI has garnered significant scrutiny, as an ineffective CI can hinder the sales and promotion of EVs (Savari et al., 2022). Users' charge anxiety can be reduced and offtake can be increased with the implementation of a solid and well-developed EV charging infrastructure (Parihar, 2021). Together with its renewable energy production, the Indian government has initiated a plan to promote EV sales penetration of 30% by 2030 (Niti Aayog, 2021). There are several reasons why the provision of electric vehicle charging infrastructure is essential to the expansion of the electric vehicle market in India:

- Range Anxiety: The limited range of EVs makes it important to have charging infrastructure readily available. The availability of charging stations at convenient locations and adequate frequency would alleviate range anxiety among EV drivers and encourage them to drive longer distances, making EVs more practical for everyday use.
- Adoption rate: The lack of adequate charging infrastructure in India has been a significant barrier to EV adoption (Maheshwari and Nair, 2021a). Consumers are hesitant to purchase EVs because they are concerned about where and how they will

charge their vehicles. With reliable and efficient charging infrastructure, consumers would be more inclined to adopt EVs as their primary mode of transportation (IEA, 2023a).

- Economic Benefits: The installation of EV charging infrastructure in India can generate significant economic benefits, such as job creation and increased investment opportunities. It can also contribute to the growth of related industries such as battery manufacturing, renewable energy, and the automobile sector (Bohnsack et al., 2014).
- Environmental Benefits: EVs produce a considerably low carbon footprint as compared to ICE vehicles and significantly reduce pollution levels, contributing to a cleaner and greener environment. The establishment of infrastructure for charging electric vehicles is expected to encourage more people to purchase electric vehicles, which would lead to a considerable decrease in emissions of greenhouse gases and an improvement in the air quality in urban areas.

The Government of India (GoI) has launched a number of measures to encourage EVs, in keeping with its goal of building a sustainable transportation network. The National Electric Mobility Mission Plan, also known as NEMMP, was implemented by the government of India in the year 2013 with the purpose of encouraging the widespread adoption of electric vehicles across the nation (Gulati, 2012). In order to facilitate the expansion of the electric vehicle industry, the strategy places a significant emphasis on the construction of charging infrastructure.

Under the NEMMP, the government aims to establish charging infrastructure in all major cities and highways to encourage EV adoption. The plan focuses on building a network of charging stations across the country, with an emphasis on providing access to charging infrastructure in public spaces, residential areas, and workplaces. In addition, the NEMMP offers financial incentives to encourage the expansion of EVCI throughout India. The

government has offered subsidies and tax incentives to individuals and organisations interested in setting up EV charging infrastructure. The plan also includes initiatives to support research and development in the domain of EV charging infrastructure, with the goals of enhancing technology and lowering associated costs.

Intended Nationally Determined Contributions (INDC) and Faster Adoption and Manufacturing of Electric Vehicles (FAME) are two programmes designed to boost the number of EVs within the transportation sector. FAME- I was a scheme implemented by the Ministry of Heavy Industries on 13th March, 2015, for promotion of hybrid and electric vehicles, with an outlay of 795 crores. The government has given its approval for the second phase of the FAME Scheme, which commenced from April 1, 2019, and would have a budget of 10,000 crores for the next three years. In June 2021, the scheme was further extended for a period of two years, up to 31st March, 2024. Demand Incentive has been allocated 86 percent of the total budgetary support in order to stimulate proliferation of EVs among the masses. This phase seeks to stimulate demand by supporting 7,000 e-Busses, 5,000,000 e-3-Wheelers, 55,000,000 e-4-Wheeler Passenger Vehicles (including Strong Hybrid), and 10,000,000 e-2-Wheelers. Provisions have been made for both inter- and intra-segment fungibility, so these figures are subject to change based on the offtake of various categories of EVs. The Ministry of Power also updated the existing guidelines for charging infrastructure of EVs (Ministry of Power, 2022). The Ministry of Power has designated the Bureau of Energy Efficiency (BEE) as the Central Nodal Agency for the National-level installation of charging infrastructure throughout the country (Bakre et al., 2020).

In spite of these ambitious targets and rules, the percentage of electric vehicles (EVs) employed by India's transportation sector is rather low when compared to the global average. The slow adoption of electric vehicles in India can be attributed to a number of factors, including cost, a lack of adequate charging infrastructure, a reliance on batteries manufactured

in foreign nations, high prices of batteries, range anxiety, battery capacity, and the absence of incentives offered by local markets. There is still a long way to go until there is a pan-India charging infrastructure that can accommodate all different types of electric vehicles. The infrastructure for charging electric vehicles in India is still in its infancy at this point. In addition, there is an apparent absence of synchronisation between the central government and the several state governments, which is a hurdle in India's ambitious objective of having 30% of its vehicles be electric by the year 2030(IEA 2017; NITI Aayog, 2021). This lack of standardisation and coordination in the charging infrastructure has led to a fragmented market, with varying levels of reliability and accessibility. Due to immature battery technologies and a lack of charging infrastructures, range anxiety is the greatest obstacle to EV penetration. (Funke et al., 2019). Contrary to automobiles powered by internal combustion engines (ICE), customers' worries about adjusting to e-mobility centre on charging periods and driving range. Consequently, the construction of charging infrastructure is essential to the propagation of EVs. This study seeks to determine the many challenges to the growth of electric mobility in India. In addition, this report highlights current improvements in India's charging infrastructure policies. Through research conducted over a span of three months, it focuses on identifying the significant issues in placing EV charging infrastructure in India, as well as the state of infrastructure deployment policies in accordance with the government's FAME II-mandated goal. Additionally, the study hopes to be of help to Ather Energy in understanding the need for policy standardisation of EV charging infrastructure and work in this direction.

1.2 Research Objectives

The objectives of the research are to:

- To conduct a comprehensive analysis of the current state of the EV charging infrastructure in India, with a focus on 2WEVs.
- To assess government policies and regulations on the establishment of the EV charging infrastructure in India with regards to India's goal of achieving 30 under 30.
- To identify the challenges and opportunities facing the standardisation policy for the EV charging infrastructure in India.
- To provide policy recommendations for improving the EV charging infrastructure in India to support the growth of 2WEVs.

2. LITERATURE REVIEW

For successful and fruitful research, it is of the utmost necessity to conduct a critical literature assessment on the issue at hand. It not only guides the researcher's actions, but also assures that he or she has the essential background and data to do the research. In addition, analysing the available literature on the issue enlightens the researcher about study gaps and prospective pathways for future research, which aids them in refining their topic to focus on certain elements of the subject.

Electric vehicles (EVs) are gaining popularity worldwide as a cleaner, more sustainable mode of transportation. As of 2021, there were more than 10 million EVs on the road globally, with sales increasing each year (IEA, 2021a). To support the growing number of EVs, charging infrastructure is essential. According to the International Energy Agency (IEA) (2021b), as of 2020, there were more than 10 million publicly accessible charging points worldwide, with China, Europe, and the United States leading in infrastructure development.

Countries have introduced numerous strategies and regulations to promote the usage of electric vehicles and encourage the creation of charging infrastructure. Norway has been excellent at facilitating EV adoption, for instance, by providing generous financial incentives such as exemptions from taxes and access to bus lanes (IEA, 2021c).The Chinese government has stipulated that a specific percentage of new automobile purchases must be electric vehicles (EVs), which has resulted in a significant surge in the number of EVs now operating on Chinese roads. (IEA, 2021d). In the United States, federal and state governments have offered tax credits, rebates, and grants to incentivize EV purchases and charging infrastructure development (NCSL, 2021). Notwithstanding established goals and governmental policies, EV proliferation in industrialised nations is slow, mostly owing to the slow rate of charging infrastructure construction (Rahman et al., 2016; Coffman et al., 2017; Gnann et al., 2018; Khan et al., 2018; Canizes et al., 2019). In addition, a number of researchers (Liu and Wei,

2018; Kore and Koul, 2022) have cited the optimisation, placement, and elimination of charging station complexities as obstacles to the rapid implementation of electric vehicles. Serradilla et al., in their article *An Evidence -based Approach for Investment in Rapid Charging Infrastructure* (2017) have explained the viability of rapid charging infrastructure which is helpful for the formulations of policy in this direction. A different investigation by Sierzchula et al. (2018) looks at the regulations supporting the growth of charging infrastructure in Europe. The authors found that strategies including standardisation, public financing, and regulatory assistance were successful in promoting the development of charging infrastructure. The study also found that the availability of charging infrastructure had a favourable impact on EV adoption. In their 2018 study, Klobasa et al. found that legislation, grants, and tax incentives all had a positive impact on the growth of charging infrastructure. According to research by Litman (2020), governmental funding and subsidies given to the infrastructure for EV charging helped to promote EV mobility and increased EV sales. Overall, these studies show that the market for electric cars (EVs) is growing quickly throughout the world, and regulations that encourage the construction of charging infrastructure are crucial for the industry's growth. Policies including public financing, regulatory assistance, grants, tax credits, and subsidies have successfully supported the construction of charging infrastructure.

Similar research carried out in other countries came to the conclusion that strong regulatory frameworks for EV charging infrastructure and policy incentives proved to be successful in promoting EV adoption and had favourable effects on sustainable transportation (Zhang et al., 2019; Hooper & Simpson 2020; Nguyen and Nguyen 2020; Zhi et al., 2020)

A study by Haghshenas et al. (2021) examined the impact of policy on EV adoption in Iran. The authors found that policies that address concerns such as range anxiety, charging infrastructure availability, and high upfront costs can increase consumer confidence in EVs and

promote adoption. Overall, these studies suggest that policy plays a significant role in promoting EV mobility and charging infrastructure development.

The Indian government has implemented various policies to promote EV adoption and charging infrastructure development. For example, the Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India (FAME) scheme , launched in 2015, offers financial incentives for EV purchases and charging infrastructure development (MNRE, 2021). Additionally, the National Electric Mobility Mission Plan (NEMMP), launched in 2013, sets targets for EV adoption and charging infrastructure development (NITI Aayog, 2018).

However, as of 2021, EVs only make up a small fraction of the Indian automobile market, with significant challenges facing adoption, including high upfront costs, lack of charging infrastructure, and range anxiety (Das et al., 2020). Studies have identified various barriers to EV adoption in India, including lack of consumer awareness, inadequate charging infrastructure, and a lack of charging standards (Sharma et al., 2020; Arora et al., 2021). Additionally, policies such as FAME have been criticised for being insufficiently ambitious (Narayan et al., 2021) and not effectively addressing the challenges facing EV adoption and charging infrastructure development in India. Research conducted by JMK Research and Analytics (2022) comments upon the lack of coordination between the central and state policy decisions that hinder the progress of large scale adoption of electric vehicles. Since EVs are a relatively new phenomenon in India, the literature available on the subject is limited. To understand the charging behaviours and infrastructure logistics, data was sourced from articles and reports of European countries apart from Indian sources to gain a comprehensive insight into the topic at hand. Studies have been carried out to understand EVs charging behaviours (Robinson et al., 2013; Morrissey et al., 2015) including the time and energy consumed while charging. Several scholars have commented upon the drawbacks caused by the non-optimal and inappropriate locations of the charging stations (Vagropoulos and Balaskas, 2017; Sachan

and Adnan, 2018). Consequently the site selection of EV charging stations is of prime importance and researches have been conducted to expound upon the different techniques for the installations of these charging stations (Hemavathi and Shinisha, 2022). Sachhan and Singh (2022) have addressed the present status and challenges for EV charging infrastructure planning in India.

3. RESEARCH METHODOLOGY

3.1 *Data Collection*

The present project employs a descriptive research design under qualitative analysis as its primary method as it uses the data collected from various government reports and ministry-provided data to study the advances in EV charging infrastructure across the nation and the policies implemented by the central and state governments, and their consequent impact upon the EV sector, with a focus on the two-wheeler sector. Additionally, a review of research journals and open-source projects was done to gain insights into the impact of policy changes on EV automobile performance and the realisation of their potential. At present 26 states in India have an EV policy, some proposed and some drafted. For the present study, 10 states with the top performances in the EV sector were taken into consideration. These are- Delhi, Telangana, Karnataka, Maharashtra, Assam, Haryana, Uttar Pradesh, Tamil Nadu, Rajasthan and Bihar. The EV policy documents of these states were perused, with special focus on the CI provisions of these policies to gather Information for analysis and comparison. A literature map of the sources used for the data collection in the study is provided In

Table 1.

A Literature Map of the Data Collected from Various Sources for the Study

S. No	Data	Source Link
1	National Level Policy	https://e-amrit.niti.gov.in/national-level-policy
2	Delhi Electric Vehicles Policy	https://ev.delhi.gov.in/vision-mission https://transport.delhi.gov.in/sites/default/files/All-PDF/Delhi_Electric_Vehicles_Policy_2020.pdf
3	Telangana Electric Vehicle and Energy Storage Policy	https://tsredco.telangana.gov.in/Updates_2020/Telangana_EVES_policy_2020_30.pdf
4	Karnataka Electric Vehicle and Energy Storage Policy	https://kum.karnataka.gov.in/KUM/PDFS/KEVESPPolicyInsidepagesfinal.pdf
5	Maharashtra State Electric Vehicle Policy	https://evreporter.com/wp-content/uploads/2021/07/MH-EV-Policy-2021.pdf
6	Electric Vehicle Policy of Assam	https://industries.assam.gov.in/sites/default/files/swf_utility_folder/departments/industries_com_oid_4/portlet/level_2/ilovepdf_merged.pdf
7	Haryana Electric Vehicle Policy	https://haryanatransport.gov.in/sites/default/files/Electric%20Vehicle%20Policy_2.pdf
8	Bihar Electric Vehicle Policy	https://www.investbihar.co.in/Download/Draft_for_e_vechile.pdf
9	Uttar Pradesh Electric Vehicle Manufacturing and Mobility Policy 2022	https://invest.up.gov.in/wp-content/uploads/2022/11/UP-EV-Policy-2022-V10-Final.pdf
10	Tamil Nadu Electric Vehicles Policy	https://investingintamilnadu.com/DIGIGOV/StaticAttachment?AttachmentFileName=/pdf/poli_noti/TN_Electric_Vehicles_Policy_2023.pdf
11	Rajasthan Electric Vehicle Policy	https://istart.rajasthan.gov.in/public/pdf/REVP_2022.pdf
12	Monthly EV Updates	https://jmkresearch.com/electric-vehicles-published-reports/monthly-electric-vehicles-update/
13	India's Electric Vehicle Transition (Council on Energy, Environment and Water)	https://www.ceew.in/sites/default/files/CEEW-India's-EV-Transition-Post-COVID-19-22Dec20.pdf
14	Electrifying Indian Mobility	https://assets.ey.com/content/dam/ey-sites/ey-com/en_in/topics/automotive-and-transportation/2022/ey-electrifying-indian-mobility-report.pdf
15	Accelerating Electric Mobility in Delhi	https://ev.delhi.gov.in/files/Accelerating-Electric-Mobility-in-Delhi8497bf.pdf

The research project has been conducted through an analysis of the current state of India's central and State EV Charging Infrastructure policies, for the purpose of which certain parameters and provisions for examination and comparison were necessary to highlight. Keeping this in mind, the following factors were considered for the study.

- Incentives: A study of the incentives offered by the central and various state govt. On the setting up and installation of charging networks, to promote faster adoption of EVs. Further, it was examined whether the incentives offered were fiscal in nature or if the government provided alternate forms of incentives.
- Public Charging Infrastructure Vs Home-Charging: Another factor under study was whether the policies at the national and the state levels detailed the provisions for the public and private charging networks separately or not.
- Charging Technologies: So far, the charging technologies predominantly in use in India are – conductive charging and battery swapping method. In a report published by

OECD in 2019, “Plug-in charging is the most mature charging technology and the most present in global CI, with more than 5 million units between private and publicly available chargers” (Bunsen et al., 2019). Table 2 provides a glimpse of the different types of EV conductive chargers and the type of EVs they are compatible with. The accompanying Figure 2 gives a pictorial representation of the EV charger types approved and standardised by the BIS. A study into the different state policies was done to find out if the governments addressed the different modes of charging and if so, which methods were supported by these policies.

Table 2.

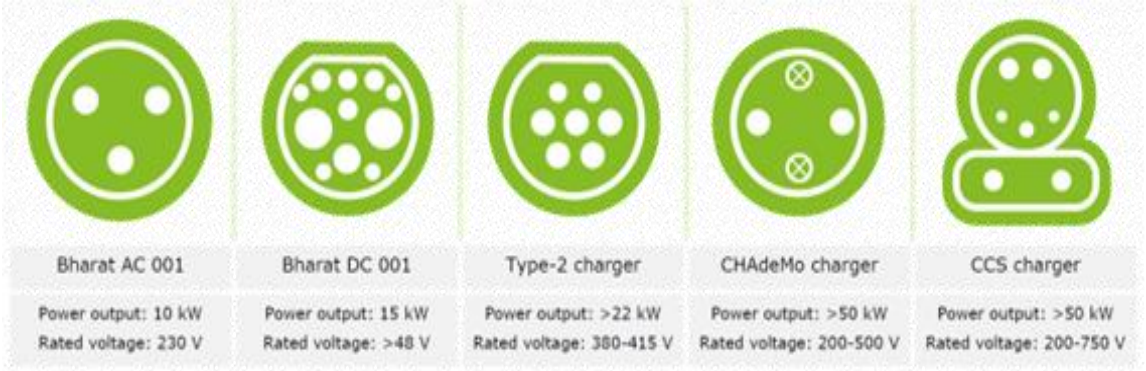
A brief overview of the Different EV Charger Types

Parameters	Level 1	Level 2	Level 3 (AC)	Level 3 (DC)
Voltage	240	380-400	200-1000	200-1000
Power	<=3.5 kW	<=22 kW	4.3 to 22 kW	Upto 400 kW
Type of Vehicle	4W, 3W, 2W	4W, 3W, 2W	4W	4W
Type of Compatible Charger	Type 1, Bharat AC-001	Type 1, Type2 GB/T, Bharat AC-001	Type 2	Type 2, CHAdeMO, CCS1, CCS2

Figure 2.

Electric Vehicle Charger Types.

Source:https://e-amrit.niti.gov.in/arai-standard



- Specific 2-Wheeler EVs Charging Infrastructure: Since one of the objectives of this project is to determine the impact of the government's CI policies on two-wheeler EVs,

it was essential to determine whether or not the policies separately addressed the rapid charging infrastructure requirements for two-wheeler EVs. To achieve this objective, states with comprehensive EV policies were considered and their policies were analysed. After perusing the EV policies implemented at the union and state levels and analysing them in the context of CI, the collected data was tabulated for a comparative study. Table 3 and Table 4 provide a brief overview of the provisions incorporated in the National and State EV policies for the development of CI.

Table 3.

National Level EV Charging Infrastructure Policy

Central Government Policy	Incentives for Charging Infrastructure	Provisions for Public & Private Charging	Charging Technologies & Vehicle type	Provisions for 2 Wheeler Charging Infrastructure	Distance between Charging Stations
Charging Infrastructure for EVs- revised consolidated guidelines & standards. (Ministry of Power)	N/A	1.Connection would be provided to public EV charging stations within 7 days in metro cities, 15 days in other municipal areas and 30 days in rural areas. 2.Owners may charge EVs at their residences using the existing electricity connections. 3. Tariff for supply of electricity for PCS shall be a single part tariff and shall not exceed average cost of supply till 31st March, 2025.	Public charging stations to have any one or a combination of different types of AC and DC charging systems approved by the Government. (Mentioned in Annexure 2 and 3 of the national CI policy).	No separate provisions.	At least one EV charging station shall be available in a grid of 3 Km X 3 Km. Furthermore, one EV charging station shall be set up at every 25 Km on both sides of highways/roads.
FAME II	1.A fund allocation of 1000 crores reserved for Charging Infrastructure. 2.Funding for establishment of charging infrastructure to the extent of 100% of cost depending upon the project proposal.	As per the guidelines issued by the Ministry of Power.	Public charging stations to have any one or a combination of different types of AC and DC charging systems approved by the Government.	No separate provisions for 2W Charging Infrastructure.	At least one EV charging station shall be available in a grid of 3 Km X 3 Km. Furthermore, one EV charging station shall be set up at every 25 Km on both sides of highways/roads.

Table 4.

State Level EV Charging Infrastructure Policies

State	Incentives for Charging Infrastructure	Separate Provisions for Public & Private Charging	Charging Technologies Mentioned	Separate Provisions for 2 Wheeler Charging Infrastructure	Distance between Charging Stations	Nodal agency
National Capital Territory of Delhi	The GNCTD shall provide a grant of 100% for the purchase of charging equipment up to Rs. 6000/- per charging point for the first 30,000 charging points (Grants shall be available for chargers that are either single-phase or three-phase input but comply with all other BEVC–AC001 specifications). A capital subsidy for the cost of chargers installation expenses shall be provided by Delhi Government to the selected Energy Operators. 100% of the net SGST accrued, shall be provided as reimbursement to the Energy Operators for the purchase of advanced batteries to be used at swapping stations	All new home and workplace parking 'EV ready' with 20 % of all vehicle holding capacity/parking required to be Electric Vehicle ready (Changes in building bye-laws shall be made accordingly). All existing residential and non-residential building owners shall be encouraged to install Private Charging Points (PCPs) within their premises.These charging points shall especially provide shared access to Electric Vehicle charging for residents of group housing societies and multistory apartment complexes.	As per FAME II guidelines.	No.	The key objective of the Delhi EV policy is to provide accessible public charging facilities within 3 km travel from anywhere in Delhi.	Delhi Transco Limited (DTL)
Karnataka	The government of Karnataka will offer incentives by way of investment subsidy for setting up the first lot of 100 fast-charging stations. Support for Manufacturing of EVs, EV components, Battery manufacturing, Charging/Swapping infrastructure development: • Investment promotion subsidies –Micro Enterprise: 25% of the Value of Fixed Assets (VFA) (max. Rs. 15.00 lakh) –Small Enterprises: 20% of the Value of Fixed Assets (VFA) (max. -Rs.40.00 lakh) –Medium Manufacturing Enterprises Rs 50.00 lakh	The government of Karnataka will facilitate providing the required electricity supply from the grid and examine special tariffs at commercially viable rates for EV charging stations (public and private). Charging infrastructure for personal transport vehicles of Government employees would be made available at Vikasa Soudha Basement/ multistorey Building parking area and covered parking areas in all Government buildings across the State	The government of Karnataka in association with Industry & Academia will come out with standards for battery, charging infrastructure & swapping mechanisms, etc to build an interoperable network where different vehicles from different OEM COI participate.	To facilitate EV mobility on highways between prominent cities with a heavy density of vehicles such as the Bengaluru-Mysuru highway and others, a fast-charging station/ battery swapping infrastructure will be provided at every 50 kilometres.	To facilitate EV mobility on highways between prominent cities with a heavy density of vehicles such as the Bengaluru-Mysuru highway and others, a fast-charging station/ battery swapping infrastructure will be provided at every 50 kilometres.	Bengaluru Electric Supply Company Limited (BESCOM)
Telangana	The state government will help set up the initial set of fast charging stations located in Hyderabad and other towns in a systematic manner with the support of state entities as well as private players.A special power tariff category will be provided by the Telangana State Electricity Regulatory Commission (TSERC) for electric vehicle charging stations.	TSREDCO (State Nodal Agency) should consider whether to create public charging stations directly or through a licensee/franchisee/public-private partnership (PPP) model.		HMR stations and TSRTC Bus depots (around the state) will provide special parking and charging points for two-wheelers in their parking zones to encourage the use of electric vehicles for last-mile commutes.	Charging/swapping stations should be promoted every 50 kilometres inside state boundaries on roads leading to cities like Bengaluru, Mumbai, and Chennai, followed by other national/state	Telangana State Renewable Energy Development Corporation Limited (TSREDCO)
Bihar	Commercial, and public EV charging stations will be eligible for a 25% capital subsidy on equipment/ machinery (limited to Rs. 5 lacs per station) for the first 500 commercial public EV charging stations.	Common charging points in residential areas, societies, bus depots, public parking areas, railway stations and fuel pumps etc. will be allowed and Development Control Rules (DCR) of all local self-Government & Special Planning Authorities will be suitably modified to allow for setting up of common public charging facilities in parking areas of malls, residential properties & parking areas etc.	No	No.	Create fast charging stations at every 50 km on state highways/national highways in the state.	Transport Department, Bihar
Maharashtra	60% subsidy on 15,000 public and semi-public slow charging stations, up to INR 10,000. - 50% of the total cost of the first 500 public and semi-public Charging Stations, up to INR 5,000,000.					Maharashtra State Electricity Distribution Company Ltd. (MSEDCL)
Haryana	Land to be provided for PCS at concessional rates.Electric Supply to PCS to be facilitated at concessional rates.	State Transport Undertaking depots and bus stops will include charging stations. Public parking will require charging stations. All petrol pumps must feature charging stations and battery banks.	Clean fuel and Renewable energy based Charging/Battery Swapping Station – for hydrogen powered fuel cells, or solar powered cells.	Facilities will be provided to set up swapping stations in the form of a kiosk to service 2 wheelers and 3 wheelers.	Fast Charging stations and battery swapping infrastructure at every 50 kms on highways.	Haryana Renewable Energy Development Agency
Uttar Pradesh	Land to be provided to both Govt. and private entities on 10 years' lease on a revenue sharing model. Provision of special tariff category for EV Charging.	Creation of charging / swapping facilities in public parking spaces, Metro stations, Bus depots/ Terminals, petrol pumps, Govt Buildings, Corporate Buildings, Educational/ Health Institutes, Shopping malls & other commercial places, Group Housing societies and RWAs, Gram Sabha land, etc.	No	No	Promotion of CI in a grid of 3km* 3km. CI to be installed at every 25 kms along Expressway/ Highways.	Invest UP
Tamil Nadu	25% subside to firms installing PCS. Fast Charging Stations- up to 10,00,000- (200 PCS) Slow Charging Stations- up to 1,00,000- (500 PCS). The first 200 public battery swapping stations in Tamil Nadu would receive a 25% capital subsidy on equipment and apparatus up to Rs. 2 lakh per station. Demand Charge Reduction: 75% for the first two years and 50% for the next two. Energy Charge Reduction - 50% reduction between 8 AM and 4 PM to encourage non-peak charging and renewable energy use for EV charging.	Electricity used by private charging stations to be considered as domestic consumption. A new category of tariff for PCS.	PCS must have 3 chargers and follow the Charging Infrastructure for Electric Vehicles - Guidelines and Standards.	No	Establishment of PCS at every 25 kms on both sides of National and State Highways.	Tamil Nadu Generation and Distribution Corporation Ltd (TANGEDCO)
Rajasthan (2022)		Private Charging permitted through existing power connections. PCS may purchase power from any source through an open access route. PCS to be set up at appropriate locations based on vehicle density and utility.				Jaipur Vidyut Vitran Nigam Limited (JVVNL)

The data collected was studied to find how these policies impacted the EV sector growth and which factors were most relevant in the promotion of EVs. The findings of the study are discussed in the later sections of this report. These findings were then assessed to highlight the gap between the present state of Indian EV Charging infrastructure policies and the desired

changes in policy to achieve the objective of 30% EV mobility by 2030. The findings also helped us understand the areas of concern and the way forward to boost the adoption of EVs by the Indian masses.

3.2 Data Analysis

The data collected from government sources revealed the total number of EV charging stations available in the country. The state-wise allocation and distribution of these CS (Figure 3) was determined through a study of different sources. The study showed that after the amendments in the FAME scheme, and largely due to the incentives offered by the government, the number of EV CS across the country went drastically up. However, the unequal distribution pattern of EVCI was also evident, and we examined the policies for their probable causes. Our analysis showed that the policies were majorly focused on the location of CS on the national and state highways, which may have been a potential factor behind this pattern of CI distribution.

Table 5.

EV Charging Stations Distribution Across the nation under FAME II

Source: Parliamentary Questions answered in Lok Sabha

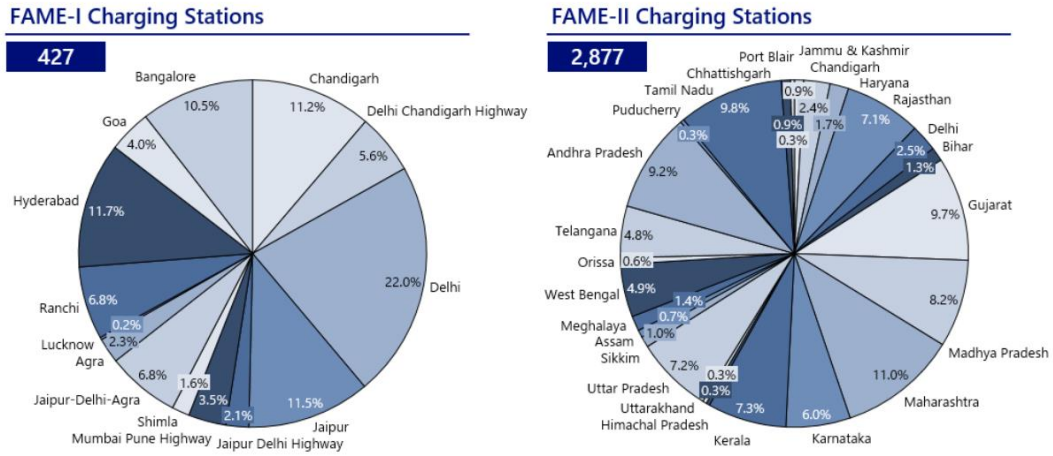
State	No. of EV chargers sanctioned
Maharashtra	317
Andhra Pradesh	266
Tamil Nadu	281
Gujarat	278
Uttar Pradesh	207
Rajasthan	205
Karnataka	172
Madhya Pradesh	235
West Bengal	141
Telangana	138
Kerala	211
Delhi	72
Chandigarh	70
Haryana	50
Meghalaya	40
Bihar	37
Sikkim	29
Jammu & Kashmir	25
Chhattisgarh	25
Assam	20
Odisha	18
Uttarakhand	10
Puducherry	10
Andaman and Nicobar (Port Blair)	10
Himachal Pradesh	10
Total	**2877**

Second step in the analysis was to find out how many of these EVCI were sanctioned under the FAME (I and II) scheme of the GoI (Figure 4), and whether the expenditure on the installation of these CI was in tandem with the budget allocated by the FAME-II scheme.

Figure 3.

State-wise allocation of CS under FAME I and FAME II

Source: *Parliamentary Questions answered in Lok Sabha*



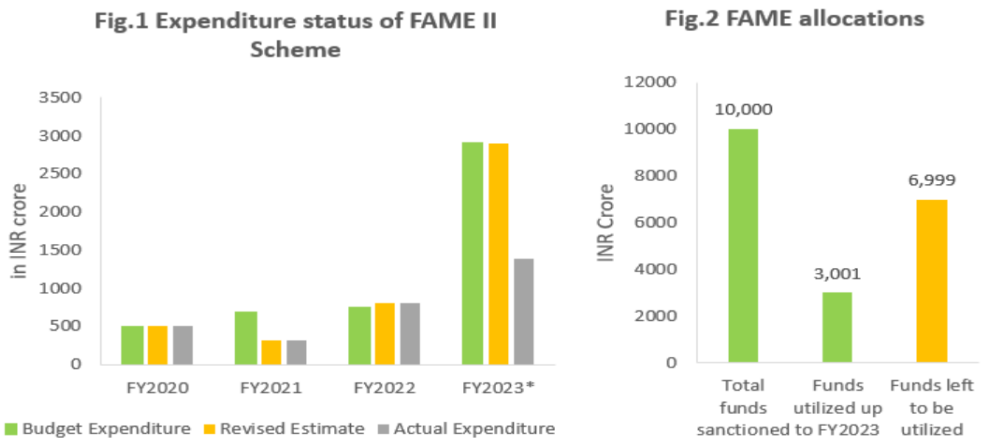
Allocation of charging stations under FAME 1 and FAME 2 by DHI

Of the total 10,000 crore rupees sanctioned for the development of EV sector, only 3000 crores have been utilised till March 2023. This underutilisation of funds resulted in a slow-paced infrastructure build-up. Separate data on the charging infrastructure fund utilisation is not provided by the government so far. However, in 2022, the ratio of EVs to Public Chargers in India stood at 135, which was way higher than the global ratio of 6 -20 EVs per public charger (Alvarez and Marsal, 2022). This shows that while EV penetration is increasing at a rapid pace, the supporting CI is still lagging behind. The implications of this mismatch between the number of EVs and the number of PCS are discussed in the later sections of this report.

Figure 4.

Expenditure under FAME-I and FAME-II

Data Source: Parliamentary Questions answered in Lok Sabha



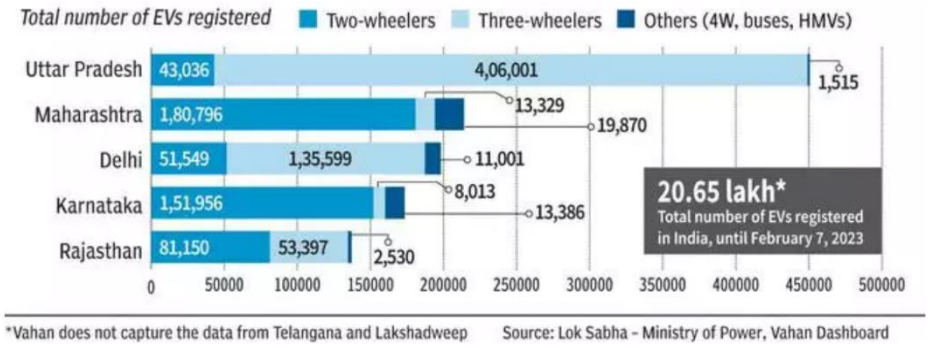
The study of National Policy alone cannot provide the whole picture of the progression of EVs and EVCI in India. The State EV Policies also required to be looked into, for a comprehensive insight into the state of CI. Formation of State Policies has resulted in a better CI availability in the states, which in turn, resulted in an increased sale of EVs. Delhi showed the highest EV growth rate, with 1.12 lakh EVs having been sold under Delhi Electric Vehicles Policy. The growth in EVs corresponded with the development of CI in the states. As seen in Figure 6, UP, Maharashtra, Delhi, Karnataka and Rajasthan are the top performers in the EV sector, and an analysis of their EV policy (see Table 4 and Table 6) in the context of aforementioned parameters shows the states' commitment to building a rich CI has been successful in increasing the EV insertion in these states.

Figure 5.

Top 5 states in EV Sales in India, with total number of EVs registered till February 2023.

Source: Parliamentary Questions answered in Lok Sabha, Ministry of Power and Vahan

(Vahan does not capture the data from Telangana and Lakshadweep)



One more critical element of the EVCI policies is the tariff levied on the CI operators for charging. A table listing the charges levied by the different states on EV charging is presented below for a comparative analysis (Table 5). Electricity is a concurrent subject in the Constitution, but the state governments have the responsibility of electric distribution (Ministry of Power, accessed March 2022). There is no standard rate of tariff for EV Charging and this has resulted in differing tariffs being issued across the states. Moreover, due to the lack of specific guidelines pertaining to Energy charges and demand charges in the National Policy, states have formulated their own rates for the two charges. There is no uniformity in the charges and this might impact the consumers' uptake of EVs.

Table 6.

State-Wise EV Tariffs

Source: Tariff Orders of respective states for the year 2021-2022 and 2022-2023

State	Issuing Agency	EV Tariff (Energy Charge)	EV Tariff (Demand Charge)
Assam	AERC	₹5.90 /KWh	Nil
Bihar	BERC	₹9.16./kVAh	Nil
Delhi	DERC	₹ 4.5/kWh and ₹ 4.0/ kVAh	Nil
Haryana	HERC	₹ 5.58 to ₹ 6.2/kVAh	₹ 100/kW per month
Karnataka	KERC	₹ 5.00/kWh	₹ 60/kW per month & ₹ 190/ kVA per month
Maharashtra	MERC	₹ 5.06/kWh	₹ 70/kVA/ Month
Rajasthan	RERC	₹ 6.00/kWh	nil
Telangana	TSERC	₹ 6.00/kWh	Nil
Tamil Nadu	TNERC	₹8.00/kWh to ₹12/kWh	₹550/ kVA per month
Uttar Pradesh	UPERC	₹ 5.9 to ₹ 7.7/ kWh	Nil

A comparative analysis of the State's EV CI Policies is summarised in Table 6. Across the specified parameters, the states of Haryana, Delhi, Maharashtra, Telangana, and Uttar Pradesh have the most comprehensive EV infrastructure policies, according to the assessment carried out in this study. However, none of the states have a clear target for year wise installation of CI. In such a scenario, it is not possible to conduct a target based comparison of CI for EVs for the states.

Table 7.

Comparison of States' EV Charging Infrastructure Policies

State	Year of Introducing EV Policy	Financial Incentives on CI (Yes/No)	Different Provisions for Domestic and Public CS (Yes/No)	Charging Methods Supported by Policy (Slow/Fast Chargers)	Specific 2-Wheeler CI
Assam	2021	Yes	Yes	Not mentioned	No
Bihar	2019	Yes	No	Both	No
Delhi	2020	Yes	Yes	Both	Yes
Haryana	2022	Yes	Yes	Both	Yes
Karnataka	2017	Yes	No	Both	No
Maharashtra	2021	Yes	Yes	Not mentioned	Yes
Rajasthan	2022	Yes	Yes	Not mentioned	No
Telangana	2020	Yes	Yes	Both	Yes
Tamil Nadu	2023	Yes	Yes	Both	No
Uttar Pradesh	2022	Yes	Yes	Both	No

Another important aspect of the CI is the charger type/technology available at the charging station. The Union Government's EVCI guidelines categorically states that "A PCS

shall have any one or more chargers, or any combination of chargers…" thus providing CI installers the freedom to install chargers discriminately. However, different segments of the EVs have different charging requirements. A combo AC/DC connector is technically suitable for the LEV to support the charging of vehicles with an onboard charger, which is common among LEVs (Rubino et al., 2017; Khalid et al., 2019). The AC part of the connector is used by the portable AC EVSE to charge from the AC LEV network. The DC part of the connector is used for fast-charging use cases from the Fast-Charging DC LEV network. Today, the CCS2 connector, which is the de facto standard in Europe (Kohler et al., 2022), is compatible for both AC and DC-Fast charging of 4-wheeler electric vehicles. The same standard will not be practically feasible for light electric vehicles (two and three-wheeler electric vehicles) due to the large form factor and cost of the CCS coupler.

4. FINDINGS:

The Indian government has framed a comprehensive policy for the development of a long-term CI across the nation that can provide a quick and efficient mechanism of charging for EV users and fasten the process of EV mobility adoption. While states have followed suit and implemented EV policies of their own, there is much work to be done still to make India an E-mobility nation.

The findings of the research are listed below:

- There are currently 6,586 operational public charging stations in India (till 21 March, 2023) with 2,877 charging stations being sanctioned under the FAME-II scheme which surpasses the FAME -II goal of setting up 2636 EV charging stations by 2023. In this regard, the national policy has been highly successful. In contrast, a large percentage of contracts for the installation of these charging stations were awarded to Public Sector Undertakings (PSUs) or other government organisations. It was permitted for PSU and government organisations to submit their proposals directly to DHI. However, private companies were required to register their applications through Urban Local Bodies (ULB), creating yet another obstacle for them (Rather et al., 2022).
- Setting up of Charging stations has become easier under FAME-II as it does not require a licence under Electricity Act, 2003. This has bolstered the CI environment of India.
- Formation of State Policies has resulted in an increased sale of EVs. Delhi showed the highest EV growth rate, with 1.12 lakh EVs having been sold under Delhi Electric Vehicles Policy.
- The CI provisions mandated by the national EV policy as well as the state policies do not provide separate guidelines for the 2 Wheeler EVs, even though 2Wh EVs accounted for around 55% of the annual EV sales in 2022.

- The State Policies do not specify the standards for electrical connections for home based EV chargers.
- Several States do not provide different guidelines for the private and public charging systems.
- State policies do not have a clear detail of the charging locations. Optimal locations of charging locations and nowhere mentioned in the policies and only a vague idea of locations is provided.
- Incentives for the setting up of CI are primarily financial in nature, in the form of subsidies in installation costs and tariffs. At present, the EV uptake by the users is largely dependent on the subsidies offered by the government. Financial incentives form the major part of the CI segment of EV policy introduced by the states, while other factors are not paid as much importance.
- The tariff rates for EV charging are not uniform across the states and the National Policy does not state any standard rate of EV charging. Many Indian states, including Gujarat, Haryana, Karnataka, and Maharashtra, have announced demand charges for electric vehicle (EV) charging stations. Electricity demand charges are fixed fees assessed to the charging station operator based on the connected capacity, regardless of the station's utilisation.
- Numerous State Electricity Regulatory Commissions have notified DISCOM of the separate EV tariff to be levied to EV CS operators. However, there are no guidelines regarding the upper limit on the charges that a CS operator could charge from the consumers.
- Each state has its own nodal agency for CI, and there is no inter-state coordinating body for facilitating charging systems.

- The combination of chargers in a Charging System according to battery capacity and requirements of different types of EVs is not defined in the EV policies. Taking into account the possible situation in which the same number of EVs with the same charging demand come up at both slow and fast charging stations, a slow charging station would be able to serve a fewer number of electric vehicles, which might result in the denial of service to EVs owing to a shortage of available chargers.
- EV Charging Systems are susceptible to Cyber attacks for which the state policies have no redressal mechanism.
- There is a lack of adequate charging infrastructure in the country because parameters set by State Policy are not in tandem with those set by the National Level Policy. The majority of the policies that are now in place only offer support between the years 2022 and 2026, and as a result, they are not in unison with the national target that aims until 2030.
- EV CI in India is still far away from the desired CI required to achieve 30% E-mobility by 2030. “The global ideal EV/public chargers ratio is also around 6-20 EVs per public charger, whereas, in India, it currently stands at an estimated 135,” stated a report by Alvarez and Marsal (2022).

5. DISCUSSION & POLICY RECOMMENDATIONS:

5.1 Discussion

Multiple stakeholders are involved in the development of charging infrastructure, including vehicle manufacturers, charging infrastructure providers, electricity distribution corporations, and local government agencies. Lack of coordination between these parties have delayed the establishment of charging infrastructure. The regulations regarding the installation of charging infrastructure are inadequately defined, resulting in ambiguity and uncertainty. In addition, there are very few state policies that have specified explicit objectives and incentives for electric vehicle charging infrastructure. The majority of state policies, on the other hand, do not have clear targets or incentives, nor do they have a plan of action to enhance electric vehicle adoption. There are just a few broad guidelines that define specific goals for charging infrastructure. This has rendered it challenging for investors to make informed investment decisions in charging infrastructure. The charging infrastructure subsidy that is offered under FAME II can presently only be accessed by government entities such as the government Oil Companies, CESL, etc., which have exceptionally extensive tender cycles and are only allowed to operate in government sites. This is made abundantly clear by the fact that the FAME budget for charging infrastructure is only partially utilised. Companies should be able to swiftly apply for and receive subsidies for public charging stations. This should be done in accordance with a method for automotive subsidies, which enables businesses to select a private host location, obtain an agreement, install a charger, and then claim the subsidy.

The factors underlying EV-specific tariffs also differ considerably from state to state. Some states have created a new category of PCS tariffs that is separate from existing consumer tariff categories. Other states have considered charging rates for charging electric vehicles under pre-existing consumer categories, such as non-domestic or non-commercial. The aforementioned categorization of EV tariffs impacts the industrial feasibility of EV charging

enterprises, as commercial electricity rates are substantially higher than residential or domestic rates. The imposition of electricity demand charges also makes it challenging for charging station operators to recover their expenses and serves as a deterrent. Last but not the least, the Light Electric Vehicles (also known as 2W and 3W) are anticipated to lead the EV revolution in India. India is distinct among large nations in its predominance of small EVs that consist of two- and three-wheeler EVs (Juyal et al., 2018). "The electric two-wheeler market in India has been growing rapidly, primarily driven by favourable government policies supporting the adoption of battery powered EVs," mentioned a report by the NITI Aayog on the status of EV Charging Infrastructure in India (Rathel et al., 2022). In order to make this transition easier, a charging infrastructure and connector that is tailored exclusively for light electric vehicles will need to be created.

5.2 Conclusion

Electric Vehicles have been gaining traction in India in recent years due to various reasons such as rising fuel prices, increased environmental consciousness, and government incentives to promote EV adoption. The Indian government's ambitious target to have only electric vehicles on Indian roads by 2030 has also contributed to the growth of the EV market. In addition, many automakers are now offering electric vehicle models in India, giving consumers more options to choose from. Despite the growth, however, the EV market share in India is still low compared to conventional vehicles, which highlights the need for more efforts to promote EVs and improve charging infrastructure in the country. Electric vehicle adoption has been associated with an adequate and optimal public charging infrastructure. While substantial advancement has been achieved in addressing the PCS deficiency in India, it is evident that the current pace will not be sufficient to meet the national goal of 30 percent EVs by 2030. Although direct fiscal incentives have the potential to be a powerful tool for making vehicle acquisition more affordable and increasing the appealing value of the product for the consumer,

it is clear that the amalgamation of regulatory reinforcement, assortment and model availability, and charging infrastructure will be the key to scaling up the industry (Roychowdhury et al., 2021). The conclusions drawn from the present study are as follows:

- The availability and accessibility of charging stations must be a standard one. It's important to make it easy for users to charge their devices both at home and on the go.
- Despite the fact that the major demand for EV charging is currently satisfied by home charging, public charging stations are required to provide the same level of convenience and accessibility as refuelling conventional vehicles (IEA 2023).
- Ambiguities in government policies regarding the CI are a major hindrance in creating an efficient charging network.
- A combination of supportive measures such as subsidies, encouraging homegrown EV production, standardisation of tariffs for CI, and an efficient regulatory framework will help to foster the development of the EV sector in India.
- Government policies need to focus on the fast charging requirements of the EVs in India and boost the installation of DC fast chargers. Currently, the policies allow the CI installers to set up any combination of the chargers incorporated in the guidelines issued by the Ministry of Power. The guidelines also allow for any other chargers approved by the BIS. But the state policies do not mention any type of charging connectors in their policy.

5.3 Policy Recommendations:

- The government should streamline the regulatory processes related to setting up charging infrastructure. This would help to reduce the ambiguity and uncertainty surrounding the regulatory environment and provide more clarity to private investors interested in investing in charging infrastructure.

- The government should develop a comprehensive regulatory framework. A well-defined regulatory framework that outlines the roles and responsibilities of various stakeholders is essential. This would include the development of technical standards, building codes, and permitting procedures for the installation of charging infrastructure.
- The use of renewable energy sources for charging infrastructure, such as solar and wind power, can help reduce the carbon footprint of electric vehicles. The government could offer incentives to promote the use of renewable energy for charging infrastructure.
- The government should establish a Nodal Agency that would operate at both the central and state levels, to ensure smooth flow of information and effective communication between all stakeholders.
- There should be a standardisation in the cost of electricity tariffs in the context of EV charging. Both central and state governments share power over the regulation and operation of the electricity sector (CEEW, 2019). The federal and the union government must act together and establish some standards for EV charging tariffs. The Bureau of Energy Efficiency should offer an ideal framework to the state administration to determine EV charging rates (Maheshwari and Nair, 2021b).
- It is also necessary for us to acknowledge that the rapid charging criteria and specifications for 2W and 4W charging alternatives are very different from one another. Because of this, there ought to be a variety of qualifying requirements for subsidies that are tailored to the various kinds of charging infrastructure.
- The EVCI Guidelines issued by the Ministry of Power (2022) should be amended to add two standards for the combo LEV AC/DC connector which are as followed -
    - Coupler standard based on IEC62196.
    - EVSE and communication standard for the coupler based on IEC61851.

- This addresses the combined AC/DC fast charging at considerably lower form-factor and cost compared to CCS, specifically targeted towards light electric vehicles (Bay et al., 2023). A combo AC/DC charging system for LEVs should be used as a standard. The salient features of this charger are that the charging connector and vehicle inlet proposed in this standard shall work with all the four Electric Vehicle (EV) charging modes (as defined by IEC 61851-1).
- In conclusion, the development of charging infrastructure in India has encountered a number of obstacles that must be overcome to promote the expansion of the electric vehicle market. Various stakeholders, including the government, private investors, and the general public, will need to collaborate to establish a favourable environment for the development of charging infrastructure.

5.4 Limitations

The present study is subject to several potential limitations. The research does not consider the aspects of EV Policies other than the provisions on Charging Infrastructure. Secondly, since the EV industry in India is still at an early stage, the understanding of its technical particulars is limited and therefore, the technical aspects of the CI have been kept outside the purview of this study. Additionally, the study does not include a detailed analysis of the financial aspects of the EV charging infrastructure. Further, data provided on official websites is often not updated which can result in inclusion of incorrect or outdated data in the study.

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