Acronyms

Acronym	Description
BESS	Battery Energy Storage System
BIS	Bureau of Indian Standards
BRP	Balance Responsible Party
CAGR	Compounded Annual Growth Rate
CCS	Combined Charging Standards
CEA	Central Electricity Authority
Chademo	CHArge de MOve
DER	Distributed Energy Resources
DHI	Department of Heavy Industries
DSO	Distribution System Operator
DST	Department of Science & Technology
DT	Distribution Transformer
ETD	Electro-technical Department
EU	European Union
EVCS	Electric Vehicle Charging Station
EVSE	Electric Vehicle Supply Equipment
FAME	Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles
GHG	Green House gases
GOI	Govt of India
GPS	Global Positioning System
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
ISO	Independent System Operator

Acronym	Description
ISO	International Organization for Standardization
IT	Information Technology
kWh	Kilo-watt hour
LCV	Light Commercial Vehicle
MoHUA	Ministry of Housing and Urban Affairs
MOP	Ministry of Power
MVA	Mega Volt Amperes
OCPP	Open Charge Point Protocol
OEM	Original Equipment Manufacturer
OLTC	On-Load Tap Changer
OpenADR	Open Automated Demand Response
OVGIP	Open Vehicle-Grid Integration Platform
PCS	Public Charging Station
PM	Particulate Matter
PPP	Public Private Partnership
RE	Renewable Energy
RMI	Rocky Mountain Institute
RTO	Regional Transmission Organization
SAE	Society of Automotive Engineers
SEPA	Smart Electric Power Alliance
SOC	State Of Charge
STATCOM	Static Compensator
TOU	Time of Use
VGI	Vehicle Grid Integration

Executive Summary

India has one of the most rapidly growing automobile markets in the world and in the last one decade, it has witnessed an annual growth of 16% in the vehicle registration, resulting mainly due to high population growth rate combined with the rapid urbanization. The rapid motorization also has its consequences in terms of increased air pollution in the country. According to the World Health Organization (WHO), transportation accounts for about 11% of India's carbon emissions and is a major source of pollution in several cities nationwide. The rapidly growing automobile market is having irreversible dependency on the petroleum products, accounting for 98% and 70% of total petrol and diesel consumption respectively. India ranks third in the world for crude oil imports, both in terms of volume and value, to meet more than 80% of its oil requirements. According to PPAC, India spent USD 111.9 billion on oil imports in 2018-19, almost double since 2015-16. The high import bills, crude oil price fluctuations and other variability factors in the international market poses challenges to India's long term fuel security. The Indian government is focusing on various measures including increasing domestic production, promoting the use of alternate fuel options, energy conservation measures, technology advancement to reduce dependence on imported crude oil. India is also committed to reduce its carbon footprint and introducing Electric Vehicles (EVs) into the countries fleet is another step to meet these commitments. The transition towards EVs is one of the most promising pathways to increase energy security, reduce oil imports, improved air quality and lower the carbon emissions.

Electric Vehicle Market and Policy landscape in India

As per the Deloitte study, there is forecast of battery electric vehicles (BEVs), accounting for a substantial 70% of global sales in the EV market by 2030[1]. In India, the projected sales figures for four wheelers EV segment is likely to reach around 4.77 million by 2030 . To achieve such growth, India's policy landscape for the EV segment has evolved over the years from providing financial incentives to a more comprehensive national EV target roadmap. In 2013, the National Electric Mobility Mission Plan (NEMMP) was unveiled to develop the roadmap outlining incentives along four priority viz. demand incentives, manufacturing, charging infrastructure development and research & development for EVs. As per an assessment by the Department of Heavy Industries, INR 6000 crore of investment would be required for setting up the EV power and charging infrastructure up to 2020. NEMMP has also launched and implementation of the Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles (FAME) scheme. In 2017, the Indian government released its policy document on "Transformative mobility for All" with a vision for the future of India's mobility system, wherein the third phase (2024-32) envisages full scale expansion along with the introduction of regulatory mechanisms to capture full grid value of EVs. To achieve these roadmaps, challenges faced by distribution utilities in provisioning and managing access to EV charging infrastructure for the end consumers' needs to be addressed. The key challenges include the technical aspects for necessary distribution system upgrades, analyze the impact on distribution transformer loading, degradation of network components, suitable locations for

[1] *Niti Aayog, May 2017, "India Leaps Ahead: Transformative Mobility for All"*

setting charging stations and optimization of distribution network, etc. Commercial challenges which include medium to long term planning for network upgrades, modes of financing and recovery, setting up of pricing mechanisms for EV charging, and provisions of incentive mechanisms for setting up of charging stations should also be a focus area.

In order to analyze the issues that India must address to introduce Electric Vehicles (EVs) into the countries fleet, the aim of this white paper is to help remove bottlenecks related to availability and development of EV charging infrastructure by distribution utilities. A network analysis was undertaken, in partnership with a Delhi based utility, to analyse the impact of EV charging at various penetration levels, recommend a priortiziation framework for rolling out charging stations, and analyse whether managed charging could be a possible way out to decongest the network, in some scenarios. The findings and recommendations of the White Paper shall help distribution utilities in developing a plan and implementation model for EV charging infrastructure, covering aspects such as flexibility, security, integrity, and economics. The White Paper also delves into analysing successful case studies and implementations in developed markets and recommend key lessons for policymakers, regulators and technology service providers, which are essential for future roadmap of EV adoption.

Summary of recommendations and roadmap

The white paper delves into the various enablers to influence increased adoption of charging infrastructure. Understanding these enablers is important in understanding the role that a particular regulator/government/utility can play in encouraging the deployment of EV charging infrastructure. Based on international benchmarking and findings of the analysis done, phase-wise roadmap has been proposed which are classified as below

- **Near term priority (1-3 years):** The near-term priorities can be tackled immediately or over the next 1-3 years through quick policy/regulatory measures and accelerated ongoing efforts.
- **Medium term priority (4-7 years):** The medium-term priorities identified are crucial and would play a pivotal role establishing a developed EVSE ecosystem. However, these would require considerable support and substantial policy, technology and/or infrastructure changes and stakeholder buy in.
- **Long term priority (after 7 years):** These are complex initiatives requiring significant expertise to be built-up over a long period of time. Owing to the level of complexity, these long-term initiatives require transformational structural changes in policies, skill development, regulations, etc.

Recommendations and Roadmap

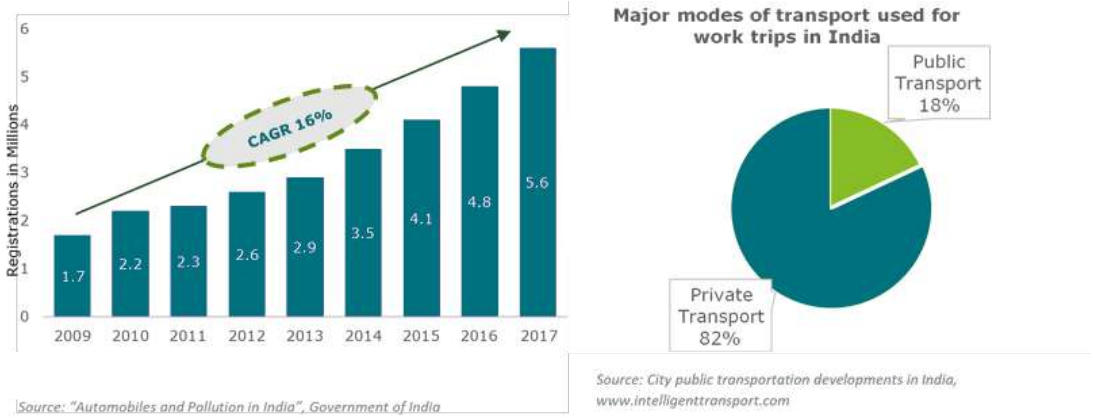
1. Introduction

1.1 Background and Context

India has one of the most rapidly growing automobile markets in the world and has witnessed an annual growth of 16% in the vehicle registration for the past decade. At current level, nearly 50,000 new motor vehicles (2-, 3-, and 4-wheelers) get registered every day. A key reason for the exponential growth in motor vehicles is high population growth rate combined with rapid urbanization. As per the World Bank, urban population accounted for 34.03% of the total population of India in 2018, an increase of 17% i.e., 69.2 million people, over 2011 levels. The slow pace of development in the public transport infrastructure has further led to heavy reliance on private transport. A recent study found that public transport has just 18.1%[2] share in work trips undertaken in the city with the rest being private.

The rapid motorization has its consequences in terms of increased air pollution in the country. Currently, fifteen of the top 20 most polluted cities in the world are in India and the transportation sector accounts for roughly approximately 20 to 30%[3] of fine Particulate matter (PM2.5) emissions in Indian cities. India is the fourth highest emitter of carbon dioxide in the world, as per a study by the Global Carbon

Figure 1: Vehicle registration in India and major transport mode



Source: "Automobiles and Pollution in India", Government of India

Source: City public transportation developments in India, www.intelligenttransport.com

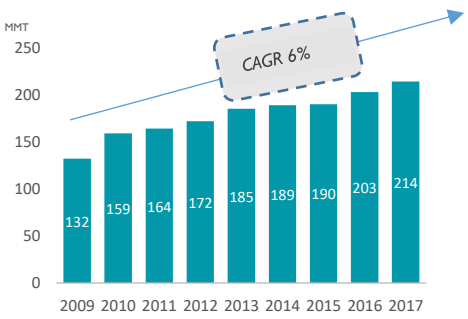
15 of the world's 20 most polluted cities are in India

-Rankings by IQAir and Greenpeace

project, which also accounted for 7% of global greenhouse gas (GHG) emissions in 2017. The transport sector contributes around 10% of these GHG emissions, while road transport accounts for 88% of transport GHGs.

Transport sector is the largest consumer of petroleum products, accounting for 98% of the total petrol consumption and 70% of total diesel consumption. India currently relies

Figure 2: India's Oil imports (FY 2009- FY 2017)



Source: MOPNG's Petroleum Planning and Analysis Cell (PPAC)

[2] Jaspal Singh, December 2016, "City public transportation developments in India", IntelligentTransport.com, https://www.intelligenttransport.com/transport-articles/21458/city-public-transportation-india/ (Accessed: August 2019)

[3] http://www.urbanemissions.info/wp-content/uploads/apna/docs/2019-07-APnA30city_summary_report.pdf

on imports to meet more than 80% of its oil needs. It ranks third in the world for crude oil imports both in terms of volume as well as value. Its oil imports account for USD 91.43 billion, constituting 27% of its total spending on imports in 2017. The fluctuations in prices of crude oil and its availability in international markets pose challenges to India's long term energy security. Reducing the dependence on imported fuel and increasing the use of alternate fuel options can reduce India's vulnerability to fluctuations in global oil prices.

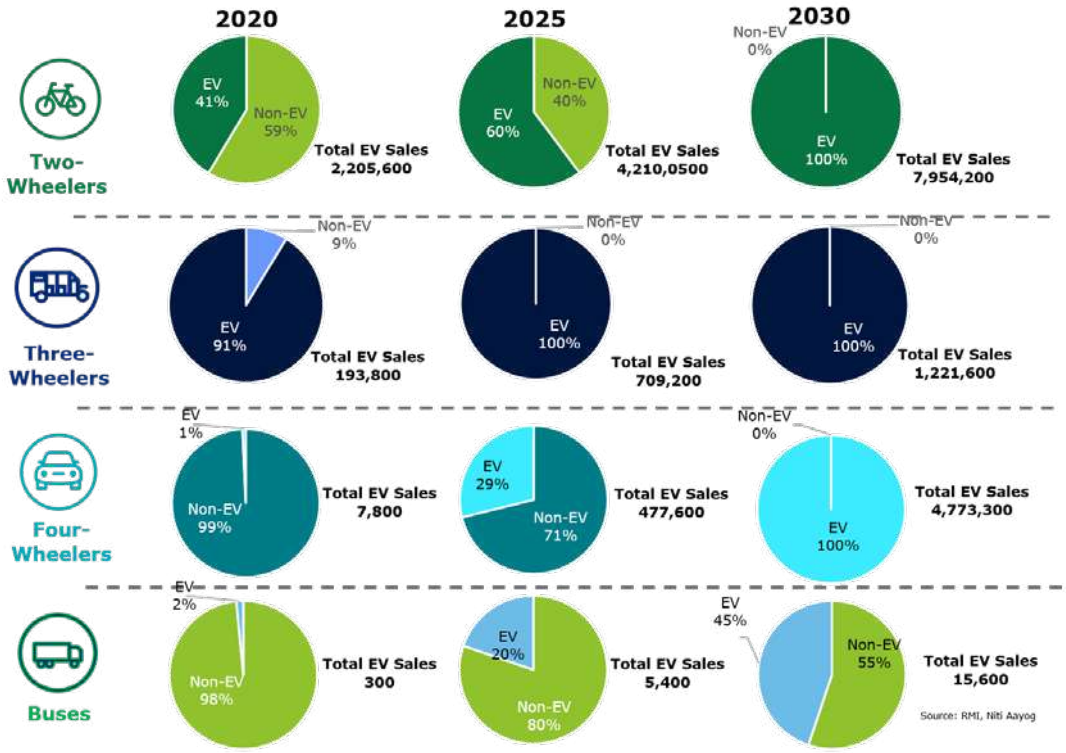
India has clearly articulated its commitment to reducing GHG emissions. At the Conference of the Parties 21 (COP21), India pledged to reduce its carbon footprint by 30-35% in 2031 from the 2005 levels. The use of electric vehicles (EVs) can be a viable option for meeting these commitments, while reducing India's dependence on imported fuel. The transition towards EVs is one of the most promising pathways to simultaneously increase energy security, reduce oil imports, lower GHG emissions, and improve air quality.

Globally, EVs have emerged as the leading option for alternative transportation in the light duty automobile sector, with China leading the pace of adoption, followed by United States.

1.2 Electric Vehicle Market in India

The Government of India has identified electric mobility as one of the key focus areas for development. Sales of EVs are projected to reach around 10.5 million for the four-wheeler segment by 2030 as per NITI Aayog and RMI. Projected sales of various EV vehicles in India for 2020, 2025 and 2030 are shown in Figure 3 below:

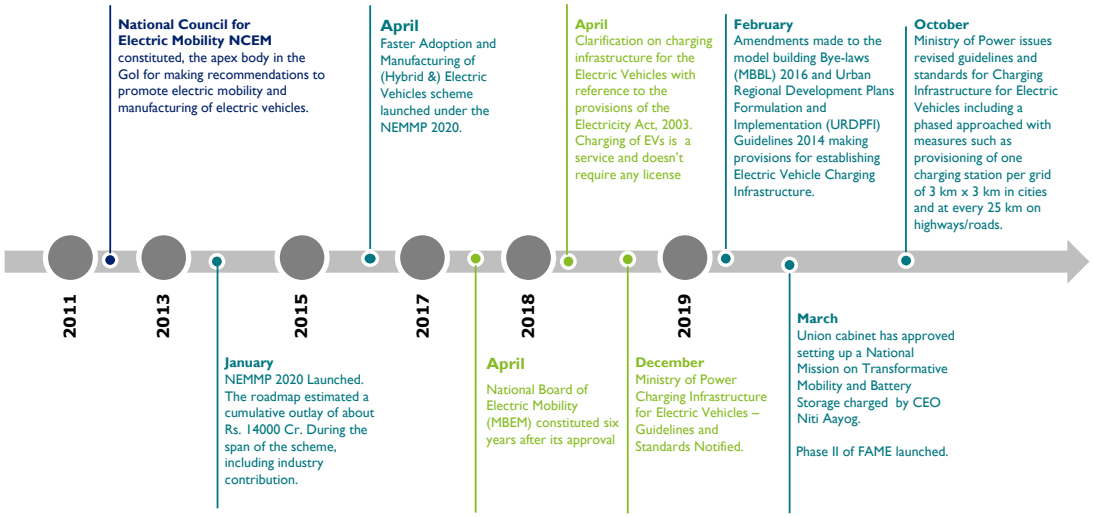
Figure 3: EV sales projections till 2030



Source: 1) Niti Aayog, April 2019, "India Electric Mobility Transformation", 2) GTG-RISE Analysis

The policy landscape for EVs in India has evolved over the years from the initial stage where the focus was on providing financial incentives for EV purchase, to a more rollout of more comprehensive policies with national level EV targets. The following figure shows the timeline of various policy and regulatory interventions:

Figure 4: Policy Roadmap for Electric Vehicles (EVs) Charging Infrastructure in India



Source: DHI, MoP, MoHUA, Niti Aayog

The National Electric Mobility Mission Plan (NEMMP) was unveiled in 2013 and provides for the development of a mission plan and roadmap for promoting electric mobility solutions in India. NEMPP outlines incentives along four priority areas for EVs: demand incentives, manufacturing of EVs, charging infrastructure development and research & development. In terms of the assessment made by the joint Government-Industry study, the total investment needed for setting up the required infrastructure up to 2020 (both power and charging infrastructure), vehicle segment wise, is summarized in following table.

Table 1: Assessment of segment wise investment requirement for EV infrastructure

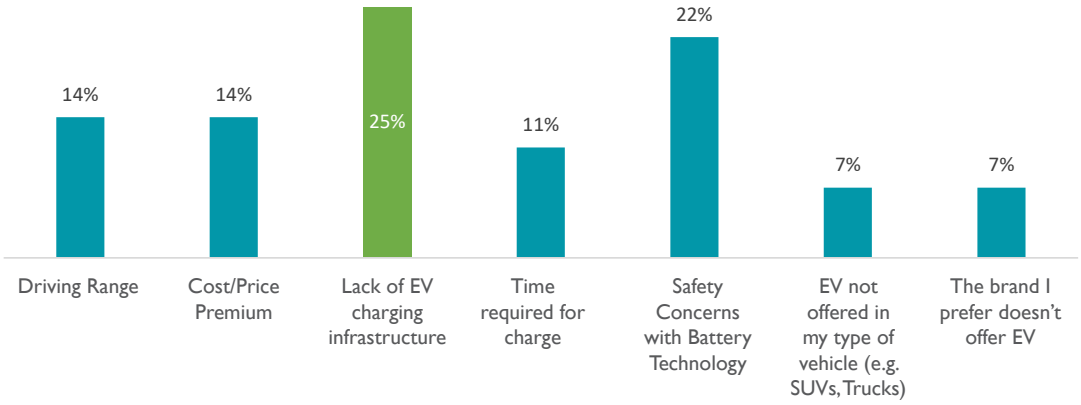
Area	4W	2W	3W	Buses	LCV	Total
Additional generation Capacity (MW)	150-225	600	10-15	<5	10-20	775-865
Power Infrastructure (Rs Crore)	1,200-1,300	3,300-3,400	75-85	20-30	90-100	4,685-4,915
Charging Infrastructure (Rs Crore)	950-1000	-	70-80	10-20	115-125	1,145-1,225

Source: Department of Heavy Industries. 2013. "National Electric Mobility Mission Plan 2020"

The Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles (FAME) programme was launched by DHI in 2015. It is the flagship scheme under the NEMMP 2020 mission plan of the Government of India (GOI) to enhance hybrid and electric technologies in India. The overall scheme is proposed till FY 2020 to support market development for EVs. Phase I of the scheme has been implemented over a two-year period starting from FY 2015-16. GOI has released its policy document on "Transformative mobility for All" in 2017 with a vision for the future of India's mobility system. Spread over three phases (I 2017-19, II 2020-23, III 2024-32), the plan entails taking near-term actions to build political and market confidence, followed by phase two which involves refining regulatory incentives and policy measures, and continued expansion of the charging network and scaling up domestic manufacturing. In phase three, market forces are expected to drive full scale expansion to meet e-mobility demand (electric vehicles, charging infrastructure, etc.) internationally, along with the introduction of regulatory mechanisms to capture full grid value of EVs.

As per Deloitte's Global Automotive Consumer Survey of 2018, the most common consumer concern preventing EV adoption in India is the lack of electric charging infrastructure.

Figure 5: Customer Concerns Regarding EV Ecosystem in India



Source: Deloitte. "New Market. New Entrants. New Challenges. Battery Electric Vehicles" 2018.

A well-established charging network may increase EV adoption, relieve range anxiety of consumers, and reduce the inconveniences associated with charging (which also serves to increase EV adoption). However, there are many challenges which need to be overcome and analyzed to ensure adequate EV penetration.

A fundamental question to be resolved is who will be responsible for developing the charging infrastructure. In the US, there is disagreement about the role of utilities in financing, owning and operating EV charging infrastructure[4]. In India, it is envisioned that the government will develop EV charging infrastructure, putting the distribution utilities (largely public entities) front and center in the process.

[4] *Source: The future of transportation electrification: Utility, Industry and Consumer Perspectives, Lawrence Berkeley National Laboratory, 2018.*

Distribution utilities face critical challenges in provisioning and managing access to EV charging infrastructure for consumers. A key challenge is the identification of necessary distribution system upgrades to support EV charging stations along with its associated costs and cost recovery mechanisms. Distribution utilities need to analyze the impact of EV charging on the distribution network (e.g., distribution transformer loading, increased ohmic losses and accelerated degradation of network components), and identify appropriate locations of EV charging stations to support EV charging while minimizing physical network impacts.

Commercial challenges include incorporating EVs in medium and long term network and resource planning, financing the charging infrastructure, setting up of pricing mechanisms for EV charging to ensure cost recovery, and creating incentives to encourage adoption of EVs and the use of charging infrastructure.

1.3 Structure of the Whitepaper

The whitepaper focuses on key issues related to availability and development of EV charging infrastructure by distribution utilities. Using examples from international experiences, the whitepaper also brings out key solutions to the challenges posed by development of EV charging infrastructure and its integration in the utility network. The whitepaper is intended to provide utilities with a framework for approaching the challenges associated with EV charging infrastructure.

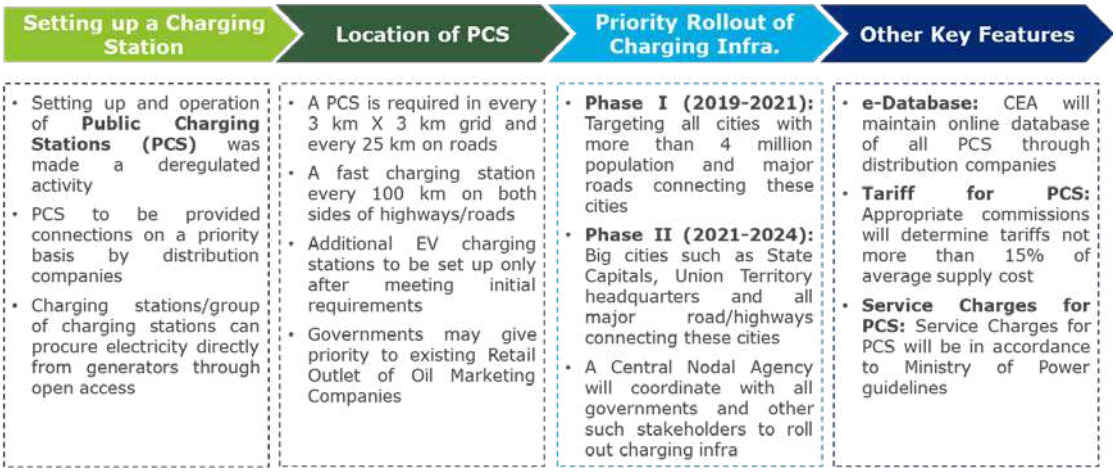
- Chapter 1 includes the context for this whitepaper.
- Chapter 2 provides the Indian context of standards and guidelines for charging infrastructure, technical and commercial aspects of EV charging and various pilots initiated across the country.
- Chapter 3 provides an extensive review of international experience in addressing challenges of EVSE integration with the help of case studies on how utilities around the world have tacked these challenges.
- Chapter 4 provides detailed analysis of the study carried out for BSES Rajdhani Power Limited (BRPL) in India. Using future scenarios, the study provides insight into the requirement of network capacity augmentation to integrate EVSE. The analysis helps understand the challenges that utilities must address going forward as they prepare for large scale adoption of EVs.
- Chapter 5 provides a gap analysis for the development of EV charging infrastructure in India and lays down key regulatory, policy and technology enablers for widespread adoption of the same. The chapter concludes with recommendations and a suggested roadmap to support integration of EV charging infrastructure.

2. EV Charging Infrastructure in India

2.1 Standards and Guidelines for Charging Infrastructure

The Ministry of Power (MOP), Government of India released the guidelines on EV charging infrastructure on December 14, 2018, which addresses the need for adequate availability of charging stations. These guidelines were subsequently revised and updated on October 1, 2019. The guidelines and standards aim to enable faster adoption of EVs in India by ensuring safe, reliable, accessible, and affordable charging infrastructure along with affordable tariffs, creating standard guidelines for EV charging businesses, and encouraging utilities and other parties to be prepared for EV adoption. Key provisions are highlighted in figure below:

Figure 6: Key provisions for development of EV charging infrastructure



Source: Ministry of Power, 2018, "Charging Infrastructure for Electric Vehicles – Guidelines and Standards"

The Ministry of Power issued a clarification on EV charging in April, 2019, namely that charging of an EV battery by a charging station is a service consisting of electricity consumption and hence should earn a revenue for this specific service. The value of the electricity is realized through a charging station operator, and hence is distinct from a typical sale of electricity. As such, EV charging does not fall under the purview of the Electricity Act of 2003 and is not subject to the other conditions of electricity retail distribution; this clarification has paved the way for participation of private players.

The minimum technical requirements for fast and slow charging stations in the guidelines are shown below.

Table 2: Guidelines for EV Charging Systems in India

Charger Type	Charger Connectors	Rated Voltage(V)	No. of charging Points/No of connector guns
Fast	CCS (min 50kW)	200-750 or higher	1 CG
	CHAdeMO (min 50kW)	200-750 or higher	1 CG
	Type-2 AC (min 22kW)	380-415	1 CG
Slow/Moderate	Bharat DC-001 (15kW)	48 72 or higher	1 CG
	Bharat AC-001(10kW)	230	3 CG of 3.3 kW each

Source: Ministry of Power, 2019, "Charging Infrastructure for Electric Vehicles – Revised Guidelines and Standards"

Other requirements are specified below:

- An exclusive transformer and related substation equipment, 33/11 kV lines, appropriate civil works, space for charging and entry / exit of vehicles, etc.
- Charging stations are required to tie up with at least one online Network Service Provider (NSP) to enable advance remote/online booking of charging slots by EV owners.
- EVSE shall be type tested by an agency/lab accredited by the National Accreditation Board for Testing and Calibration Laboratories (NABL) periodically.

The guidelines do not specify load flow studies or other forms of analysis for locating PCSs. However the guidelines provide a rule of thumb: one PCS on a grid of 3km x 3 km, one fast charging station every 100 km on highways, which can serve as a framework for discoms in identifying necessary network upgrades.

Following is a review of international charging standards as prevalent in various select countries:-

Table 3: International Charging Standards in Select Countries

	Conventional	Slow		Fast		
Level	Level 1	Level 2		Level 3		
Current	AC	AC		AC, tri-phase	DC	
Power	<= 3.7 kW	<=22 kW	<=22 kW	<=43.5 kW	< 200 kW	
US	SAE J1772	SAE J1772	Tesla	SAE J3068	CCS Combo 1 / Chademo	
China	Type 1	GB/T 20234 AC	Tesla		GB/T 20234 DC	
Germany	Type C/F/G	IEC 62196-2 Type 2 Tesla	IEC 62196-2 Type 2	CCS Combo 2 (IEC 62196-3) 62196-3)	CCS Combo 2 (IEC 62196-3) 62196-3)	Tesla and CHAdeMO (IEC 62196-3 Type 4)

The Ministry of Housing and Urban Affairs introduced the Model Building Bye-Laws for EV charging infrastructure in February, 2019. Key provisions are highlighted below:

Table 4: Amendments to Model Building Bye-Laws , MoHUA

Particulars	Details
Parking bays for EV charging	Residential and commercial buildings to allot about 20% of their parking space for EV charging infrastructure.
Power load for EV charging	Building premises should have additional power load equivalent to the power required for all charging points to be operated simultaneously with a safety factor of 1.25.

Particulars	Details			
	4W	3W	2W	PV (Buses)
No of slow and fast chargers	One slow charger for 3 EVs One fast charger for 10 EVs	One slow charger for 2 EVs	One slow charger for 2 EVs	One fast charger for 10 EVs

Source: Ministry of Housing and Urban Development(MoHUA), February 2019, "Amendments in Building Bye-Laws (MBBL-2016) for Electric Vehicle Charging Infrastructure"

Separate and independent consultative committees have been formed under the Automotive Research Association of India (ARAI), Central Electricity Authority (CEA) and ETD-51 (under BIS) which are evaluating charging and EV testing standards. The objective of these multiple committees is to help establish India's own EV charging standards. Key highlights of the report published by the Bureau of Energy Efficiency (BEE) are:

The Bureau of Indian Standards (BIS) and the Department of Science and Technology (DST) have been working on an indigenous charging standard for India. BIS has published BIS:17017[5] (derived from IEC 61851) which covers general requirements and safety for EVSE.. The standards recognize DHI supported Bharat Chargers (AC-001 and DC-001) for low voltage EVs (less than 120 V). For higher voltage levels, the standard supports CCS-2 and CHAdeMO. Recent amendments in the charging guidelines allow any AC or DC charger that complies with Standards AIS 138 – 1, and AIS 138 – 2 respectively. So, it is expected that CHAdeMO, CCS-2, Type 2 AC and the Bharat Chargers will all co-exist in India.

There are additional two different working groups in BIS to decide on connectors and communication protocols, which will be important from an interoperability perspective. Until working groups have identified these protocols, the existing charging standards (Bharat Chargers, CCS-2 and CHAdeMO) and their references to connectors and communication protocols will be followed.

Based on stakeholder consultations conducted by BEE, the following specifications for charging options were identified:

Table 5: Charging options

Type	Standard	Power level (kW)	Typical charging time			
			2W	3W	4W	Bus
			1.25 kWh	3 kWh	15 kWh	100 kWh
Slow AC	Bharat Charger AC-001	3.3	1-5 hour	1-5 hour	5-8 hour	NA
Fast AC	Type-2 AC	Min 22	NA	NA	~35 min	NA

[5] *https://www.standardsbis.in/Gemini/search/Browse.action?saleModeName=SOFT_COPY&subDivisionId=406#*

Type	Standard	Power level (kW)	Typical charging time			
			2W	3W	4W	Bus
			1.25 kWh	3 kWh	15 kWh	100 kWh
Fast AC	Type-2 AC	Min 22	NA	NA	~35 min	NA
Slow DC	Bharat Charger DC-001	15	0,5-1 hour	~45 mins	~50 min	NA
Fast DC	CCS-2/ CHAdeMO	Min 50	NA	NA	~15 min	
High Power Fast DC	CCS-2/ CHAdeMO	Min 100	NA	NA	NA	

Source: Bureau of Energy Efficiency

2.2 Technical and Commercial aspects of EV Charging

Figure 7: Charging connector used in e-rickshaws

To cater to the large demand of electric 2-wheeler and 3-wheelers (EV2W and EV3W), which form the majority of EVs currently on the road, India has adopted the Bharat EV Charger AC-001 and Bharat EV Charger DC-001 standards. Both charger types cater to the low voltage requirements for EV2Ws and EV3Ws (battery voltage less than 100 V). Bharat Charger AC-001 can charge three different vehicles simultaneously and provides an output of single-phase AC at 230 V and 15 Amps (A). The charge rate for the vehicle is limited to 3.3 kW at each of the three connections. Bharat DC-001 has an output of 72-200 V with a maximum current of 200 A (i.e., 15 kW). MOP has set the following minimum requirements for PCSs in India:

Table 6: Guidelines for EV Charging Systems in India

Charger Type	Charger Connectors	Rated Voltage(V)	No. of charging Points/No of connector guns
Fast	CCS (min 50kW)	200-1000	1/1 CG
	CHAdeMO (min 50kW)	200-1000	1/1 CG
	Type-2 AC (min 22kW)	380-480	1/1 CG
Slow/ Moderate	Bharat DC-001 (15kW)	72-200	1/1 CG
	Bharat AC-001(10kW)	230	3/3 CG of 3.3 kW each

Source: Ministry of Power, 2018, "Charging Infrastructure for Electric Vehicles – Guidelines and Standards"

The following table provides the charger specifications for Bharat EV AC (AC-001) and DC (DC-001) standards:

Table 7: Bharat EV AC and DC charger specifications

Charger Type	Charger Connectors	Rated Voltage(V)
Input requirement		
AC supply system	Three phase, 5 wire AC system	Three phase, 5 wire AC system
Nominal Input voltage	415 V (range of +6% to -10%) as per IS 12360	3 phase, 415 V (range of +6% to -10%) as per IS 12360
Input frequency	50 Hz (tolerance of 1.5 Hz)	50 Hz (tolerance of 1.5 Hz)
Environmental requirements		
Ambient temperature range	0-55 degrees C	0-55 degrees C
Ambient humidity	5-95%	5-95%
Ambient pressure	86-106 kpa	86-106 kpa
Output requirement		
No of outputs	3	2
Type of each output	230 V (+6% to -10%) single phase, 15 A as per IS 12360A.C	Type 2: Single vehicle charging at 48 V with a maximum of 10 kW power of 60 V / 72 V with a maximum power of 15 kW or a 2W vehicle charging at 48 V with maximum 3.3 kW
Output current	Three vehicles charging simultaneously, each at 15 A	200 A Max
Limiting output current	16A	16 A
Converter efficiency	-	>92% at nominal output power.

Source: 1) Ministry of Power, 2018, "Charging Infrastructure for Electric Vehicles – Guidelines and Standards", 2) EESL

These standards have been included in the MOP guidelines released in December 2018 for charging infrastructure standards. While the Bharat standards cater to the EV2W and EV3W segment for slow charging, the MOP guidelines have also been specified for fast charging, which apply to CCS and CHAdeMO, and Type-2 AC chargers. This has been specified by keeping in mind the growth of E4W and international car brands being launched in India. It has also been clarified that any forthcoming new BIS standards will be applicable, whenever they are notified.

2.3 EV charging infrastructure pilots in India

Over the past few years, public and private entities have taken up pilot projects in installing EV charging stations. While large scale EV charging infrastructure pilot projects are still under the planning and implementation stages, there has been a steady increase in standalone charging station pilots. Some of these examples are shown below:

Table 8: Select EV charging station pilots across India (non-exhaustive list)

S No	City/ State	Implementing Agency	Detail
1	**Nagpur (Maharashtra)**	Nagpur Municipal Corporation	200 electric cars, buses, e-rickshaws, and four public charging stations launched as part of the 'Multi-Model Electric Vehicle Project' in 2017.
2	**Delhi**	Niti Ayog	55 locations shortlisted across Gurgaon-IGI-South Delhi-Noida Corridor for installing 135 EV charging stations (46 – DC Fast, 89 – AC Slow). Project is still under planning and implementation stage
3	**Mumbai (Maharashtra)**	Magenta Power	Installed DC Fast charging infrastructure in 2018 in Turbhe Mumbai and also launched an APP which provides consumers with location of chargers, status, and type.
4	**Jaipur (Rajasthan)**	MNIT Jaipur	Five charging stations installed at different locations in MNIT Jaipur under the FAME scheme in 2018.
5	**Hyderabad (Telangana)**	Telangana Municipal Corporation and Urban Development	The Municipal Corporation and Urban Development Corporation launched EV smart parking and charging station on 18, March 2019
6	**Kochi (Kerala)**	Bharat Petroleum	Installed 3 charging stations in Kochi. Charging station installed at least 6 meters away from fuel vending machine due to safety reasons. Both direct charging and battery swapping facilities are available.
7	**Kolkata (West Bengal)**	New Town Kolkata Development Authority (NKDA)	New Town Kolkata Development Authority (NKDA) has installed 10 public charging stations for e-scooters and e-cars. These have been installed near the Kolkata gate, Tata medical centre, and eco parking area gates in 2018.
8	**Bengaluru (Karnataka)**	BESCOM	BESCOM has installed a total of 5 no. of charging at different locations across the city.
9	**Vishakhapatnam (Andhra Pradesh)**	NTPC	NTPC has installed a charging station at Simhadri which is capable of charging 3 numbers of EV simultaneously.
10	**Jammu & Kashmir**	J&KSRTC	J&K Road Transport Corporation is planning to commission six charging stations for supporting its fleet of 30 electric buses provided by TATA Motors.
11	**Guwahati (Assam)**	Assam Power Distribution Company Limited (APDCL)	APDCL has set up charging infrastructure for 15 e-buses procured under the FAME scheme

Source: GTG-RISE analysis

EESL has set up 60 power charging stations for electric vehicles in Delhi which is one of the largest public charging station programs in India. USAID, through its Smart Power for Advancing Reliability and Connectivity (SPARC) program, supported EESL in the roll out.

Though India is still at a nascent stage in terms of EV penetration, a range of policies, guidelines, and regulatory orders have been initiated to address some of these requirements. While a supportive framework is being put in place, utilities in India will have to prepare for meeting challenges in managing EVSE integration in distribution networks.