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On behalf of:

Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection

of the Federal Republic of Germany

In Cooperation with

NITI Aayog

REPORT 3

Electric Vehicle Charging Infrastructure and its Grid Integration in India

Status Quo, Critical Analysis and Way Forward

Integration of Electric Vehicles Charging Infrastructure with Distribution Grid: Global review, India's Gap Analysis and Way Forward

Led by IIT Bombay

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Acknowledgement

This publication has been prepared by Indian Institute of Technology Bombay (IIT Bombay) with funding from The Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ) on behalf of the German Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV), as a part of the Nationally Determined Contributions - Transport Initiative for Asia (NDC-TIA) initiative. The NDC-TIA is part of the International Climate Initiative (IKI). The Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV) supports the initiative on the basis of a decision adopted by the German Bundestag.

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FOREWORD

With the second-largest road network in the world, India's road transport contributes towards nearly 64% of the country's overall goods movement and caters to around 90% of India's total passenger traffic. This provides a huge opportunity to decarbonize the transport sector but there are also challenges. Government of India has taken proactive measures towards fostering a clean, connected, shared and cutting-edge transportation system by providing policy and regulatory support.

As India embarks on this ambitious journey towards sustainable mobility, a robust charging infrastructure will play a pivotal role. It must be understood that sector coupling between the energy and transport sectors is vital for e-mobility. With the growing number of EVs, the need for development of large network of charging infrastructure will only increase in the future. To support deployment of charging infrastructure in the country, the Government of India has allocated a total fund of INR 1000 Crore under the FAME II scheme. Under public procurement, Department of Heavy Industry (DHI) has sanctioned 2,636 EV Charging Stations, in 62 cities across 24 States/UTs and 1,544 such stations on highways under FAME II scheme. EV charging is a delicensed activity in India and the Ministry of Power (MoP) has published revised guidelines for Charging infrastructure for Electric Vehicles to facilitate the deployment of charging infrastructure. Apart from this, several states have announced targets for EV deployment including special EV tariff to incentivize EV charging in India. For the uptake of EV adoption in India, a major challenge of integrating the charging infrastructure with the electrical network needs to be tackled. The continued development of EV charging infrastructure and its integration will depend, among other things, on policy and regulatory environment, which must also account for grid stability.

I am glad to know that the Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ) has initiated a study focused on EV charging infrastructure, related policy and regulatory measures, grid integration of EVs, critical international review from eight countries, and way forward for smooth integration of EV charging infrastructure with the Indian grid.

I congratulate GIZ for the publication of this report.

(Amitabh Kant)

Place- New Delhi
Dated- July, 2021

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FOREWORD

At the COP21 conference in Paris in 2015, India targeted to reduce its carbon footprint for every dollar of economic output by 33 to 35% within 2030 from what it was in 2005. The transportation sector being one of the largest consumers of oil and gas and emitters of greenhouse gases globally, need to be addressed on a priority basis. Fuelled by reducing manufacturing and component prices of equipment and improving the affordability of personal vehicles, India has seen a rise in on-road automobiles. Naturally, the transportation sector in India is one of the largest consumers of crude oil and a significant source of GHG emissions, even from an international standpoint. In 2013, the National Electric Mobility Mission Plan (NEMMP) 2020 was envisioned with a vision and roadmap for faster adoption of hybrid and electric vehicles and boosting indigenous manufacturing to achieve national fuel security and mitigate the adverse environmental impacts of road transport vehicles. Government of India further brought out the ambitious Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) scheme to promote electric mobility in the country. The first phase of the scheme (FAME-I) began in 2015 and was extended till 2019, following which the second phase (FAME-2) began which has recently been extended till 2024. The initiatives being taken also have a broader plan to de-license the charging infrastructure business and mandate specific guidelines and standards for charging infrastructure for electric vehicles. This would further strengthen the market of public charging infrastructure and warrant a roadmap for the development of charging infrastructure. Although the Government has taken decisive steps towards faster adoption of EVs, several challenges and gaps are existing in the Indian EV ecosystem that needs to be addressed.

The Nationally Determined Contribution-Transport Initiative for Asia (NDC-TIA), a joint project of seven organisations, on behalf of the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) and with the engagement of China, India, and Vietnam is a welcome action. The project aims to promote a comprehensive strategy to decarbonising transport, i.e. a coherent system of effective policies coordinated among various sector ministries, civil society, and the private sector.

IIT Bombay is committed to playing a constructive role in achieving green and sustainable electrified transportation sector in the country. This specific study, "*Integration of Electric Vehicles Charging Infrastructure with Distribution Grid: Global review, India's Gap Analyses and Way Forward*", which is led by IIT Bombay, focuses on EV charging infrastructure, related policy and regulatory measures, grid integration of EVs, and the way forward for smooth EV adaption in the Indian EV ecosystem.

I would like to congratulate the authors, all the stakeholders involved, the reviewers, and the funding agencies contributing to the successful preparation of these reports.

(Subhasis Chaudhuri)

Date: 02.08.2021
Place: Mumbai

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Abbreviations

2W	Two wheeler
3W	Three wheeler
4W	Four wheeler
ACE	Area Control Error
ACoS	Average Cost of Supply
ADC	Analog to Digital Converter
ADMS	Advanced Distribution Management System
AENS	Average Energy Not Served
AFSTP	Alternate Fuels for Surface Transportation Program
AGC	Automatic Generation Control
AMP	Automotive Mission Plan
APERC	Andhra Pradesh Electricity Regulatory Commission
APPCB	Andhra Pradesh Pollution Control Board
ARAI	Automotive Research Association of India
ARM -	advanced RISE (reduced Instruction Set Computing) machine
ARR	Annual recurring revenue
ASMC	Automotive Suppliers Manufacturing Centers
BBMP	Bruhat Bengaluru Mahanagara Palike
BEB	Battery Electric Buses
BEV	Battery Electric Vehicle
BIS	Bureau of Indian Standards
BMRCL	Bangalore Metro Rail Corporation Limited
BMS	Battery Management System
BMTC	Bengaluru Metropolitan Transport Corporation
BRPL	BSES Rajdhani Power Limited
BRTS	Bus Rapid Transit System
BSF	Battery Swapping Facility
BSO	Battery Swapping Operator
BYPL	BSES Yamuna Power Limited
CAAR	Centre for Advanced automotive Research
CAIDI	Customer Average Interruption Duration Index
CAN	Controller Area Network
CASM	Center for Advancement of Smart Mobility
CBD	Central Business District
CCS	Combined Charging System
CEA	Central Electricity Authority
CERC	Central Electricity Regulatory Commission
CESC	Calcutta Electric Supply Company
CESL	Convergence Energy Services limited
CHAdeMO	CHArge de MOve
CLU	Change of Land Use
CPO	Charge Point Operator
CSP	Charging Service Provider
CT	Current Transformer
DCR	Development Control Rules
DER	Distributed Energy Resource
DGVCL	Dakshin Gujarat Vij Company Limited
DHI	Department of Heavy Industry
DISCOM	Distribution Company
DLIC	District Level Implementation Committee
DMRC	Delhi Metro Rail Corporation
DOD	Depth of Discharge
DoS	Denial-of-Service
DPIIT	Department for Promotion of Industry and Internal Trade
DSO	Distribution System Operator
DT	Distribution Transformer
DTC	Delhi Transport Corporation
DTL	Delhi Transco Limited
EDU	External Development Charges
EEPBD	EU Energy Performance of Buildings Directive

EESL	Energy Efficiency Services limited
ELCB	Earth-leakage circuit breaker
EM	Electromagnetic
EMD	Earnest Money Deposit
eMIP	e-mobility Interoperation Protocol
eMSP	e-mobility Service Provider
ENS	Energy Not Served
EO	Energy Operator
ESCOM	Electricity Supply Company
ESS	Energy Storage Solutions
ETP	Effluent Treatment Plants
EV	Electric Vehicle
EVCC	Electric Vehicle Communication Controller
EVSE	Electric Vehicle Supply Equipment
FAME	Faster Adoption and Manufacturing of (Hybrid and) Electric Vehicles
FCI	Fixed Capital Investment
GNCTD	Government of National Capital Territory of Delhi
GoAP	Government of Andhra Pradesh
GoMP	Government of Madhya Pradesh
HMI	Human Machine Interface
HPCL	Hindustan Petroleum Corporation Ltd
HT	High Tension
ICE	Internal Combustion Engine
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineer
IEMF	India E-Mobility Finance Facility
IGBT	Insulated-gate bipolar transistor
ILAC	International Laboratory Accreditation Corporation
IOCL	Indian Oil Corporation Limited
IP	Internet Protocol
IRENA	International Renewable Energy Agency
ISO	International Organisation for Standards
ITI	Industrial Training Institute
JBVNL	Jharkhand Bijli Vitran Nigam Limited
KSRTC	Karnataka State Road Transport Corporation
LDO	Low Dropout regulator
LIN	Local interconnected networks
LOM	Loss of Mains
LT	Low Tension
MaaS	Mobility as a Service
MCB	Miniature Circuit Breaker
MCU	Micro Controller Unit
MNRE	Ministry of New and Renewable Energy
MoEFCC	Ministry of Environment, Forest, and Climate change
MoF	Ministry of Finance
MoHIPE	Ministry of Heavy Industries and Public Enterprises
MoHUA	Ministry of Housing and Urban Affairs
MoP	Ministry of Power
MoRTH	Ministry of Road Transport and Highways
MOSFET	Metal–Oxide–Semiconductor Field-Effect Transistor
MoST	Ministry of Science and Technology
MPU	Micro Processor Unit
MSBTE	Maharashtra State Board of Technical Education
MSME	Ministry of Micro, Small & Medium Enterprises
MSSDS	Maharashtra State Skill Development Society
NAB	National Automotive Board
NABL	National Accreditation Board for Testing and Calibration Laboratories
NATRiP	National Automotive Testing and R&D Infrastructure Project
NBEM	National Board for Electric Mobility
NCEM	National Council for Electric Mobility
NCT of Delhi	National Capital Territory of Delhi
NDMC	New Delhi Municipal Council
NEKRTC	North Eastern Karnataka Road Transport Corporation
NEMMP	National Electric Mobility Mission Plan
NHAI	National Highways Authority of India
NITI	National Institution for Transforming India

NWKSRTC	North Western Karnataka Road Transport Corporation
OCHP	Open Clearing House Protocol
OCPI	Open Charge Point Interface Protocol
OCPP	Open Charge Point Protocol
OEM	Original Equipment Manufacturer
OICP	Open Interchange Protocol
OLEV	Online Electric Vehicle
Open ADR	Open Automated demand response
OSCP	Open Smart Charging Protocol
PCS	Public Charging Station
PHEV	Plugin Hybrid Electric Vehicle
PLC	Power Line Communication
PPP	Public–Private Partnership
PSPCL	Punjab State Power Corporation Limited
PSU	Public Sector Undertaking
PT	Potential Transformer
PWM	Pulse Width Modulation
R&D	Research and Development
RERC	Rajasthan Electricity Regulatory Commission
RFID	Radio-frequency identification
RoCoF	Rate of Change of Frequency
RSCL	Raipur Smart City Limited
RTO	Regional Transport Office
RWA	Residential Welfare Association
SAE	Society of Automotive Engineers
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SAVFI	System Average Voltage Fluctuation Index
SAVMVI	System Average Voltage Magnitude Violation Index
SAVUI	System Average Voltage Unbalance Index
SCADA	Supervisory Control And Data Acquisition
SCDOI	System Control Device Operation Index
SECC	Supply Equipment Communication Controller
SELI	System Energy Loss Index
SERC	State Electricity Regulatory Commission
SGST	State Goods and Services Tax
SIDCO	Small Industries Development Corporation
SIPCOT	State Industries Promotion Corporation of Tamil Nadu
SOC	State of Charge
SRPDI	System Reactive Power Demand Index
STU	State Transmission Utility
STU	State Transport Undertakings
SVNIT	Sardar Vallabhbhai National Institute of Technology
TANGEDCO	Tamil Nadu Generation and Distribution Corporation Limited
TCO	Total Cost of Ownership
TDD	Total Demand Distortion
TNERC	Tamil Nadu Electricity Regulatory Commission
TNSDC	Tamil Nadu Skill Development Corporation
TPDDL	Tata Power Delhi Distribution Limited
TSREDCO	Telangana State Renewable Energy Development Corporation Limited
TSRTC	Telangana State Road Transport Corporation
UDHD	Urban Development and Housing department
ULB	Urban Local Bodies
UT	Union Territory
VFA	Value of Fixed assets
VPP	Virtual Power Plant
WBSEDCL	West Bengal State Electricity Company
WBTC	West Bengal Transport Corporation
WPT	Wireless power transfer


Z.E.

01

Introduction

The global Electric Vehicle (EV) fleet is poised to increase exponentially in what has been dubbed the electric mobility revolution. The push for EVs is driven by the global climate agenda established under the Paris Agreement to reduce carbon emissions to limit global warming. Importantly, not only would a switch from combustion-engine vehicles to EVs lead to lower emissions leading to decreased local air pollution, but they would also significantly reduce the noise pollution in heavy traffic areas. In addition, the deployment of EVs is driven by national agendas to reduce oil demand and as such dependence on oil imports, as well as the encouragement of a local EV manufacturing industry for job creation. On the other hand, EVs through several grid support services are expected to strengthen the grid and help in accommodating higher renewable energy penetration while maintaining secure and stable grid operation.

The global electric mobility revolution is today defined by the rapid growth in electric vehicle (EV) uptake, with EV sales for the year 2020 reaching 3 million. The global EV fleet has reached 10 million by the end of 2020 with EVs accounting for approximately 1% of the global vehicle stock[1]. Further 6.5 million EVs were registered worldwide in 2021 alone[2], bringing the total EV stock globally close to 17 million till the end of 2021.

During recently concluded COP26 in Glasgow, India has made a commitment of 500 GW of generation capacity from non-fossil fuel-based sources by 2030, and of meeting 50% of the country's energy requirements using renewable energy resources[3]. India has also set target to achieve net zero emissions by 2070. To reduce carbon emission, besides ambitious targets of RE integration, India has set major goals to reduce emissions from the transportation sector through different policy and regulatory interventions for electrification of the Indian transportation sector.

In India, EVs currently represent a small share with approximately 10,00,495 vehicles by the end of January 2022 (0.52% of the total registered vehicles[4]). However, more than 30% of new vehicles expected to be electric vehicles by 2030. India by the end of January 2022, has over 283 million vehicles, dominated by 2-wheelers which

1 IEA, "Global EV Outlook 2021," 2021.

2 The Economic Times, "Global electric vehicle sales up 109% in 2021, Tesla leads with 14% share", February 2022, https://economictimes.indiatimes.com/industry/auto/auto-news/global-electric-vehicle-sales-up-109-in-2021-tesla-leads-with-14-share/articleshow/89590350.cms

3 CEEW, "COP-26: CEEW Unpacks India's 2070 Net-Zero Target and other Climate Mitigation Measures", https://www.ceew.in/news/cop-26-ceew-unpacks-indias-2070-net-zero-target-and-other-climate-mitigation-measures

4 VAHANSEWA, "DASHBOARD," Ministry of Road Transport & Highways, 2021, https://vahan.parivahan.gov.in/vahan4dashboard/vahan/view/reportview.xhtml.

account for 75% of the total vehicles registered4. Amongst the different vehicle segments, public buses, taxi fleets, 2-wheelers and three-wheelers are expected to be the first adopters of EVs. As of February 2022, close to 66% of all EVs sold in the country are e-3W, followed by e-2W which comprises about 30% of the Indian EV stock. The remaining 4% is e-4W and other heavy duty vehicles. Since the country is at an early stage of EV adoption, public charging infrastructure is still limited. A number of states have started introducing policies to promote EV adoption and charging infrastructure deployment, and as of March 2022, a total of seventeen states/UTs have notified their final EV policies, while five States/UTs have released draft EV policies. The rapid growth in EV uptake required to reach India's policy targets will have to address two major challenges. The first challenge is ensuring the deployment of the charging infrastructure required to serve the needs of the ever-growing number of EVs. The second challenge is the integration of the EVs into the power system securely and efficiently. The success of the EV revolution hinges primarily on the timely deployment of effective EV charging infrastructure. However, at the same time, EV adoption is the main driver for the business case of EV charging infrastructure. Policy and regulation, informed by a thorough understanding of the EV charging ecosystem, can offer solutions to this chicken-and-egg problem.

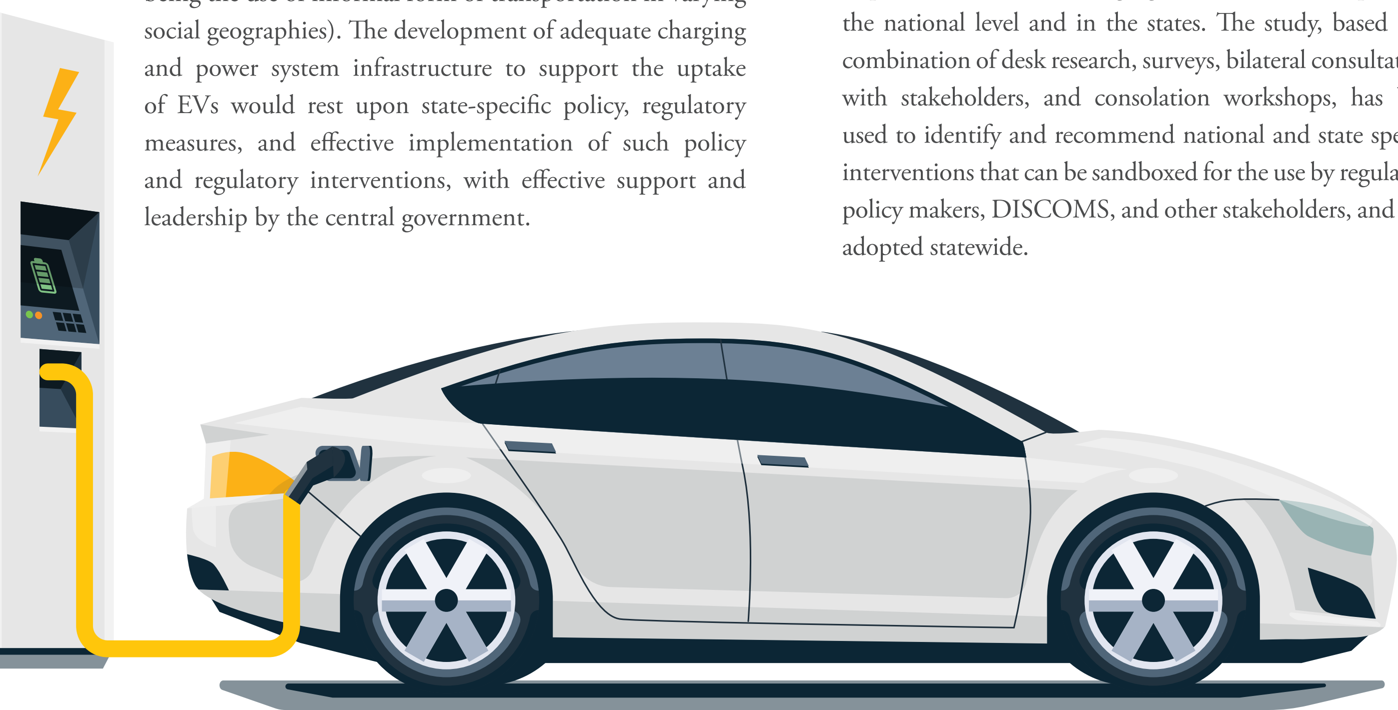
Although the e-mobility plan is developed at the central level, the onus is on the state governments, which have to develop and implement policies and regulatory frameworks to enable the adoption of EVs and deployment of charging infrastructure in their respective states. Thus, considering India's federal structure as well as the wide variance in the social-geographic and economic variances between states, a one-size fits all approach cannot be applied (an example being the use of informal form of transportation in varying social geographies). The development of adequate charging and power system infrastructure to support the uptake of EVs would rest upon state-specific policy, regulatory measures, and effective implementation of such policy and regulatory interventions, with effective support and leadership by the central government.

1.1 Study overview

The Nationally Determined Contribution – Transport Initiative for Asia (NDC-TIA) is a regional initiative funded by the International Climate Initiative (IKI) of German Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV). It is a joint project of seven organizations and with the engagement of China, India, and Vietnam. The organizations partnering with GIZ on this project are World Resources Institute (WRI), International Council on Clean Transportation (ICCT), International Transport Forum (ITF), Agora Verkehrswende, REN21 and SLOCAT. For the India component of the NDC-TIA project, the implementing partner is the National Institution for Transforming India (NITI Aayog).

Under the NDC-TIA India Component, we have an ongoing study "Integration of Electric Vehicles charging infrastructure with distribution grid: Global review, India's gap analyses and way forward" which is focused on conducting Indian and International review on overall environment related to EV charging. This study is carried out by consortium led by IIT Bombay along with Florence School of Regulation (FSR), Technical University Denmark (DTU), Cardiff University and Universidad Pontificia Comillas.

This specific study focused on EV charging infrastructure, related policy and regulatory measures, grid integration of EVs, and way forward for smooth EV adaption in Indian EV ecosystem. The study developed a framework along with the inputs from a detailed critical international review on EV charging infrastructure development and its grid integration from different EV rich countries. The developed framework has been used as a basis for identifying gaps and scope for improvement in EV charging infrastructure adoption at the national level and in the states. The study, based on a combination of desk research, surveys, bilateral consultations with stakeholders, and consolation workshops, has been used to identify and recommend national and state specific interventions that can be sandboxed for the use by regulators, policy makers, DISCOMS, and other stakeholders, and later adopted statewide.



1.1.1 AIM OF THE STUDY

The aim of this study was to conduct a detailed study with high impact/quality reports that can supplement decision making by the Government of India including State Governments, distribution system operators, transmission system operators, planning and regulatory agencies and other stakeholders (EV industry etc.) to frame, adapt, and/or revise policies, regulations, technical charging standards, communication protocols related to the integration of EV charging infrastructure with distribution and the transmission grid.

1.1.2 OBJECTIVES OF THE STUDY

A detailed study was conducted based on critical analysis of international experience on EV charging infrastructure and its grid integration from different EV rich international countries (besides India) with the main thrust on the following points:

- Planning and operation of distribution grid with integration of EV charging infrastructure
- Grid support services from electric vehicles to facilitate large-scale renewable energy integration
- Technologies and standards for EV charging infrastructure's integration with distribution grid
- Policies and regulations for EV charging infrastructure and integration with distribution grid
- Identifying the key challenges and recommendations for efficient, effective and sustainable integration of EV charging infrastructure in India

1.1.3 ORGANISATION OF THE STUDY REPORTS

The outcome of this study is documented in a series of four technical reports. The four reports listed below cover different aspects of EV integration in a structured manner for effective, organised, and easy dissemination of the study outcome.

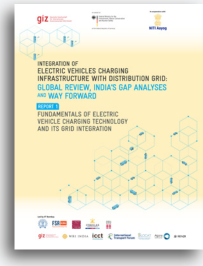
1.1.4 SCOPE OF THE REPORT

This specific report is the third report in the series of four reports of this study. This specific report is focused on detailed documentation and analysis of EV charging infrastructure and its grid integration in Indian EV ecosystem covering the current status analysis of various aspects including EV charging technology, standards and protocols applicable in India, grid integration status of EVs, stakeholders in Indian EV ecosystem, policy and regulatory matters related to EV charging infrastructure (both at central and state level).[5] Moreover, gap analysis in EV charging infrastructure and its grid integration in Indian EV ecosystem is also presented in this report. Since the Indian EV market currently constitutes of mainly electric 2W, 3W and 4W (e-cars), the main focus of this report is on these passenger vehicle segments. E-buses and heavy duty trucks which currently have very low penetration in Indian EV market, are not the focus of this report.

Report-1:

Fundamentals of Electric Vehicle Charging Technology and its Grid Integration

(Link to download, Link to download from NITI Aayog Website)



Report-2:

International review of Electric Vehicle Charging Infrastructure and its Grid Integration

(Link to download, Link to download from NITI Aayog Website)

Report-3:

Electric Vehicle Charging Infrastructure and its Grid Integration in India
Status Quo, Critical Analysis and Way Forward

Report-4:

Gap analysis and Recommendations for EV integration in India

5 The information and data provided in the report are latest up to February 2022.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02

EV Charging Technologies, Standards and Communication Protocols in Indian EV Ecosystem

2.1 EV charger standards

The standards for electric vehicle (EV) and EV charging in India have been primarily inspired by international standards related to EV and their charging. The key international organizations responsible for providing different EV standards include International Electrotechnical Commission (IEC), Institute of Electrical and Electronics Engineer (IEEE), International Organization for Standards (ISO) and Society of Automotive Engineers (SAE), depending on the ongoing trends and thriving technologies.

Among all the international standards, India majorly follows the IEC standards. However, India has also developed its own standards to harmonize the EV related standards with the EV industry worldwide. The standards can be classified into charging, connectors, safety, and communication standards based on the application and functionality in the e-mobility ecosystem. The evolution of Indian EV related standards has been summarized in Figure 2.1.

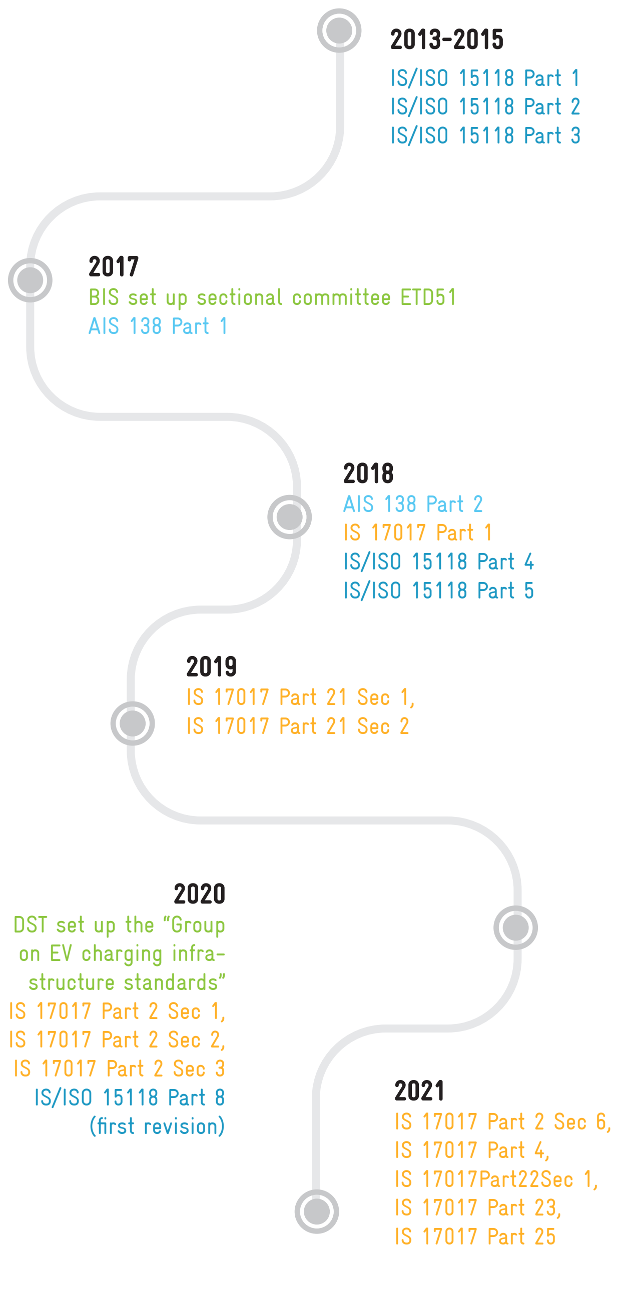


Figure 2.1: Evolution of Indian EV standards

IS/ISO standard · AIS standard · IS standard · key event

The Indian standards and the respective international standards used for developing the Indian standards are provided in Table 2.1.

Table 2.1: List of international standards assisted Indian standards

Indian standard		Reference International standard	
Standard	Title	Standard	Title
AIS 138: Part 1	Electric Vehicle Conductive AC Charging System	IEC 61851-1	Electric vehicle conductive charging system - Part 1: General Requirements
		IEC 61851-21	Electric vehicle requirements for conductive connection to an AC /DC supply
		IEC 61851-22	Requirements for AC electric vehicle charging stations for conductive connection.
AIS 138: Part 2	Electric Vehicle Conductive DC Charging System	IEC 61851-1	Electric vehicle conductive charging system - Part 1: General Requirements
		IEC 61851-21	Electric vehicle requirements for conductive connection to an AC /DC supply
		IEC 61851-23	General requirements for the control communication between a DC EV charging station and an EV.
		IEC 61851-24	Requirements for digital communication between DC EV charging station and electric vehicle for control of DC charging
IS 17017 (Part 1) : 2018	Electric Vehicle Conductive Charging System Part 1 General Requirements	IEC 61851-1: 2017	Electric vehicle conductive charging system - Part 1: General requirements
IS 17017 (Part 2/Sec 1) : 2020	Electric Vehicle Conductive Charging System Part 2 Plugs, Socket-Outlets, Vehicle Connectors, and Vehicle Inlets Section 1 General requirements	IEC 62196-1: 2014	Plugs, socket-outlets, vehicle connectors and vehicle inlets - Conductive charging of electric vehicles - Part 1: General requirements
IS 17017 (Part 2/Sec 2) : 2020	Electric Vehicle Conductive Charging System Part 2 Plugs, Socket – Outlets, Vehicle Connectors and Vehicle Inlets Section 2 Dimensional compatibility and interchangeability requirements for a.c. pin and contact-tube accessories	IEC 62196-2: 2016	Plugs, socket-outlets, vehicle connectors and vehicle inlets - Conductive charging of electric vehicles - Part 2: Dimensional compatibility and interchangeability requirements for a.c. pin and contact-tube accessories
IS 17017 (Part 2/Sec 3) : 2020	Electric Vehicle Conductive Charging System Part 2 Plugs, Socket – Outlets, Vehicle Connectors and Vehicle Inlets Section 3 Dimensional compatibility and interchangeability requirements for d.c. and a.c./d.c. pin and contact-tube vehicle couplers	IEC 62196-3 : 2014	Plugs, socket-outlets, vehicle connectors and vehicle inlets - Conductive charging of electric vehicles - Part 3: Dimensional compatibility and interchangeability requirements for d.c. and a.c./d.c. pin and contact-tube vehicle couplers

Indian standard		Reference International standard	
Standard	Title	Standard	Title
BIS IS 17017 (PART 21 / SEC 1): 2019	Electric Vehicle Conductive Charging System Part 21 Electromagnetic Compatibility requirement Section 1 ON board chargers	IEC 61851-21-1 : 2017	Electric vehicle conductive charging system – Part 21-1 Electric vehicle on board charger EMC requirements for conductive connection to AC/DC supply
BIS IS 17017 (PART 21 / SEC 2) : 2019	Electric Vehicle Conductive Charging System Part 21 Electromagnetic Compatibility requirement Section 2 Off board chargers	IEC 61851-21-2 : 2018	Electric vehicle conductive charging system – Part 21-2: Electric vehicle requirements for conductive connection to an AC/DC supply – EMC requirements for off-board electric vehicle charging systems
IS 17017 (Part 25) : 2021	Electric Vehicle Conductive Charging System Part 25 D.C. EV Supply Equipment where Protection Relies on Electrical Separation	IEC 61851-25 : 2020	Electric vehicle conductive charging system – Part 25: DC EV supply equipment where protection relies on electrical separation

Indian charging standards for AC and DC conductive charging given by Automotive Industry Standards (AIS) are named as AIS 138 part-1 and part-2. These standards cover all the aspects of conductive charging ranging from general requirements for charging, rating, charging modes, connectors, the safety of EV Supply Equipment (EVSE), and protection against electric shocks. The Bureau of Indian Standards (BIS) has also issued the IS 17017 series of standards for EV Supply Equipment (EVSE), connectors, sockets plug, outlets, its design, compatibility, and interoperability.

2.1.1 AIS 138

AIS 138 part 1 is an AC conductive charging standard issued in 2017. It is applicable for a supply voltage of 1000V[6]. It mentions two modes of AC conductive charging: AC slow charging for the maximum rating of 15 A (single-phase) and AC fast charging mode for the maximum rating of 63A (three-phase). The instruction to disconnect the EV from EVSE given in the standard is essential in protecting from electric shocks. Specific requirements of vehicle inlet, connectors, sockets, and plugs based on temperature, breaking capacity, life span, and forces connecting and disconnecting the connector are discussed. Functional and operational requirements viz, emergency service, dielectric withstand characteristic, insulations, clearance distance, leakage, protection, and earthing are giving the guideline for operating an EVSE. Different environmental, mechanical, electromechanical tests are mentioned, which ensure the proper working of the equipment. The standard has documented the control pilot pin function using PWM modulation, establishing a connection between EV and EVSE, basics of vehicle coupler, and different connectors used for AC slow and fast charging. The rating of the power converter, classification of EVSE and different cable assemblies for AC conductive charging has also been mentioned. This complete information provides an idea of EV charging and the concerned requirements and guidelines.

Similar to AIS-138 part 1 for AC conductive charging, **AIS 138 part 2** encapsulated the knowledge of DC conductive charging and was released in 2018. It applies for AC or DC voltage up to 1000 V AC and 1500 V DC supply. It provides DC charging, charger, and connectors basics as given in AIS part 138 part 1. In addition to the basics, it also includes the details of constant current charging and constant voltage charging modes. Communication between EV and DC EVSE covering system specifications, charging states and digital communication architecture is also given. The modulation of the control signal on the control pin using DC communication between EV and EVSE is presented stepwise. The standard provides information about the DC charging station's functionality, digital communication, requirements, and essentials for DC conductive charging. Key points covered in AIS 138 standards are summarized in Table 2.2

6 The Automotive Research Association Of India, "AIS-138 Part-1: Electric Vehicle Conductive AC Charging System," February 2017, https://hmr.araiindia.com/Control/AIS/210201752832PMAIS138_Part1.pdf.

Table 2.2: Key points covered in AIS 138 standards

Standard	Title of the standard	Key points covered	Parameters
AIS 138: Part 1	Electric Vehicle Conductive AC Charging System	General system requirement for AC charging, safety functions of AC EVSE, charging cable assembly requirement, EVSE requirement	0-1000 V AC with a maximum current rating of 15A (single phase) and 63A (three phase)
AIS 138: Part 2	Electric Vehicle Conductive DC Charging System	General system requirement and functions of DC charging, connection and communication between EV and EVSE, protection against electric shock, requirement of vehicle coupler, cable assembly and EVSE requirements	1000 V AC and 1500 V DC

2.1.2 IS 17017

BIS introduced the first standard IS 17017 (Part 1):2018 for EV charging in 2018. The standard is focused on the general requirements, characteristics, operations, and communication connection between EV and EVSE for a conductive EV charging system[7]. It is applicable for EV systems with supply voltage of up to 1000 V AC or 1500 V DC and output voltage up to 1000 V AC and 1500V DC. It covers the key steps, communication architecture and procedure for initialization of charging, completion of charging, emergency conditions via control signal transfer on control pin in dc charging system. It also defines the mode of charging, and the minimum functionality required in different modes of charging. Digital communication between EV and EVSE at different charging modes and protection against shocks are also mentioned in the standards. Cable assembly, EVSE constructional requirement and testing, overload and short circuit protection, marking and instructions are specified in detail. The working of control pin and communication over control line and test procedure for various tests have also been provided.

IS 17017: Part 2: Section 1: 2020 covers the general requirement of plugs, sockets, vehicle connectors, and inlets for conductive charging. The standard applies to the system rating not exceeding 690 V AC at a rated current of 250 A and 1500 V DC at a rated current of 200 A[8]. It covers the details of wiring, terminals, ratings, a connection between power supply and EV. The classification of accessories according to various differentiators such as purpose, connection method, serviceability, interface, etc. is mentioned. Marking for accessories, dimensions of various components, protection against shock, provisions for protective earthing, and terminals are covered in the standard. Various tests, interlocks, construction, and dimensionality of the components, protection, insulation, and normal operation are provided in the standard. This standard is also sectionalized into sections as mentioned below in Table 2.3.

7 BIS, "IS 17017 Part 1: 2018 Electric Vehicle Conductive Charging System Part 1 General Requirements," Bureau of Indian standard, 2018, https://standardsbis.bsbedge.com/BIS_SearchStandard.aspx?Standard_Number=IS%2017017%20:%20Part%201&id=23427.

8 BIS, "IS 17017 : Part 2 : Sec 1 : 2020 : Electric Vehicle Conductive Charging System - Part 2 Plugs, Socket-Outlets, Vehicle Connectors, And Vehicle Inlets - Section 1 General Requirements," July 2020, https://standards.bsb.co.in/BSBEdgedrmviewpdf.aspx.

Table 2.3: Sections of IS 17017 Part 2

Standard	Title of the standard (Section)	Key points covered	Parameters
IS 17017: Part 2: Section 1 [7]	IS 17017: Part 2: Electric Vehicle Conductive Charging System: Plugs, Socket, Outlets, Vehicle Connectors and Vehicle Inlets Section 1: General requirements	Specifies general requirement of plug, socket, outlet, connectors, inlet. Provides mechanical, electrical, and performance requirements.	690V AC at rated current of 250A and 1500 V DC at rated current of 200A
IS 17017: Part 2: Section 2, 2020[9]	Section 2: Dimensional compatibility and interchangeability requirements for AC pin and contact-tube accessories	Provides detailed construction and design of vehicle inlets, connectors, latches for AC charging.	415 V AC, rated current not exceeding 63 A three-phase or 70 A single phase
IS 17017: Part 2: Section 3[10]	Section 3: Dimensional compatibility and interchangeability requirements for dc and ac/dc pin and contact-tube vehicle couplers	Provides detailed construction and design of vehicle inlets, connectors, latch for DC charging.	Up to 1500 V DC and rated current up to 250 A, and 1000 V AC and rated current up to 250 A

IS 17017 Part 21 standardizes electromagnetic compatibility of EV charger and provides electromagnetic compatibility of on-board EVSE. **IS 17017 Part 21 Section 1** covers immunity to electromagnetic radiated RF-fields, immunity to pulses on supply lines, emissions of harmonics on AC power lines, emissions of voltage changes, voltage fluctuations, flickers on AC lines[11]. High frequency conducted disturbances on AC/DC power lines and network and telecommunication access are also covered in the standard. **IS 17017 Part 21 Section 2** provides electromagnetic compatibility for Off-board EVSE and mentions all the above topics covered in IS 17017 Part 21 Section 1[12].

IS 17017 Part 22 Section 01: 2021 covers the conductive charging configuration for light Electric vehicle AC charge point with a supply voltage of 240 V AC and current up to 16 A AC[13]. It constitutes the requirement of LEV, its functionality, energy measurement, electrical and mechanical safety consideration, and environmental aspects. LEV AC charging point would be used with Mode 1 type of charging and shall provide protective earthing conductor from plug to vehicle connector. IS 60309 industrial socket and plug would be used for LEV AC charging. The charging point for LEV can use two types of connection as shown in Figure 2.2 and Figure 2.3. In

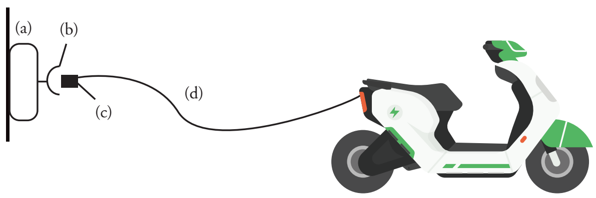


Figure 2.2: Case A for connection for 2W and 3W

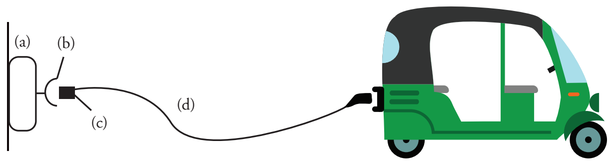


Figure 2.3: Case B for connection for 2W and 3W

Case A, the plug and cable are permanently attached to the vehicle and detectable from the charging equipment. In contrast, Case B has a noticeable cable from both sides, as shown in Figure 2.3.

It can use a mobile app or other appropriate interfaces for enabling bill payment. It should be equipped with Bluetooth Low Energy (BLE) communication protocol compatible with 4.0 and higher for communicating with mobile applications and other interfaces.

9 BIS, "IS 17017 : Part 2 : Sec 2 : 2020 : Electric Vehicle Conductive Charging System - Part 2 Plugs, Socket- Outlets, Vehicle Connectors And Vehicle Inlets - Section 2 Dimensional Compatibility And Interchangeability Requirements For A.C. Pin And Contact-Tube Accessories," June 2020,

10 BIS, "IS 17017 : Part 2 : Sec 3 : 2020 : Electric Vehicle Conductive Charging System Part 2 Plugs, Socket-Outlets, Vehicle Connectors And Vehicle Inlets - Section 3 Dimensional Compatibility And Interchangeability Requirements For D.C. And A.C/D.C. Pin And Contact-Tube Vehicle Couplers," July 2020,

11 BIS, "IS 17017 : Part 21 : Sec 1 : 2019 : Electric Vehicle Conductive Charging System - Part 21 Electromagnetic Compatibility (EMC) Requirements - Section 1 On-Board Chargers," August 2019,

12 BIS, "IS 17017 : Part 21 : Sec 2 : 2019 : Electric Vehicle Conductive Charging System - Part 21 Electromagnetic Compatibility (EMC) Requirements - Section 2 Off-Board Chargers," August 2019,

13 BIS, 'IS 17017 : Part 22 : Sec 1 : 2021: Electric Vehicle Conductive Charging Systems Part 22 AC Charging Configurations Section 1 - AC Charge Point for Light Electric Vehicle, 2021,

IS 17017 Part 25: 2021 is for DC EVSE where the protection relies on electrical separation. It is applicable on DC EVSE with rated input voltage up to 400 V AC or 600 V DC, and rated output voltage and current should not exceed 120 V DC and 100 A respectively. The standard is specified for communication between DC EVSE and EV, however, it does not cover the requirement for bidirectional power flow, safety aspect for maintenance, and DC charging for heavy electric vehicles. DC EVSE's constructional requirements and tests such as touch current, dielectric withstand voltage, overload and short circuit protection, and temperature test are mentioned.

IS 17017 Part 23: 2021 covers DC EVSE with rated input voltage up to 1000 V AC or 1500 V DC and output voltage up to 1500 V DC. It specifies the requirement of bidirectional power flow and communication between DC EVSE and EV. Non-isolated system and non-regulated DC EVSE are not covered in this standard. The standard mentions the general requirements, modes and functions, communication, protection against electric shocks, constructional requirement, and other relevant testing of DC EVSE.

Some of the additional standards are listed in Table 2.4.

Table 2.4: IS 17017 Part 2 standards

Standard	Title of the standard (Section)	Key points covered	Parameters
IS-17017 Part 2 Section-2	Part 2 Plugs, socket-outlets, vehicle connectors, and vehicle inlets Section 6 Dimensional compatibility and interchangeability requirements for AC and contact-tube vehicle coupler	It mentions about high-power DC and combined AC/DC interface of vehicle couplers	Rated operating voltage up to 415 V, 50 Hz AC and rated current up to 63 A three-phase or 70 A single-phase
IS-17017 Part 2 Section-3	Section 6 Dimensional compatibility and interchangeability requirements for DC and AC/DC pin and contact-tube vehicle coupler	It mentions high power DC and combined AC/DC interface of vehicle couplers	Rated operating voltage up to 1000 V AC and 1500 V DC and rated current up to 250 A
IS-17017 Part 2 Section-6 (2021)	Section 6 Dimensional compatibility requirements for DC pin and contact-tube vehicle couplers intended to be used for DC EV supply equipment where protection relies on the electrical separation	It mentions the accessories used for DC conductive charging, whereas the protection depends on the electrical separation between the primary and secondary sides of DC EVSE	Rated operating voltage up to 20 V DC and current up to 100 A

The consolidated information of different EV standards according to different EV charging options are as given in Table 2.5[14].

Table 2.5: Summary of LEV AC, LEV DC, parkbay AC/DC, and eBus charging

Light EV AC Charge Point				
Power Level 1	Charging Device	EV-EVSE Communication	Charge Point Plug/ Socket	Vehicle Inlet/ Connector
Up to 7 kW	IS-17017-22-1	Bluetooth Low Energy[15]	IS-60309	As per EV manufacturer
Light EV DC Charge Point				
Power Level 1	Charging Device	EV-EVSE Communication	Charge Point Plug/ Socket	Vehicle Inlet/ Connector
Up to 7 kW	IS-17017-25 [CAN]	Combined Socket under development		IS-17017-2-6
Parkbay AC Charge Point				
Power Level - 2	Device/ Protocol	EV-EVSE Communications	Infrastructure Socket	Vehicle Connector
Normal Power ~11 kW/ 22 kW	IS-17017-1	IS-15118 [PLC] for Smart Charging	IS-17017-2-2	IS-17017-2-2
Parkbay DC Charge Point				
Power Level-2	Device/ Protocol	EV-EVSE Communications	Infrastructure Socket	Vehicle Connector
Normal Power ~11 kW/ 22 kW	IS-17017-23	IS-17017-24 [CAN] IS-15118 [PLC]	IS-17017-22-2	IS-17017-2-3
DC Charging Protocol				
Power Level 3	Charging Device	EV-EVSE Communication	Connector	Power Level 3
DC 50 kW to 250 kW	IS-17017-23	IS-17017-24 [CAN] IS [PLC] -15118	IS-17017-2-3	DC 50 kW to 250 kW
eBus Charging Station (Level-4: 250 to 500 kW)				
Power Level 4 DC High Power (250 kW to 500 kW)	Charging Device	EV-EVSE Communication		Connector
Dual Gun Charging Station	IS-17017-23-2	IS-15118 [PLC]		IS-17017-2-3
Automated Pantograph Charging Station	IS-17017-3-1	IS-17017-3-2		IS-17017-3-2

14 Ministry of Power, "Final_Consolidated_EVCI_Guidelines_January_2022_with_ANNEXURES.Pdf," January 2022, https://powermin.gov.in/sites/default/files/webform/notices/Final_Consolidated_EVCI_Guidelines_January_2022_with_ANNEXURES.pdf.

15 BLE is between EV user (mobile app) and EVSE

The list of Indian standards under preparation as of January 2022 are given in Table 2.6[16].

Table 2.6: Upcoming IS standards as of January 2022

Standards	Status	Broad topics covered in the standard
IS-17017-23-2: Dual Gun (eBus Charger)	Drafting under process	It will standardize the dual gun charging for high power eBus charging
IS-17017-3-1: Automated Pantograph (eBus Charger)		It will mention electrical interface, power flow, communication, and safety system
IS-17017-3-2: Automated Pantograph (eBus Charger)		It will cover connection arrangement, connection locations, bus geometry, and alignment.
IS-17017-22-2	Under planning	Socket/combined charge point for DC parkbay/destination charge point
IS-btswp-1-1		Interoperable light EV battery swap: General Guidelines & Pack Dimensions
IS-btswp-1-2		Interoperable light EV battery swap: Connection System
IS-btswp-1-3		Interoperable light EV battery swap: Communication Protocol
IS-btswp-1-4		Interoperable light EV battery swap: Backend for Interoperability
IS-btswp-2-1		Interoperable ebus battery swap: General guidelines
IS-btswp-2-2		Interoperable ebus battery swap: Safety requirements
IS-btswp-2-3		Interoperable ebus battery swap: eBus Battery Swap Communication
IS-btswp-2-4		Interoperable ebus battery swap: Battery Connection System
IS-btswp-2-5		Interoperable ebus battery swap: Dimensions of the pack
IS-btswp-2-6		Interoperable ebus battery swap: Standard Operating Procedures (SOP)

2.1.3 BHARAT AC001 AND BHARAT DC001

Department of Heavy Industry (DHI) under the Ministry of Heavy Industries and Public Enterprises (MoHIPE) has introduced two chargers for the Indian EV market viz, Bharat AC 001 and Bharat DC 001. Bharat AC 001 uses IEC 60309 pin, however, without communication protocols between EVSE and EV. For communication and authentication between EVSE and the Central Management System (CMS), Open Charge Point Protocol (OCPP) is used. On the other hand, Bharat DC 001 is developed considering IEC 61851-1 and is recommended to use GB/T 20234.3 while it uses CAN bus communication based on IEC 61851-24. Further technical information on Bharat AC 001 and Bharat DC 001 is given in Table 2.7[17].

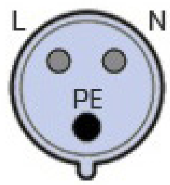
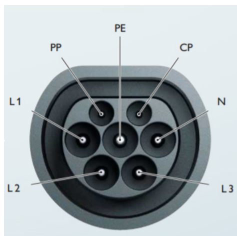
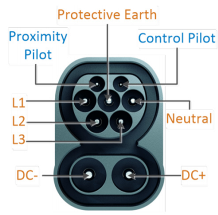
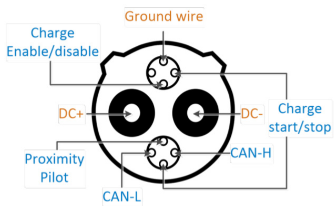
16 DST, "Report on Indian Standards for EV Charging Infrastructure," August 2021.
17 DHI, "Standardization of Protocol for Charging Infrastructure," 2017

Table 2.7: Specification of Bharat AC 001 and Bharat DC 001 chargers

Bharat AC 001		Bharat Chargers	
		Bharat DC 001	
Parameters	Input system specification	3 phase 5 wire AC system	3 phase 5 wire AC system
	Input Voltage	415 V	415 V
	Input supply backup	1 hour battery backup for control system and billing unit	Minimum 1 hour battery backup for control system and billing unit
	Output specification	230 V single phase	48 V/60V/72 V
	Number of outputs	3	2
	Output current	15 A	200A
	Connector type	IEC 60309	GB/T 2023.4

Table 2.8 provides the connector type with its constructional design for different charging standards.

Table 2.8: Connector type for different charger standards

Standard	Charging type	Connector	Connector design
AIS 138: Part1	Slow charging (AC low power charging) Bharat AC-001	IEC 60309	
	Fast charging (AC high power charging up to 43 kW)	IEC 62196	
AIS 138: Part 2	Fast Charging (DC low power charging 10/15 kW) Bharat DC-001	GB/T 20234.3	
	Fast Charging (High power charging up to 350W)	CCS 2	
	Fast Charging (High power charging)	CHAdeMO	

2.2 Communication protocols used in India

For communication, India follows the OCPP protocol[18], an open-source protocol that provides a communication link between the EV charging station and the central management system. It allows the charging station to connect with different EVSEs in the charging station and Charging Station Management System (CSMS). India has adopted the OCPP version 1.5 and the higher versions of the same for its EV ecosystem. It facilitates interactive communication with secure authentication and complete information of tariff and estimated charging bill. It provides compatibility between different EVSEs operational in a charging station constructed by a third party CPO/EVSE OEM.

IS 17017 Part 24: 2021 is a communication-related standard that covers the digital communication between DC EVSE and EV for control of DC charging for a system with rated voltage up to 1000 V AC or 1500 V DC and output voltage up to 1500 V DC. It focuses on DC communication of DC EVSE and EV for charging and discharging. Two digital communication using CAN and Homeplug Green PHYTM over control pin are described in the standard for communication between DC EVSE and EV.

IS/ISO 15118 is a series of standards related to communication between a vehicle and vehicle-to-grid communication interface. It covers general requirements, use-case definition, network and application protocol requirement, and interconnection between physical and data link layers[19]. Additional parts of IS/ISO 15118 standard are listed Table 2.9.

Table 2.9: IS/ISO 15118 standard

Standard	Title
IS/ISO 15118-1:2013	Road vehicles - Vehicle to grid communication interface - Part 1: General information and use case definition
IS/ISO 15118-2:2014	Road vehicles - Vehicle-to-Grid Communication Interface - Part 2: Network and application protocol requirements
IS/ISO 15118-3:2015	Road vehicles - Vehicle to grid communication interface -- Part 3: Physical and data link layer requirements
IS/ISO 15118-4:2018	Road vehicles - Vehicle to grid communication interface - Part 4: Network and application protocol conformance test
IS/ISO 15118-5:2018	Road vehicles - Vehicle to grid communication interface - Part 5: Physical and data link layer conformance tests
IS/ISO 15118-8:2020	Road vehicles - Vehicle to grid communication interface - Part 8: Physical layer and data link layer requirements for wireless communication

18 "OCPP 1.5, Protocols, Home - Open Charge Alliance," accessed April 16, 2021, https://www.openchargealliance.org/protocols/ocpp-15/
19 Bureau of Indian Standards, "Indian Standards IS 15118," accessed February 20, 2022, https://standardsbis.bsbedge.com/BIS_SearchStandard.aspx?Standard_Number=IS+15118&id=0.

03

Stakeholders in Indian EV Ecosystem

The EV ecosystem is a cooperative system involving multiple stakeholders. A coordinated effort of different entities and shareholders including policy makers, equipment manufacturers, financial service providers, electrical distribution utilities testing and certification authorities, EV specific entities and the users is needed for smooth integration of EVs into the Indian transportation sector. The relationship between the different entities is summarised in Figure 3.1 and Table 3.1.

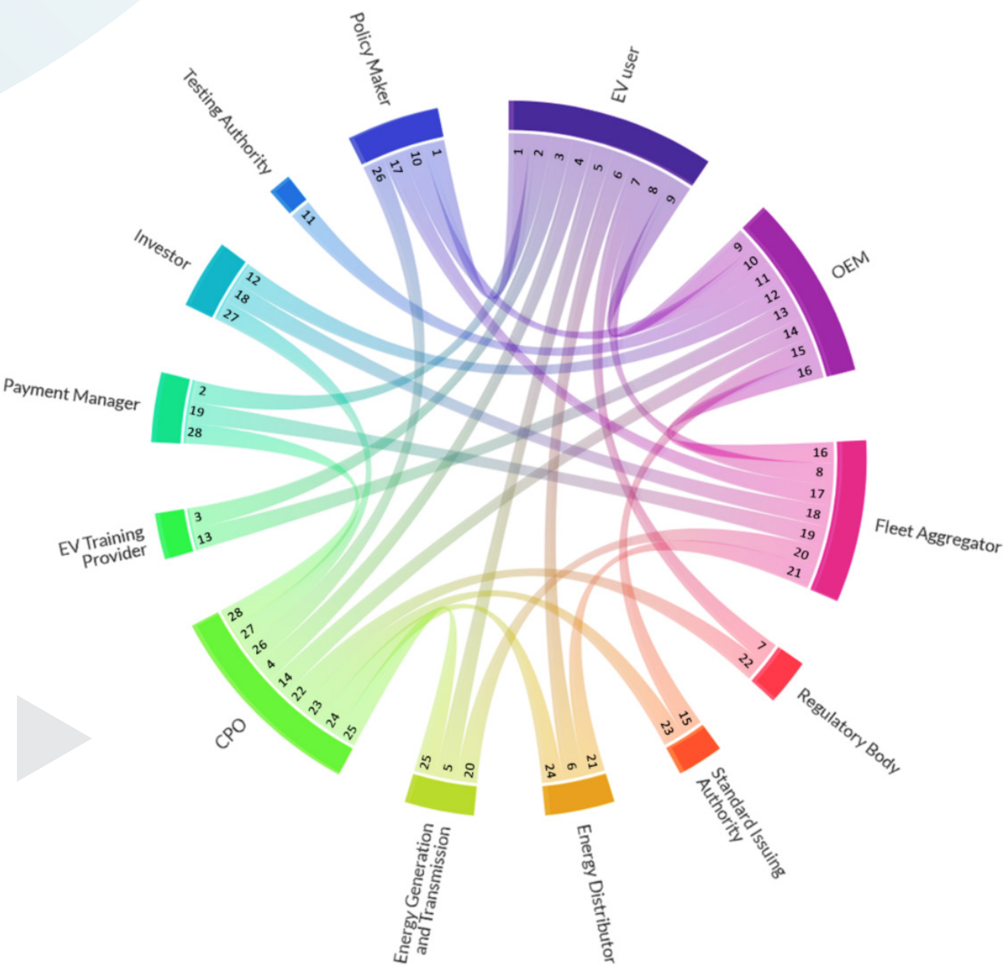


Figure 3.1: Chord diagram showing the different stakeholders involved in the EV ecosystem (The relationship between the different stakeholders which have been numbered are defined in Table 3.1)

Table 3.1: Definition of inter stakeholder relationship in the EV ecosystem

1.	EV incentive policies
2.	Payment for EV charging at CPO
3.	Provision of EV O&M services
4.	EV public charging
5.	EV participation in grid support services
6.	EV participation in grid support services
7.	Regulation for installation of private EV charger
8.	Fleet aggregators as EV user
9.	EV and EV charger manufactured by OEMs
10.	Policies for OEMs
11.	Manufactured units tested by testing authority
12.	Investors required for setting up of new OEMs
13.	Skilled workforce required in OEMs
14.	CPOs purchase EV chargers from OEMs
15.	OEMs manufacture units as per issued standards
16.	Fleet aggregators purchase EVs from OEMs
17.	Favourable policies for fleet aggregators
18.	Investors required for creation of fleet aggregators
19.	Payment for utilization of fleet aggregator services by user
20.	Participation of fleet aggregator in grid support services
21.	Participation of fleet aggregator in grid support services
22.	Regulations for CPOs
23.	Standards for CPOs
24.	Participation of CPO in grid support services
25.	Participation of CPO in grid support services
26.	Policies for CPOs
27.	Investment needed for CPOs
28.	Payment manager utilized by CPOs

3.1 Original Equipment Manufacturers

Original Equipment Manufacturers (OEMs) are responsible for manufacturing of EV parts, assembling EV, and manufacturing EV chargers and other related products. The automobile sector of India is now transitioning through a technological change with the advent of EVs. Several start-ups have already cropped up in this sector, with established OEMs of the automobile sector also looking to expand into the EV domain. Further, different oil and power companies have created verticals under their umbrella to invest in EV charging infrastructure. List of some OEMs for different categories of EVs and EV components have been provided in Table 3.2.

Table 3.2: List of some OEMs selling products in India

e-2W	e-3W	e-4W	e-Bus	Chargers	Battery Manufacturers
Ather	Mahindra electric	Mahindra electric	TATA Motors	Delta Electronics	Exide-Leclanche
Okinawa	Lohia	TATA Motors	Olectra Greentech Ltd	Okaya Power	Panasonic
Ampere	Kinetic Green	Force	PMI Electro Mobility	Magenta Power	LG Chem
Revolt	Bahubali	Hyundai	Ashok Leyland	Exicom	TATA Chemicals
TVS	Jitendra EV Tech	Morris Garages (MG)	JBM Solaris	Mass-Tech	Amara Raja
Benling	Piaggio Motor	Mercedes-Benz		BrightBlu	Goldstar Power Ltd.
Hero Electric	Altigreen Propulsion Labs	Maruti Suzuki (Upcoming)		ABB	Base Batteries
Tork Motors	Y C Electric Vehicle	Renault (Upcoming)		Schneider	Log9 Materials
YObykes	Champion PolyPlast			Powertron	
Ola Electric	SKS Trade India Pvt. Ltd.			Aeidth	
Bajaj	Terra Motors			Amara Raja Group	
Simple Energy	Shigan Evoltz Ltd.			P2 Power	
Ultraviolette	Goenka Electric Motor Vehicles Pvt. Ltd.			EVRE	
Earth Energy EV					
Pure EV					
Oben Electric					

3.2 Charge Point Operator

The charge point operator (CPO) is the next important stakeholder involved in the EV ecosystem. The CPO is responsible for the operation and maintenance of the charging stations. The number of charge point operators in the country represents the level of market competitiveness in the EV charging business. For example, in Europe there are 22 different charge point operators with each operator having at least 3000 charging points.

Comparatively, in India, as of now, the number of charge point operators are limited. However, the state electricity distribution companies have been playing an active role in installing EV chargers. Hence, with growing interest, the DISCOMs of several states will also play the role of CPO.

The different CPOs in India are listed in Table 3.3.

Table 3.3: List of CPOs in India

CPO	Entity Type
Energy Efficiency Services Ltd. (EESL)	Public Sector
Rajasthan Electronics & Instruments Ltd. (REIL)	Public Sector
National Thermal Power Corporation Ltd. (NTPC)	Public Sector
New & Renewable Energy Development Corporation of Andhra Pradesh Ltd. (NREDCAP)	Public
Kerala State Electricity Board (KSEB)	DISCOM (State Owned)
Navi Mumbai Municipal Transport	Public
Power Grid Corporation of India Ltd. (PGCIL)	Public Sector
Bangalore Electricity Supply Company Ltd. (BESCOM)	DISCOM (State Owned)
BSES Rajdhani Private (BRPL)	DISCOM (Private)
PlugNgo	Private
Fortum Charge & Drive	Private
Ather	Private
ChargeZone	Private
Volttic	Private
Magenta Power	Private
TATA Power	Private
Prakriti e-mobility Private Ltd.	Private
Ola Electric	Private

3.3 Fleet Aggregator

The fleet aggregators find EVs as an attractive option due to their low TCOs with high usage. This interest has led to the adoption of EVs as the primary vehicle for evolving fleet aggregators. Fleet aggregators are potentially early adopters of EVs as it minimizes their carbon footprint while lowering operating costs. These aggregators have multiple numbers of vehicles that can be effectively managed for optimal operational efficiency. Due to the low operating cost of EVs, commercial and public utility vehicles have more attractive economics than privately owned vehicles, as such public utility vehicles generally have more usage than private vehicles. So, fleet aggregators are one of the important stakeholders in the EV ecosystem. With fleet aggregators, it is also possible to participate in grid support services, as the charging of the EV fleet can be optimized so that there is a minimum power capacity to bid into the energy markets.

Some of the EV fleet aggregators in India are listed below.

3.4 Regulatory Bodies

Regulator is required to regulate and design a fair and affordable EV tariff structure applicable for the EV public charging interface (PCI) to promote wider adoption of EVs. The electricity regulators in India include Central Electricity Regulatory Commission (CERC) and State Electricity Regulatory Commissions (SERCs) as given in Table 3.4. CERC monitors and works at national/central level, whereas SERCs' jurisdiction is at state level and electricity tariff structure for the demand including EV charging is primarily regulated by SERCs. CERC has an additional function of promotion of efficiency and economy in the activities of EV market. SERC creates affordable electricity tariff structure for EV charging stations such that it facilitates EV adoption and helps in performing grid stability using block-tariff according to the nature of load in various time slots/durations. Several SERCs in India have notified separate EV tariff for EV charging. The Revised Charging Infrastructure Guidelines issued by the Ministry of Power (MoP) have further capped the ceiling of the service charges levied by the public charging stations from the EV users. Another role of SERCs is to address the issues related to use of multiple connections in a single premise, for the PCIs installed in existing locations such as parking lots of malls and shopping complexes etc. CEA is another regulatory body that issues guidelines and standards regarding charging infrastructure. It also issues measures related to safety and electricity supply and collects information regarding public charging stations from DISCOMs.

Table 3.4: Regulators for EV regulations in India

State / Region	Regulatory body
National	CERC
	CEA
States	SERCs
	CEA

3.5 Policy Maker

The Indian electric automotive eco-system comprises several stakeholders with a primary role of creating an efficient eco-system that encourages the adoption of technologies, increases investments, and ensures proper system operation. They include committed ministries and other key actors which play a vital role in designing and implementing policies, technical standards, and regulatory structures for EVs in India .

3.5.1 MINISTRY OF HEAVY INDUSTRIES AND PUBLIC ENTERPRISES (MoHIPE)

Department of Heavy Industries (DHI), working under MoHIPE, is catering to the country's coordination and implementation of policy measures for faster vehicle electrification. The Faster Adoption and Manufacturing of (Hybrid and) Electric Vehicles in India (FAME) scheme was notified by DHI in 2015 and 2019 in two phases to achieve decarbonization and energy security objectives. The primary role of DHI (under MoHIPE) is framework development for the successful implementation of FAME schemes, while the two agencies described in the next two sections, monitor operations and actions under FAME schemes.

3.5.2 NATIONAL AUTOMOTIVE BOARD

This agency works under DHI for implementing FAME India schemes. The state wise progress is monitored on a regular basis and a web portal is maintained for updating data and dissemination[20].

3.5.3 PROJECT IMPLEMENTATION AND SANCTIONING COMMITTEE (PISC)

It is an Inter-ministerial committee formed to monitor, sanction, and implement the scheme under FAME II program launched in March 2019. It comprises nine members, including CEO, NITI Aayog, Secretaries of various ministries such as MoRTH, MoF, MoP, MNRE, etc., Financial Advisors and Directors of DHI and ARAI. The terms of references and responsibilities of PISC are listed below:

1. Sanctioning Projects for assistance under FAME.
2. Modifying coverage of various components and sub-components of the Scheme.
3. Modifying limits of the fund allocation among vehicle segments.
4. Review of demand incentives annually based on price and technology trends.
5. Review of capping of maximum incentive per vehicle, annually depending on offtake of vehicles under the scheme.
6. Decide other scheme parameters for smooth implementation and resolve issues as and when required.

20 Link to portal: https://dash.heavyindustries.gov.in/

3.5.4 AUTOMOTIVE RESEARCH ASSOCIATION OF INDIA (ARAI)

ARAI is a research institute under MoHIPE working towards fuel economy, low emissions, cost efficiency etc. with recent research including simulator for EV chargers, Hybrid vehicle development, offline and real -time simulators for EV/HEV. ARAI also assists the GoI in the formulation of automotive industry standards and harmonization of regulations. These standards are marked as AIS-XXX standards and AIS 138 (part 1) and AIS 138 (part 2) are related to Electric vehicle conductive AC charging and DC charging, respectively. These standards are defined for all electric vehicles (2/3/4 W) except trail buses, rail transportation and off-road industrial automobiles.

3.5.5 MINISTRY OF ROAD TRANSPORT AND HIGHWAYS (MoRTH)

It is the apex body which formulates and administrates laws and regulations associated with road and transport system in India. They also formulate non-financial incentives for increasing EV penetration in mobility sector which include green number plates, exemption of EVs from permit requirement for plying as transport vehicle, providing provisions for parking infrastructure etc.

3.5.6 MINISTRY OF POWER (MoP)

MoP is charged with overseeing electricity production including power generation, transmission and distribution, and infrastructure development in the power sector. The ministry formulates policies associated with electric charging stations/ charging infrastructure and handles central and state nodal agencies which enables implementation of charging infrastructure in different states /cities. MoP also published standards and guidelines related to charging infrastructure and its amendments/revisions time to time for Electric Vehicles. Bureau of Energy Efficiency (BEE) is entrusted with the role of Central Nodal Agency (CNA), along with 25 State Nodal Agencies (SNAs).

3.5.7 CENTRAL AND STATE ELECTRICITY REGULATORY COMMISSIONS (CERC AND SERCs)

CERC, formed under the electricity act 2003, is a statutory body responsible for regulations in the electricity sector at central level. SERCs are accountable for structuring electricity tariffs applicable for PCI. ERCs are also responsible for handling various grid connection regulation, and tariff related disputes arising from various electricity stakeholders including EV charging infrastructure. For example, for the PCIs installed in parking lots of Malls, shopping complexes etc., the issues arising from use of multiple connections in a single premise are handled by SERCs.

3.5.8 MINISTRY OF HOUSING AND URBAN AFFAIRS (MoHUA)

Encouraging electric vehicles as a viable option for short and long-distance trips with appropriate charging infrastructure is, the pre-condition for the paradigm shift/ phased migration to sustainable transportation. In order to steer the development of charging facilities in commercial and residential building complex, MoHUA is playing a key role by amending building bye-laws. MoHUA notified that residential and commercial complexes would have to allot 20% of their parking space for electric vehicle charging facilities. MoHUA has also amended Model Building Bye-Laws in 2016, to include the formulations of norms and standards for charging infrastructure in the city infrastructure planning.

- **Urban Development Departments:** These government bodies at the state levels are responsible for amendments to the building bye-laws and other urban planning frameworks as suggested by MoHUA.
- **Urban Development Authorities:** It is a civilian government body which oversees and sanctions various aspects of infrastructure development and construction across suburbs of states/cities of India. One important parameter for setting up EV charging stations is the provision of land or parking spaces to locate charging facilities. Land and urban development are mandates of state governments. Hence, state UDAs/municipal corporations are responsible for handling building bye-laws amendments and different urban planning frameworks, including EV charging related provisions.

MoHUA issued an amendment of building bye-laws 2016 that provides guidelines to State governments, urban local bodies, and urban development authorities for incorporating relevant directives to implement charging infrastructure in the building premises and core urban areas of the cities in accordance with the charging standards and guidelines provided by Ministry of Power (MoP). However, only State Governments are empowered to adopt and enforce such suggested amendments to building byelaws through UDAs/municipal corporation. At the local level, DISCOMs and urban local bodies are responsible for the permission, approvals, and certifications needed for installation of EV charging infrastructure.

3.5.9 MINISTRY OF FINANCE (MoF)

The Ministry of Finance is one of the key ministries that has enormously helped in uptake of electric mobility in India. In 2019, Ministry of Finance rationalized the customs duty for all categories of vehicles, battery packs and cells to support Make in India. It also reduced the GST rates for the purchase of electric vehicles from 12% to 5% and announced income tax rebate of INR 1,50,000 (EUR 1,737) on purchase of electric vehicles. The tax rate is also reduced from 18% to 5% on EV chargers.

3.5.10 MINISTRY OF ENVIRONMENT, FOREST, AND CLIMATE CHANGE (MoEFCC)

Ministry of Environment, Forest and Climate Change is the main concerned union ministry in the "National Electric Mobility Mission Plan 2020" initiative. The ministry also notified Draft Battery Waste Management Rules, 2020 to strengthen the ecosystem for handling and disposal of batteries across India.

3.5.11 MINISTRY OF SCIENCE AND TECHNOLOGY (MoST)

The MoST has formed a "Technology Platform for Electric Mobility (TPEM)", funded primarily by the MoHIPE. MoST is playing a key role in developing an electric mobility standardization roadmap for India.

Figure 3.2 below represents the various ministries playing an important role in creating an ecosystem for electric mobility in the country by issuing the necessary policy guidelines and regulatory framework.

3.5.12 NITI AAYOG

National Institution for Transforming India (NITI Aayog) is the premier policy 'think tank' of the Government of India (GoI), established in January 2015 via a resolution of the union cabinet which is aimed to provide both directional and policy inputs. The key focus of this commission is to achieve sustainable development through cooperative federalism in the policy-making process by fostering the involvement of state governments of India using a bottom-up approach. In addition to designing long-term and strategic policies for GoI, it also furnishes relevant technical advice to the country's national and state governments. The Prime Minister of India chairs it, and a governing council comprises Chief Ministers of all states and Lt. Governors of Union Territories (UTs).

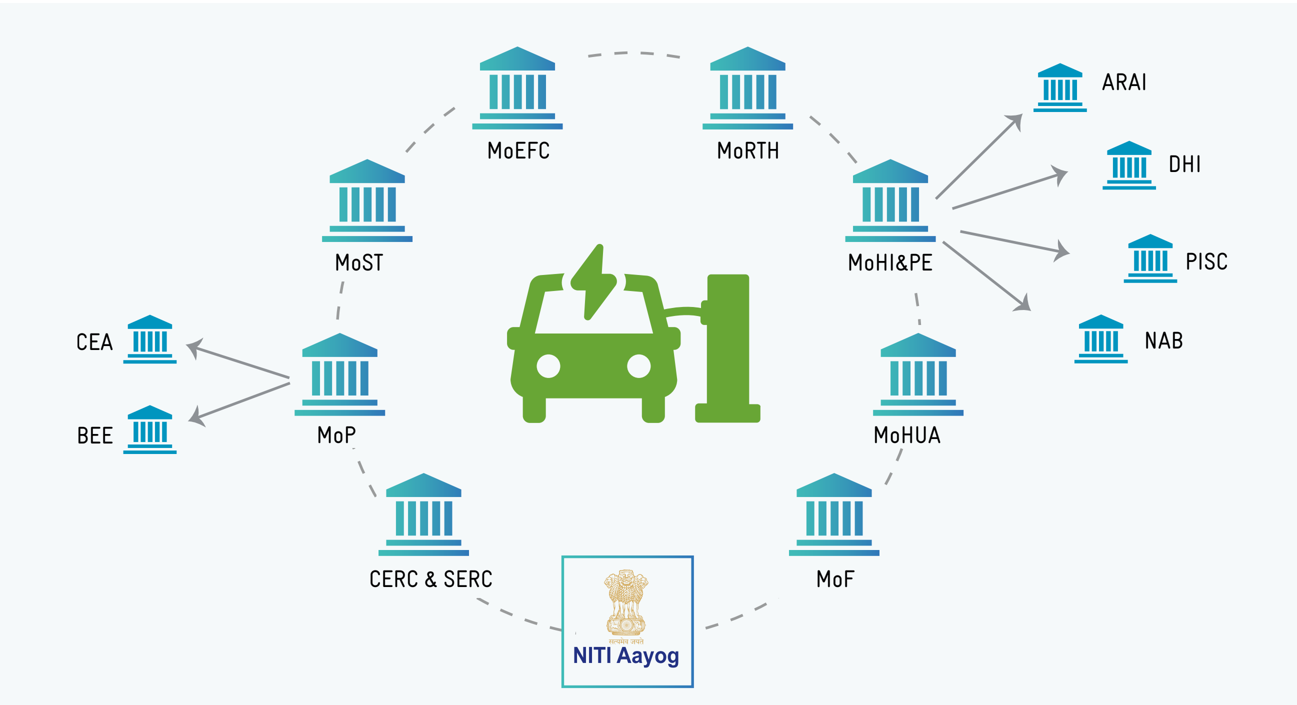


Figure 3.2: Key ministries and Commissions involved in formulating EV-related policies, schemes and regulations

NITI Aayog has taken several initiatives and issued policy guidelines under India's vision of transitioning to sustainable and green mobility through faster and efficient EV adoption across the nation. The commission issued a Model concession Agreement in January 2019 to cater e-bus procurement proposed under FAME phase II. This agreement is based on various standards issued by NITI Aayog and requires modifications according to the city's local needs. It also gives guidelines for the installation of charging stations across the country.

NITI Aayog is working along with Ministry of Finance (MoF) and Reserve Bank of India (RBI) under Electric Vehicle Finance Forum, on a series of measures in order to ensure banks and financial institutions offer credit at affordable rates to EV customers, as well as greater availability of finance products specifically customized for EVs. The objective of EV Finance Forum is to create a convening platform to bring together various stakeholders from the financial industry, OEMs, and fleet operators with government bodies to identify useful steps that the government and industry partners jointly can take to accomplish an EV financing market of INR 3.9 lakh crore (EUR 43.91 billion) by 2030 .

3.6 Standard Issuing Authority

The successful growth of EVs from all fronts requires the adequate development of appropriate standards and codes by the concerning organization overseeing the whole process. EV standards may include specific standards for charging, grid integration and safety aspects. International organizations like the International Electrotechnical Commission (IEC) have been instrumental in assisting stakeholders in this business to come up with the entire EV infrastructure globally. Following a similar approach, several standards related to EV and EV charging infrastructure have come up in India in recent times by the concerning entities to supervise the growth of EVs and maintain uniformity throughout the transition in the electrification of transportation all over the country. The authorities responsible for issuing the relevant standards and guidelines in the Indian EV ecosystem are as follows:

3.7 Energy Distributor/Retailer

Electrical power distribution or retailing is the final stage in transmitting and delivering power from the generators to the individual consumers. Technically, they act as an intermediary between the generator and the consumer. More often than not, it is not possible for a particular consumer to choose the distributor but instead the distributor is allocated depending on the area where the consumer wishes to avail the electricity connection. The distribution substations owned by these distribution companies (DISCOMs) connect to the transmission network and transform the transmission voltage to medium voltages ranging between 2-35 kV using step-down transformers. With the advent of EVs and their rising growth in recent years, they have technically become a new set of consumers for the DISCOMs, which amount to a significant rise in demand on the grid. There can be severe congestion issues and overloading of network components if the distribution network does not consider the rising EV charging loads beforehand. As a result, there has been a massive thrust in recent times for the DISCOMs to assess and upgrade their networks in preparation for the EV charging loads predicted to increase rapidly in the next few decades. Further, with V2X capabilities that a large fleet of EVs may possess in the near future, DISCOMs have also started looking into the prospects of back-feeding of power and accordingly prepare for it.

मानकः पथप्रदर्शकः

Bureau of Indian Standards (BIS) has been active in issuing several standards related to the EVs, chargers, sockets, connectors, and other EV related components. EV charger, connectors, and electric vehicle supply equipment (EVSE) standards for various types of energy transfer viz, conductive and inductive are covered in BIS standards (BIS, 2018).

Ministry of Road Transport and Highways

Ministry of Road Transport and Highways (MoRTH) also works towards issuing standards. MoRTH with other research institute s and departments works on standardizing AC and DC EV charging and EVSE. AIS 138 part 1 for AC electric vehicle conductive charging and AIS 138 prat 2 for DC conductive charging is issued by MORTH in 2017 and 2018 respectively (Automotive Research Association of India, 2018, 2018).

Government of India
Power of ministry
Central Electricity Authority

Central Electricity Authority (CEA) has been playing an active role in publishing essential standards and guidelines on EV charging infrastructure connection and the location of EV charging stations. It has also laid down measures related to the safety aspects of the charging infrastructure as well.

Currently, DISCOMS are responsible for providing the electrical connections for EV charging as well as implementation of the EV tariffs set by the SERCs.

The DISCOMs present in the different states and union territories of the country are shown in Table 3.5.

Table 3.5: Energy distributor/ retailers in the India

State / Region	Energy distributor/ retailer
Andhra Pradesh	• Andhra Pradesh Southern Power Distribution Company Limited (APSPDCL) • Eastern Power Distribution Company of Andhra Pradesh Ltd. (APEPDCL)
Arunachal Pradesh	• Department of Power, Government of Arunachal Pradesh
Assam	• Assam Power Distribution Company Limited (APDCL)
Bihar	• North Bihar Power Distribution Company Limited (NBPDCL) • South Bihar Power Distribution Company Limited (SBPDCL)
Chhattisgarh	• Chhattisgarh State Power Distribution Company Limited (CSPDCL)
Goa	• Electricity Department, Government of Goa
Gujarat	• Uttar Gujarat Vij Company Limited (UGVCL) • Madhya Gujarat Vij Company Limited (MGVCL) • Pashchim Gujarat Vij Company Limited (PGVCL) • Dakshin Gujarat Vij Company Limited (DGVCL) • Torrent Power Ltd.
Haryana	• Uttar Haryana Bijli Vitran Nigam (UHBVN) • Dakshin Haryana Bijli Vitran Nigam (DHBVN)
Himachal Pradesh	• Himachal Pradesh State Electricity Board (HPSEB)
Jharkhand	• Jharkhand State Electricity Board (JSEB) • Bokaro Power Supply Company Limited (BPSCL)
Karnataka	• Bangalore Electricity Supply Company (BESCOM) • Mangalore Electricity Supply Company (MESCOM) • Hubli Electricity Supply Company (HESCOM) • Gulbarga Electricity Supply Company (GESCOM) • Chamundeshwari Electricity Supply Company (CESCOM)
Kerala	• Kerala State Electricity Board Limited (KSEB)
Madhya Pradesh	• Madhya Pradesh Paschim Kshetra Vidyut Vitaran Company Limited • Madhya Pradesh Poorv Kshetra Vidyut Vitaran Company Limited • Madhya Pradesh Madhya Kshetra Vidyut Vitaran Company Limited
Maharashtra	• Maharashtra State Electricity Distribution Company Limited (MSEDCL) / Mahavitaran / Mahadiscom • Tata Power Limited • Reliance Energy Limited • Adani Electricity Mumbai Limited (AEML) • BEST Undertaking
Manipur	• Manipur State Power Distribution Company Limited (MSPDCL)
Meghalaya	• Meghalaya Power Distribution Corporation Limited (MePDCL)
Mizoram	• Power & Electricity Department, Government of Mizoram
Nagaland	• Department of Power, Government of Nagaland
Odisha	• Tata Power Northern Odisha Distribution Limited (TPNODL) • Tata Power Western Odisha Distribution Limited (TPWODL) • Tata Power Southern Odisha Distribution Limited (TPSODL) • Tata Power Central Odisha Distribution Limited (TPCODL)
Punjab	• Punjab State Power Corporation Limited (PSPCL)

State / Region	Energy distributor/ retailer
Rajasthan	• Jodhpur Vidyut Vitran Nigam limited • Ajmer Vidyut Vitran Nigam limited • Jaipur Vidyut Vitran Nigam limited
Sikkim	• Energy and Power Department, Government of Sikkim
Tamil Nadu	• Tamil Nadu Generation and Distribution Corporation Limited (TANGEDCO)
Telangana	• Northern Power Distribution Company of Telangana • Southern Power Distribution Company of Telangana
Tripura	• Tripura State Electricity Corporation Limited (TSECL)
Uttar Pradesh	• Purvanchal Vidyut Vitaran Nigam Limited • Paschimanchal Vidyut Vitran Nigam Limited
Uttarakhand	• Uttrakhand Power Corporation Limited
West Bengal	• West Bengal State Electricity Distribution Company (WBSEDCL) • Calcutta Electric Supply Corporation (CESC)
Andaman and Nicobar Islands	• Electricity Department, Andaman and Nicobar Administration
Chandigarh	• Chandigarh Administration (Privatization in progress)
Dadra and Nagar Haveli and Daman and Diu	• Dadra and Nagar Haveli Distribution Corporation Limited • Daman and Diu Electricity Department
Delhi	• Delhi Power Company Limited (DPCL) – Holding Company • Indraprastha Power Generation Company Limited (IPGCL) – GENCO • BSES Rajdhani Power Limited (BRPL) (South & West Delhi) • BSES Yamuna Power Limited (BYPL) (Central & East Delhi) • North Delhi Power Limited (NDPL) (North Delhi) • Tata Power Delhi Distribution Limited (TPDDL) • New Delhi Municipal Council (NDMC) • Military Engineering Services (MES)
Jammu and Kashmir	• Jammu and Kashmir Power Development Department
Lakshadweep	• Electricity Department, U.T. Administration of Lakshadweep
Pondicherry	• Electricity Department, Government of Puducherry
Ladakh	• Electric M&RE Division

3.8 Transmission System Operator

A Transmission System Operator (TSO) is an entity responsible for the reliable transport of energy through electrical power on a national or regional level from the generators to regional or local distribution networks, using fixed infrastructure that primarily comprises a high voltage electrical network. Because of the heavy costs involved in setting up and maintaining a national transmission framework, TSOs are often a natural monopoly in most countries and are subject to the state's regulations.

For the efficient electrification of the transportation system, one of the key goals is to assess the readiness of the transmission infrastructure on whether the systems are capable of handling the increasing EV charging load if required and if not, what kind of upgrades would be necessary considering the futuristic growth of EVs.

Some of the biggest challenges that a TSO might face with the rise of EVs are primarily based on the volume and the timing of charging. The overall projection of demand coming from EVs that directly stresses the transmission network is massive and will become a significant challenge for electricity grids globally. The grids are often constrained in their transmission capability and may rapidly face network congestion without appropriate upgrades.

The complete list of TSOs operating in the different regions of the country are given in Table 3.6.

Table 3.6: List of TSOs in India

State / Region	Transmission System Operator
National	Power System Operation Corporation Limited (POSOCO)
Andhra Pradesh	Transmission Corporation of Andhra Pradesh (APTRANSCO)
Arunachal Pradesh	Department of Power, Government of Arunachal Pradesh
Assam	Assam Electricity Grid Corporation Limited (AGECL)
Bihar	Bihar State Power Transmission Company Limited
Chhattisgarh	Chhattisgarh State Power Transmission Company Limited (CSPTCL)
Goa	Electricity Department, Government of Goa
Gujarat	Gujarat Energy Transmission Corporation Limited (GETCO)
Haryana	Haryana Vidyut Prasaran Nigam Limited (HVPNL)
Himachal Pradesh	Himachal Pradesh Power Transmission Corporation Limited (HPPTCL)
Jharkhand	Jharkhand Urja Sancharam Nigam Limited (JUSNL)
Karnataka	Karnataka Power Transmission Corporation Limited (KPTCL)
Kerala	Kerala State Electricity Board (KSEB)
Madhya Pradesh	Madhya Pradesh Power Transmission Company Limited (MPTRANSCO)
Maharashtra	Maharashtra State Electricity Transmission Company Limited (MAHATRANSCO)
Manipur	Manipur State Power Company Limited (MSPCL)
Meghalaya	Meghalaya Energy Corporation Limited (MeECL)
Mizoram	Power & Electricity Department, Government of Mizoram
Nagaland	Department of Power, Government of Nagaland
Odisha	Odisha Power Transmission Corporation Limited (OPTCL)
Punjab	Punjab State Power Corporation Limited (PSPCL)
Rajasthan	Rajasthan Rajya Vidyut Prasaran Nigam Limited (RVPN)
Sikkim	Department of Power, Government of Sikkim
Tamil Nadu	Tamil Nadu Transmission Corporation Limited (TANTRANSCO)
Telangana	Transmission Corporation of Telangana (TSTRANSCO)
Tripura	Tripura State Electricity Corporation Limited (TSECL)
Uttar Pradesh	Uttar Pradesh Power Transmission Corporation Limited (UPTRANSCO)
Uttarakhand	Uttarakhand Power Corporation Limited
West Bengal	West Bengal State Electricity Transmission Company (WBSETCL)
Andaman and Nicobar Islands	Electricity Department, Andaman and Nicobar Administration
Chandigarh	Electricity Department, Government of Chandigarh
Dadra and Nagar Haveli and Daman and Diu	Dadra and Nagar Haveli Distribution Corporation Limited & Daman and Diu Electricity Department
Delhi	Delhi Transco Limited (DTL)
Jammu and Kashmir	Jammu And Kashmir State Power Development Corporation
Lakshadweep	Electricity Department, U.T. Administration of Lakshadweep
Pondicherry	Puducherry Power Corporation Limited (PPCL)

3.9 EV Training Providers

Skill development is another key domino in the EV chain. Different levels of technically sound people are required to build the confidence of the people to delve into the EV ecosystem. From highly skilled engineers and designers to skilled mechanics in the local repair shop, there is need for skilled labour across the spectrum. For this, skill development course is needed to create the necessary skills in the labour pool. Some of the academies/institutions that are providing skill development for EVs are listed in Table 3.7

Table 3.7: List of EV training provider in India

Institution	Location
Academy of EV Technology	West Bengal, Maharashtra, Uttarakhand
Amika Global Education	New Delhi
Autobot India	Maharashtra
Devise Electronics	Pune
Decibels Lab	Karnataka
Pmanifold EV Training and Certification Program	Maharashtra
Pragyatmika	Uttar Pradesh
ARAI Academy Training Centre	Maharashtra
DIY Guru	Haryana
Academy of EV technology	West Bengal
Logiczap Technologies OPC	Odisha
SkillShark EduTech	Telangana
Haritha TechLogix	Karnataka
TESLA EV Academy	Maharashtra

3.10 Payment Mechanism for EV Charging

Generally, a payment manager is the entity in the EV market that is directly connected to the customers for bill or payment collection. The payment manager can be a separate entity but sometimes payment manager can be the Charge Point Operator. If e-roaming facilitates EV markets, payment managers are the independent companies that manage the billing and transaction aspects in EV charging. Presently, payment managers are not actively participating in the Indian EV market, where CPOs directly receive payments from the customers using credit card, debit card, eWallets, and UPI, Net banking, PayTM, Gpay, PhonePay, Mobikwik, Paypal, etc .

3.11 Investors in EV Ecosystem

Investors act like fuel for running the EV market. They are the experts in the markets with sufficient investment and risk-taking ability. As EV market is an upcoming and developing market, it has high risk with comparatively less return guarantee. At present, investors in EV markets are the big firms, organizations, or teams that collectively and combinedly take investment decisions. Due to the newer sector, higher risk, and updated technology, investors in the EV markets are highly analysis-oriented. Investors use data mining techniques to analyse the risk, benefits, and optimised investment in the market. Data scientists, investors, big data, and data mining techniques synchronize to invest in the growing EV market. List of the Investors in Indian EV market is given in Table 3.8.

Table 3.8: Few prominent investors in the EV sector in India

Region	Investors in EV market
Nationwide	• Inventous Capital India, Bengaluru • Rocketship, US Based (For YULU) • Bajaj Auto Ltd • Blume Ventures • 3one4 Capital • Wavemaker • TVS Motors • Inflection Point Ventures • Survam Partners, • Venture Catalysts, • Mumbai Angels, • Chhattisgarh Investments Limited, • JITO Angels, • Lets Venture Fund, • Kaplavriksh Fund (For Blusmart) • Hero MotoCorp(For Ather Energy)

3.12 Testing Authority

To ensure safety and compliance with applicable regulations, all the present and upcoming EV models need to undergo stringent testing for homologation, from both a vehicular and individual component point of view. Today, the testing process goes a step further than just testing the EV and its components. It also involves the charging stations, which can be either AC or DC-based, and all the auxiliary systems associated with it. One of the critical aspects of EV testing is testing the battery packs, which, although a plentiful energy source, is also a potential hazard. Its constituent modules comprise many individual battery cells and are all subjected to different testing criteria.

In keeping with the emphasis on e-mobility by the Government of India, which has resulted in significant growth of EVs, the Automotive Research Association of India (ARAI), an autonomous body affiliated to the Ministry of Heavy Industries and Public Enterprises and the leading R&D and certification institute in India, has established a Centre of Excellence (CoE) for electric mobility to support the automotive industry in the development, evaluation and certification of the EVs and its associated components. The organization accommodates state-of-the-art facilities for the testing of a wide variety of EVs ranging from 2W/3W, passenger cars, buses and commercial vehicles, the constituent components key to the making of an EV such as batteries, motors, controllers, and chargers, as per the applicable testing and evaluation standards. Some of the critical activities undertaken by ARAI in the context of EVs and the associated charging infrastructure are:

- Battery Performance and Safety Testing
- Electric Motor Characterization
- Vehicle Performance and Homologation as per CMVR on Chassis Dynamometer and Test Tracks
- Charger Testing and Certification
- EV Development
- Lithium-Ion Battery Technology from Space to Automotive
- Chassis Design and Development for Electric City Bus
- Rechargeable Energy Storage System (RESS) Evaluation using Computer-Aided Engineering (CAE)
- Four Poster durability of EV in Climatic Chamber for structural adequacy
- Suspension Evaluation of EVs using Multi-axis Technique
- Evaluation of Battery Structure and supports using Multi-axis Shaker table "MAST"

National Automotive Testing and R&D Infrastructure Project (NATRiP) is a government-funded testing project. Under NATRiP, six different testing sites are available out of which three sites are in use for EV testing, as mentioned in Table 3.9[21].

Table 3.9: EV testing and certification centres in India

Region	Testing centres
Nationwide	• National Automotive Test Tracks (NATRAX), Indore, Madhya Pradesh • International Centre for Automotive Technology, Manesar, Haryana • Automotive Research Association of India, Pune

21 GoI, "National Automotive Testing and R&D Infrastructure Project (NATRiP)," accessed January 2, 2022, http://www.natrip.in/#.


240V~
110V~

04

EV Policies, Regulations and State-wise EV Statistics in India

Electrification of vehicles is regarded as an important intervention to strengthen the efforts taken to reduce carbon emissions. India, an oil import dependent country, as being a signatory of the Paris agreement on climate change has initiated a new era of sustainable mobility by creating a momentum through several policy and regulatory interventions that encourage adoption of electric vehicles. The growing interest among the policy makers to encourage this paradigm shift to Electric Vehicle by phasing out fossil fuel based Internal Combustion Engine (ICE) based vehicles are driven by five major imperatives:

1. To reduce excessive dependence on petroleum imports and improve the country's energy security.
2. To reduce vehicular pollution: emission of greenhouse gases, particulate matter etc. which depletes air quality.
3. Identifying pattern of effective EV adoption across the vehicle segments: 2W, 3W and 4W private and commercial.
4. Analysing the role of EV Charging infrastructure, both at the technical and the financial levels
5. Effective off-take of Renewable energy in EV supply

Policies play a critical role in unleashing potential of new technologies and promoting new opportunities. Similarly, technical standards are essential to streamline technological development aspects along with the compatibility of various components used in a value chain. It is also important to ensure the reliability of technologies which in turn increase consumer confidence thus providing a conducive environment for the technology adoption. The Government of India's (GoI) determination to leapfrog to a sustainable mobility future is evident through its conducive and effective policies and regulatory measures set in motion offering strong and attractive incentives to switch to electric vehicles. In line with the efforts at the National level, 16 Indian states and 1 union territory have so far published final version and 3 states and 1 UT have released draft version of their respective EV policies. India has a significant potential to become one of the largest EV markets in the world and to support India's goal to be a leader in sustainable development, the role of its private-public collaboration should be enhanced in adoption and diffusion of EVs and intelligent policy development across the country. This section will focus on detailing out various policy and regulatory measures set in action by several key stakeholders, such as ministries under central and state government, and other sector regulators who shape an eco-system of electric mobility in India. In this section, special focus has been given to specific clauses of the policies that are related to EV charging infrastructure and its integration with the distribution grid.

4.1 EV Road map: Journey of Indian Electric Mobility Sector

India has taken multiple initiatives to promote electrification of vehicles by various policy incentives, regulatory support, fiscal and non-fiscal measures which resulted in the faster growth of electric vehicles in Indian automobile sector. The statistics shows a significant increase in the paradigm shift from ICE vehicles to EVs in last 10 years shown in Figure 5.2, which recorded numerous promotional measures such as fiscal incentives for EV buyers, development of public EV charging infrastructure etc. which supports uptake of e-mobility in the country. Policy and regulatory measures are vital to provide a push to promote electric vehicle adoption, the government had been pushing firmly in developing policies and support structures for the transition to cleaner transport system. This sub section reviews various policies issued at different stages of the journey of Indian electric mobility through the years. The first milestone in the Indian EV history is National Mission for Electric Mobility (NMEM) developed to steer and synergize efforts of all the stakeholders in and outside of government. The two inter-related key objectives of NMEM are improvement of national energy security and growth of manufacturing capabilities of EV technologies in the domestic market. The formation and setting up of National Council for Electric Mobility (NCEM) and National Board for Electric Mobility (NBEM), which were the apex bodies under GoI aimed to make recommendations to promote e-mobility and electric vehicle manufacturing. But the growth of number of EVs in India was kickstarted by an incentive scheme implemented by MNRE during 2010 through its Alternate Fuels for Surface Transportation Program (AFSTP) (MNRE, 2010). It proposed an incentive of 20% capital subsidy which resulted in high sales of e-bikes in the country during the year. Later the scheme was scrapped and it was re-introduced as NEMMP 2020, but the demand incentive scheme was started in 2015-16 after the implementation of FAME scheme. Figure 4.1 represents the timeline for key national level initiatives taken by policy makers and regulators to promote adoption of e-mobility in India.

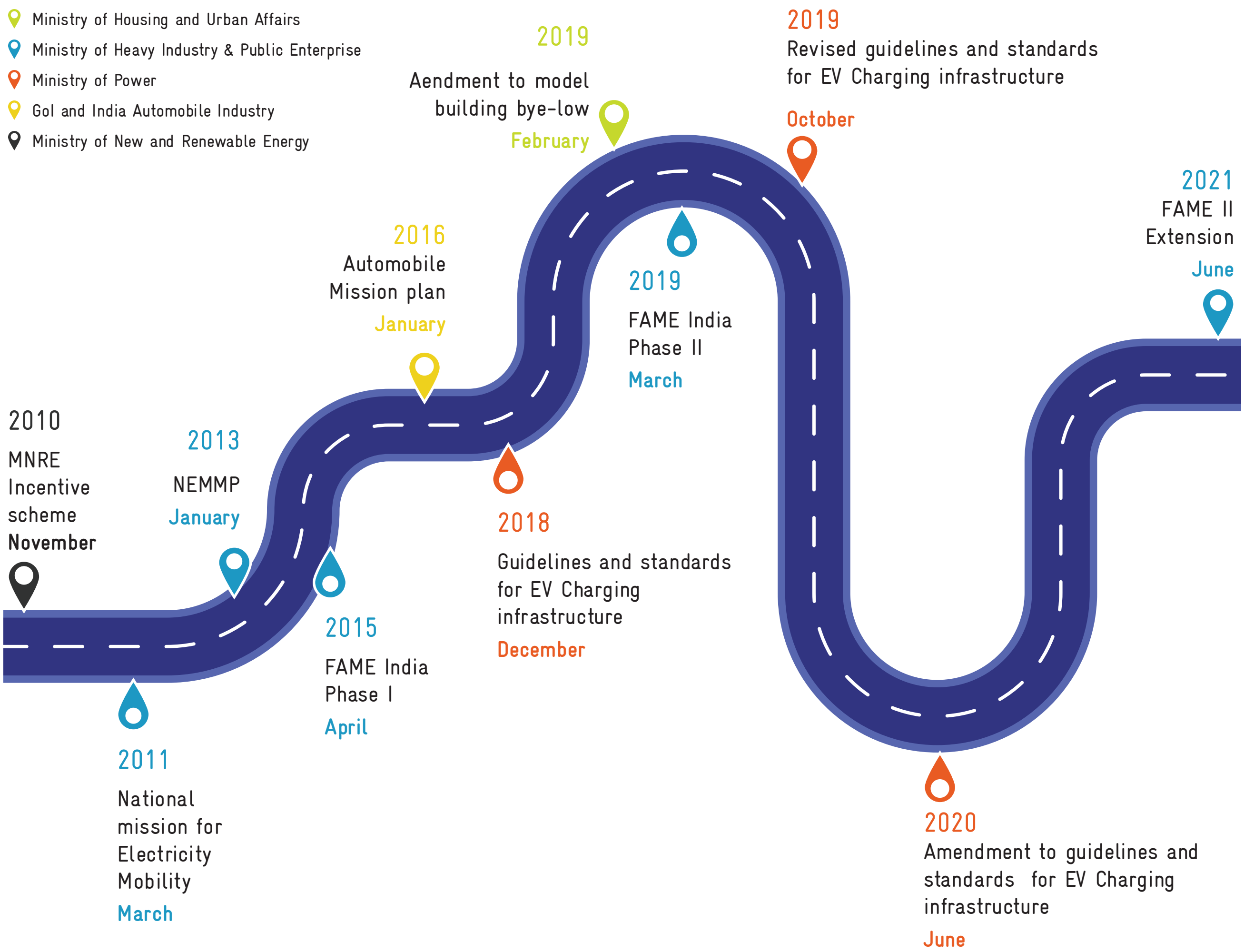


Figure 4.1: Policy Roadmap for EV development in India

4.1.1 NATIONAL ELECTRIC MOBILITY MISSION PLAN (NEMMP) 2020

In 2013, Government of India launched NEMMP 2020 under DHI with a vision of promoting electric vehicles in India[22]. It intended to reduce (a) India's extreme dependency on crude oil import for transportation and thereby improving energy security, and (b) carbon emissions and air pollution by removing ICE based automobiles. The different objectives of NEMMP have been shown in Figure 4.2.

Indian automobile sector has made a tremendous progress in the last decade and is emerged as one of the fastest growing automobile industries globally (sixth largest vehicle market in world in 2020[23]). The nation is highly dependent on the import of crude oil for its energy needs, where the percentage of oil import by India has risen form 85% in 2010 to a forecasted 92% of the total demand by 2020 posing a serious challenge to future energy security[24]. Through NEMMP, the flagship program envisioned to achieve national energy security under NMEM, India set out ambitious targets of 6-7 million electric / hybrid vehicles on road (5-10% of total vehicles) in the country by 2020 with an expected fuel savings of 2.2 to 2.5 million tonnes. Various schemes, interventions, policies, and projects were finalized and approved for roll out by NBEM/NCEM and the different priority areas considered for outlining the incentives under NEMMP were EV manufacturing, development of charging infrastructure, demand incentives and research and development.

Based on the assessment made by the joint Government-Industry study, the total investment for setting up the required infrastructure, vehicle segment-wise as envisaged in the NEMMP document is summarised in Table 4.1. It includes both generation of power and charging

Table 4.1: Vehicle segment-wise Infrastructure investment

Area	4 W	2 W	3 W	Buses	LCV	Total
Additional Generation Capacity (MW)	150-225	600	10-15	<5	10-20	775-865
Power Infrastructure (in million) (INR/ EUR)	(12,000 -13,000) / (136-147)	(3300-3400) / (37.4-38.6)	(75-85) / (0.85-0.96)	(20-30) / (0.23-0.34)	(90-100) / (1.03-1.13)	(4685-4915)/ (53.2-55.8)
Charging Infrastructure (in million) (INR/ EUR)	9,500 -10,000 / (108 – 114)	-	(70-80) / (0.79-0.91)	(10-20) / (0.11-0.23)	(115-125)/ (1.31-1.42)	(1145-1225)/ (13-13.9)

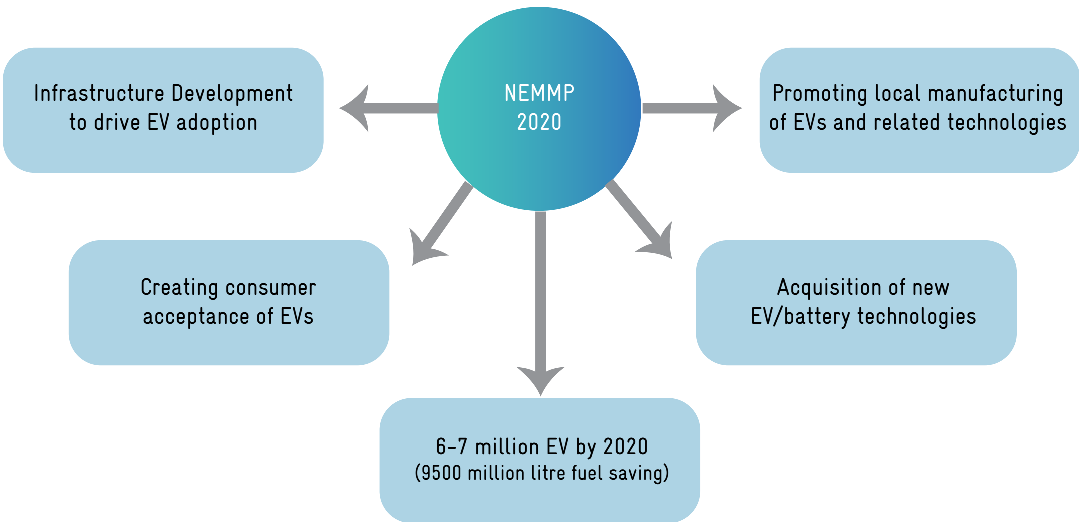


Figure 4.2: NEMMP 2020 Objectives

22 DHI, "National Electric Mobility Mission Plan 2020," Ministry of Heavy Industries & Public Enterprises, Government of India, 2013.
23 International Organization of Motor Vehicle Manufacturers, "2020 Production Statistics", https://www.oica.net/category/production-statistics/2020-statistics/
24 DHI, "National Electric Mobility Mission Plan 2020." Ministry of Heavy Industries & Public Enterprises, Government of India, 2013.

infrastructure investments where the major portion is slated for setting up additional power generation capacity in order to meet demand from the projected EV penetration by 2020.

The rollout of EV charging infrastructure was planned in a phased manner as indicated in Figure 4.3. It is a three stage approach in which the first phase spanning for a year involves achieving immediate to short-term objectives. The second phase involves medium-term objectives and activities mainly focused on the initial essential work done and include deeper impact assessment studies and programs. The final phase involves medium to long term objectives and focus on regular and reliable electricity supply options along with advanced and fast charging/ recharging infrastructure developments.

It was expected that the Government of India would support the setting up of EV charging infrastructure in the initial stages of development when the pilot projects would be rolled out for cities; and during the phase when the businesses would be at the nascent stages. Subsequently, participation from private sector was also expected in developing countrywide charging infrastructure. However, despite the considerable measures and plans the Government of India had taken to keep efforts aligned with the provisions laid down under NEMPP, the EV penetration level stood nowhere near to the anticipated target level. It indicates that the steps undertaken to promote E-mobility across the country were not sufficient enough to make it successful. Nevertheless, the actions under NEMMP have provided the initial boost for the uptake of the EV sector as well as helped in spreading awareness to consumers and industry players.

4.1.2 FASTER ADOPTION AND MANUFACTURING OF (HYBRID AND) ELECTRIC VEHICLES (FAME I)

It was the flagship scheme of central government under NEMMP 2020 mission, launched in April 2015 by GoI, and aimed at bringing down the price of hybrid and electric vehicles to stimulate early adoption of these vehicles and provide a strong domestic market for such vehicle technologies .

This scheme provides subsidies/ financial incentives in order to achieve the objectives of NMEM. The total proposed capital for the scheme was INR 795 crore (EUR 92 million) which was later increased to INR 895 crore (EUR 103 million) . The entire scheme is proposed till FY 2022 to enhance EV market in India. It was launched for a span of 2 years, starting from FY 2015-2016 and FY 2016-2017, and was then extended four times, spanning six months each and for a period of one year during FY 2017-2019.

Under this scheme, EV buyers were provided direct subsidy for purchasing EVs using the funds of FAME I. Along with this direct subsidy, special grants were also allocated for specific projects under the pilot projects. Research and development technologies, public charging infrastructure components etc. were sanctioned under this scheme and 465 public transport buses were purchased and presented to various states/cities. Though this scheme could not utilize the sanctioned fund completely, (only 41% of the total INR 895 crore (EUR 103 million) was utilized in its four years period) it has provided the steppingstone for the growth of

Phase I (1st year)	Phase II (Year 1st - 3rd)	Phase III (3rd - 2020)
In depth evaluation of various options, prioritization and putting in place the required framework, enabling policies, charging infrastructure standards, laws and undertaking detailed studies that will facilitate the roll-out of the optimum EV infrastructure	This phase deals with finalisation of legal framework, rollout of EV charging infrastructure on pilot project mode in various cities, EV infrastructure consortium building activities, development of possible business models for reuse and recycling of Li-ion batteries etc.	i. Ensure availability of reliable and regular electricity supply ii. Making available adequate recharging facilities with convenient access iii. Development of EV charging as a viable business entity iv. Synergic linkage of EV charging infrastructure with RE generation infrastructure v. Development of public rapid charging infrastructure. (fast chargers/battery swapping centers)

Figure 4.3: Phased approach for rollout of infrastructure under NEMMP

Electric mobility in Indian automobile sector. Under this scheme 520 EV charging stations were sanctioned out of which 452 charging stations were installed as of December 2021[25]. The scheme proved to be successful in spreading awareness among consumers and industry players about electric vehicles and provided the momentum for the transformation to cleaner transport systems.

4.1.3 AUTOMOTIVE MISSION PLAN 2016-26 (AMP)

It is a collective initiative by GoI, and India Automotive Industry envisioned to lay down roadmap for the entire automobile sector development, specifically focused on where vehicle industry along with its auto components and tractor industry should reach over the next ten years (2016-26). The development and success of the plan are to be defined in terms of a number of factors such as the total size of the sector, its contribution towards country's GDP growth, global footprint in technology, competitiveness in the respective markets and its capabilities. AMP 2016-26 is proposed as a continuation of AMP 2006-16 which is considered as a successful intervention that made India not only an automobile producing hub but also a design and development hub at global level by the exemplary Government-Industry partnership. This indicated that faster adoption of xEVs and their manufacturing in Indian territory is a wise investment that the nation can make to achieve sustainable growth for future generations. Among the various objectives under this scheme, majorly focused on boosting manufacturing, employment, mobility, and export, it also put forward vision on growing technologies like **electric vehicles and associated infrastructure with** new fuel-efficiency regulations.

4.1.4 FASTER ADOPTION AND MANUFACTURING OF (HYBRID AND) ELECTRIC VEHICLES (FAME II)

The second phase of FAME scheme (FAME II) announced by GoI in March 2019 had a budgetary provision of INR 10,000 crore (EUR 1158 Million), which included the unspent INR 366 crore (EUR 42 Million) from FAME I scheme (GoI, 2019). It was launched for a two-year span from FY 2019-20 till FY 2021-22. FAME II aims to leverage the buzz created by its first phase and to promote the take-off of EV mobility sector in India. About 86 % of its total outlay is reserved specially for meeting demand incentive requirements as the scheme is focused on supporting demand aspects.

As far as the vehicle subsidies are considered, the scheme is supporting sale of almost 1.56 million vehicles of all categories, but the subsidies are limited to EVs using advanced Li-batteries and other newer technologies only.

4.1.4.1 Recent amendments to FAME II

FAME II policy has been extended by two years i.e., till 31st March 2024 with the approval of MoHI&PE on 25 June 2021. The policy is revised with addition of some points on 11 June 2021. The additional points are as listed below:

- A revised demand incentive of INR 15,000 (EUR 174)/- per kWh will be given to 2W electric vehicles.
- The cap on maximum incentive per vehicle for 2W EVs will be 40% of the cost of the vehicle.

Table 4.2: Summary of EV Schemes in India

Elements	Mention in Scheme		
	NEMMP 2020	FAME I	FAME II
Release Date	August 2012	April 2015	March 2019
Duration	8 years (till 2020)	7 years (till 2022)	5 years (till 2024)
Present status	GoI has taken considerable measures to keep efforts aligned to the provisions laid down under NEMMP. The EV penetration target of 14%-16% by 2020 as envisaged under NEMMP was not achieved.	2.8 lakh vehicles sold, 30 OEMs registered and only 41 % of overall outlay was utilized. FAME I scheme is considered failure in terms of its fund utilization.	FAME II scheme allotted 10% of its overall outlay for EV charging infrastructure development.

25 MoHI&PE, "Ministry of Heavy Industries Sanctions 520 Charging Stations under the Phase-I of FAME India Scheme" (Press Information Bureau, December 7, 2021), https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1778958.

Elements	Mention in Scheme		
	NEMMP 2020	FAME I	FAME II
Budget Allocated	INR 20,000 to 23,500 crore (EUR 2316-2720 million)	INR 795 crore (EUR 92 million) which was later increased to INR 895 crore (EUR 103 million)	INR 10,000 crore (EUR 1158 million)
Focus Area	1. Demand Incentives 2. R&D investment 3. Power Infrastructure 4. Charging infrastructure	1. Technology Development 2. Demand Creation 3. Pilot Projects 4. Charging Infrastructure	1. Demand Incentives 2. Charging Infrastructure 3. Administration
Impact on the charging ecosystem in India	No significant impact on charging ecosystem recorded under this scheme.	452 charging stations had been installed across the country out of 520 EVCS sanctioned (as of 7 December 2021)	DHI has sanctioned 2,877 EV Charging Stations, amounting to Rs 500 Crore (EUR 58 Million) (Approx.) in 62 cities across 24 States/UTs under FAME scheme phase II. Also 1544 chargers allocated for highways.

4.2 Building Bye-laws in India

Setting up an EV charging station in the residential area is essential to regularise the EV as the main transportation component. Building bye-law provides the standard that governs the adequacy of EV charging infrastructure in local and residential area. Norms in the bye-laws set the number of charging stations at specific location considering the charging technology, types of available EVs, and type of location to ensure charging requirements are fulfilled. Bye-laws mainly cover the building and residential premises for establishing the norms for minimum charging infrastructure. The Ministry of Housing and Urban Affairs has already released an amendment to the existing building bye-laws to cater to the charging needs of the EV users[26]. The proposed guidelines would act as a guiding document to the respective authorities to incorporate norms and standards for EV charging infrastructure in the respective building bye-laws. The amendments made by MoHUA have been discussed in this section.

Based on the maximum possible EV holders, the parking capacity and minimum parking space for the charging infrastructure needs to be established. "Amendments in Model Building Bye-Laws (MBBL – 2016) for Electric Vehicle Charging Infrastructure" states that the EV charging infrastructure in the building should be at least 20% of the total vehicle holding capacity or parking space in the building. There are different locations identified for setting up EV charging: private houses, fuel refilling station, commercial/private buildings and standalone charging station. Charging infrastructure requirement norms for house or self-plot is given below.

Charging options and their information for different type of vehicles are given in Table 4.3

In a public charging station (PCS) at building premises, the service provider needs to install more charging points than the minimum required charging point to meet the above-stated ratio of charging points to the number of EVs. Another vital point for service providers is that the PCS should have spot payment options for ease in charging. The establishment of a battery swapping station and fluid cool battery charging station[27] is not mandatory for PCS in building premises.

Slow charger symbolises AC slow charging with 15 A/230 V single phase plug with a maximum power rating of 2.5 kW. Fast charger symbolises DC fast charging with a power rating of 50 kW or more. It is generally useful for top-up charging rather than the full charging of the vehicle. This type of charging is useful for fleet operators.

While complying with increased power requirement due to EV charging point at building premises, EV charging load sanctioning is important. DISCOM should sanction the additional load requirement. Under 2019 amendment to MBBL 2016, it has been advised that for the long-term vision of 30 years, a safety factor of 1.25 times the cumulative power capacity of all the charging points is to be assigned to the premises by respective DISCOM to cater

26 GoI, "Amendments in Model Building Bye-Laws (MBBL - 2016) for Electric Vehicle Charging Infrastructure" (Ministry of Housing and Urban Affairs, Govt. of India, 2019), http://mohua.gov.in/upload/whatsnew/5c6e472b20d0aGuidelines%20(EVCI).pdf

27 Fluid cooled battery charging station uses fluid cooling heat management methods for battery cells and packs. Fluid cooling includes conductive looped cold plates or full immersed into dielectric fluid.

Ownership of charging station: House or landowner

Meter type: Domestic meter

Charger type: Slow charger, but it can be adopted to any other type as per owner's requirement.

Charing type and number of guns: AC charging with single charging gun

Number of charging stations: Minimum single charging station is required and can be increased as per the owner's requirement.

Charging facility in one's own home should be constructed by the owner and is eligible for private use, not commercial use.

Charging requirements for all other buildings, including apartments:

Any public charging station established in any building or private premises should provide a minimum charging facility at that public charging station. For providing sufficient charging points as per types of EV share, the ratio of different charging infrastructure type such as slow charging stations and fast charging stations are provided below.

Ownership of charging station: Service provider

Meter type: Commercial meter

Charger type: As per the minimum requirement stated in MoP guidelines

Number of charging stations:

4-wheeler	3-wheeler	2-wheeler	Public vehicle
Slow charger: each 3 EVs Fast Charger: each 10 EVs	Slow charger: each 3 EVs Fast Charger: each 10 EVs	Slow charger: each 3 EVs Fast Charger: each 10 EVs	Fast charger: each 10 EVs

for the future load requirement due to advancements in charging technologies and gradual increase in EV adoption.

The modified facility of fuel refill stations states that PCS with minimum requirements indicated by MoP guidelines and minimum area of 13.5m x 5.5m should be allotted to PCS. A fast-charging station with CCS and CHAdeMO connector should have minimum area of 15m x 7m.

Public charging station should establish the charging points considering the ratio of one fast charger for 10 EVs and one slow charger for 3 EV in a distance of 25 km and 3 km, respectively.

The public charging station should establish the charging points considering the ratio of one fast charger for 10 EVs and one slow charger for 3 EV in a distance of 25 km and 3 km, respectively.

At present, some states have adopted the amendment MBBL-2016 while few others have taken measures to facilitate installation of EV chargers. The key measures taken by Delhi, Karnataka, Gujarat, Odisha, Maharashtra, Tamil Nadu, Punjab, and Goa are summarised in Table 4.4.

Table 4.3: Charging options for various vehicle types (by ownership)

Type of vehicle	Private Charging Infrastructure	Public charging station	Generally established charging place
2 Wheelers	Slow charging/ battery swapping	Slow charging	Resident and workplace
3 Wheelers	Slow charging/ battery swapping	Slow charging/ battery swapping	Residential spaces/ Parking spaces
Cars	Slow charging/ battery swapping	Fast charging	Residential spaces/ Parking spaces/ workplace
Buses	-	Fast charging/ battery swapping	Depot/ Bus terminals

Table 4.4: Building bye-laws adopted by different State Governments

<table>
<tr><th>State</th><th>Key points</th></tr>
<tr><td>Delhi[28] and Karnataka[29]</td><td>

In the building premises, charging infrastructure for EVs shall be 20% of the all vehicle holding capacity/ parking capacity based on the occupancy pattern and total parking provision in a building type
For public charging station, additionally, the premises will have a power load equivalent to the power requirement of simultaneous operation of all charging points with a safety factor of 1.25
The private charging station based on ownership should be equipped with domestic meter and slow charger as per the owner's requirement with AC gun having minimum of 1 slow charging point.
Semi-public spaces including malls, shopping complexes, movie theatres, hotels etc. having a parking capacity higher than 100 should have at least 5% of the capacity fitted with EV chargers with a minimum of 3.3 kW output[30].
For ensuring the sufficient charging points at public charging station the ratio of charging points to EVs are specified as below:

<table>
<tr><td>EV type</td><td>Number of charging point</td></tr>
<tr><td>2W</td><td>1 slow charger for each 2 EV</td></tr>
<tr><td>3W</td><td>1 slow charger for each 2 EV</td></tr>
<tr><td>4W</td><td>1 slow charger for each 3 EV and 1 fast charger for each 10EV</td></tr>
<tr><td>Passenger vehicle/ buses</td><td>1 fast charger for each 10 EV</td></tr>
</table>
</td></tr>
<tr><td>Gujarat[31]</td><td>
Minimum area and frontage of the building premises with EV charging station, and charging station with service station is as follows:
<table>
<tr><td>EV charging station type</td><td>Minimum area of building (sq. mts)</td><td>Minimum frontage on road side (mts)</td></tr>
<tr><td>Charging station without service station</td><td>500</td><td>16.5</td></tr>
<tr><td rowspan="2">Charging station with service station</td><td>2000 (other than category D7(B) D8, and D10)</td><td rowspan="2">30</td></tr>
<tr><td>500 (for category D7(B) D8, and D10)</td></tr>
</table>
Minimum parking requirement for EV charging station is as follows:
<table>
<tr><td>Fuelling and EV Charging station's area (sq. mts)</td><td>Minimum parking required</td></tr>
<tr><td>500</td><td>3 cars and 5 two-wheelers</td></tr>
<tr><td>2000 (other than category D7(B) and D8)</td><td rowspan="2">For every 500 sq.mts more than 1000sq.mts, additional parking for 1 car and 2 two-wheelers shall be required</td></tr>
<tr><td>500 (for category D7(B) and D8)</td></tr>
</table>
</td></tr>
<tr><td>Odisha[32]</td><td>
30% of the total parking space in new development of building projects with more than 1 acres, high rise buildings, and multilevel car parking projects shall be ensured with EV charging points.

Minimum requirement of 30% parking space for EV charging can be changed as per the relevant policy of the government.
</td></tr>
</table>

28 Delhi Development Authority, "Modifications in the Unified Building Bye-Laws (UBBL) for Delhi 2016," February 22, 2020, http://119.226.139.196/ddaweb/ubbl.aspx.

29 Governor of Karnataka, "Draft Bye-Law Karnataka," January 29, 2021, https://legalitysimplified.com/wp-content/uploads/2021/02/Karnataka-Municipal-corporation-model-bylaw.pdf.

30 Govt. of NCT of Delhi, "Regarding providing of Charging Infrastructure for Electric Vehicles as per Unified Building Bye-Laws (UBBL), 2016, 5th Feb., 2021.

31 Urban Development and Urban Housing Department Gujarat, "Comprehensive General Development Control Regulations –2017 Part II," January 15, 2019, https://ghtc-india.gov.in/Content/GUJ/CGDCR-2017-PART-II-PLANNING-REGULATIONS.pdf.

32 Housing and Urban Development Department Odisha, "Modified Building Bye Law Odisha," March 10, 2020, https://sujog.odisha.gov.in/Deshboard/images/Odisha%20Planning%20and%20Building%20Standard%20Notification%202020.pdf.

State	Key points
Maharashtra[33]	In a new building 20% of the total parking spaces must be EV ready. Of these 20%-30% spaces should be unreserved and for use as common parking spaces. All dedicated off-board parking spaces must convert minimum 25% of the space into EV ready by 2023 Similarly, all institutional and commercial complex shall convert 25% of their total capacity EV ready by 2023 All government offices shall covert 100% of their parking spaces as EV ready by 2025.
Punjab[34]	It states that petrol pump or filling-cum-service station shall have charging station for electric vehicle
Goa[35]	New and renovated residential building managed by Residents Welfare Associations with 10 or more than 10 equivalent parking spaces, should have at least 20% EV ready spaces with conduit installed.
Tamil Nadu[36]	Policy document mentions that apartment association with more than 50 families is encouraged to provide charging points and township with more than 500 families is encouraged to install a charging station. Additionally, the commercial building should have a charging station covering at least 10% parking of the earmarked area.

While the building bye-law amendment guidelines have been in place since 2019, they are yet to be adopted/implemented by the State Governments. Lack of adoption of the guidelines can be attributed to various factors including i) low EV penetration of EVs, more so in suburban and rural areas, and ii) potential increase in real state process due to additional infrastructure cost. Currently public charging infrastructure establishment is promoted through various subsidies to public charging stations. However, promoting EV charging infrastructure in building premises can potentially play a critical role in EV adoption.

4.2.1 AMENDMENTS TO URBAN AND REGIONAL DEVELOPMENT PLANS FORMULATION AND IMPLEMENTATION GUIDELINES (URDPFI – 2014) FOR ELECTRIC VEHICLE CHARGING INFRASTRUCTURE

Electric vehicle as viable option for long distance trips and inter-regional travel is an important aspect for overall EV adoption. To support long distance travel using EVs, The Urban and Regional Development Plans Formulation and Implementation Guideline 2014 has been amended to include electric vehicle charging infrastructure. This amendment was created considering the implementation of electric mobility in the next 30 years, technological evolution, type of chargers, and the number of charging points in public charging station. The amendment is as summarised in Table 4.5.

33 Environment and Climate Change Department Maharashtra, "Maharashtra Electric Vehicle Policy, 2021.," July 23, 2021, https://maitri.mahaonline.gov.in/PDF/EV%20Policy%20GR%202021.pdf.

34 Punjab government gazette, "Punjab Urban Planning and Development Building Rules, 2021," September 10, 2021, https://puda.punjab.gov.in/sites/default/files/Building%20Rules%202021.pdf.

35 GoI, "Goa Electric Mobility Promotion Policy," 2021, https://www.goa.gov.in/wp-content/uploads/2021/07/draft-of-Goa-Eletric-mobility-promotion-policy-2021.pdf.

36 "Tamilnadu Electric Vehicle Policy 2019" (Government of Tamil Nadu, 2019), https://powermin.gov.in/sites/default/files/uploads/EV/Tamilnadu.pdf.

Table 4.5: Amendment to urban and regional development plans formulation and implementation guidelines[37]

Sr. No.	Category	Population served per unit	Land area requirement		Other control
			Type of facility	Area requirement	
1. Petrol/Diesel filling/EV charging* and service center					
			• Public charging station with the minimum requirement as per MoP guide-lines • Fluid cooled battery charging station (CCS, CHAdeMO) • Battery swap-ping station (optional)	• Min 13.5 m x 5.5 m • Min 15 m x 7 m • Earmarking area for "battery-fit-ting"	• Charging station and all equipment layout with dispensing unit (DU)/fuel tank to be as per Petroleum & Explo-sives Safety Organiza-tion (PESO) rules. • Equipped with CCE and LCC in addition to PCS requirement • Optional in addition to PCS by the service provider
2. Standalone Public Charging Stations (PCS)					
A.	Public Charging	Every 25 km, both sides of highways and roads	PCS with charging ratio 1 fast charger for every 10EV 1 fast charger for every 3 EV	Additional area as per parking capacity at the restaurant/ eateries	Equipped with CCE and LCC
B.	Fast charging facility /fluid cooled charging station (long-distance/heavy duty)	At least 2 charger 1CCS 1 CHAdeMO (min 100 kW each)		• Min 15 m x 7 m	Maybe coupled with PCS at item A above, with CCE and LCC
C.	Battery swapping station	Optional pro-visions as per MoP guidelines	Standalone/ Provide alone with fluid-cooled charging station	• Min 5.5 m x 2.75 m	Maybe coupled with PCS at item A above or FCBCS at item B above

LCC: Liquid Cooled Cables, CCE: Climate Control Equipment, CS: charging station

37 Ministry of Urban Development, "Urban and regional development plans formulation and implementation (URDPFI) guidelines", January 2015, https://mohua.gov.in/upload/uploadfiles/files/URDPFI%20Guidelines%20Vol%20I.pdf

4.3 National Programme on Advanced Chemistry Cell Battery Storage

The Ministry of Heavy Industry and Public Enterprises has notified the Production Linked Incentive (PLI) Scheme. The 'National Programme on Advanced Chemistry Cell (ACC) Battery Storage' was floated by Department of Heavy Industry (DHI) on 9th June 2021. This PLI scheme is aimed to achieve manufacturing capacity of Fifty (50) Giga Watt Hour (GWh) of ACC and 5 GWh of "Niche" ACC with an outlay of INR 18,100 crore (EUR 2.05 billion). The Government of India in January 2022 has released Request for Proposal (RFP) for inviting bidders under the PLI scheme for setting up manufacturing facilities in India[38].

Advanced Chemistry Cell (ACC) are the new generation of advanced energy storage technologies that can store electric energy either as electrochemical or as chemical energy and convert it back to electrical energy as and when required. Their applications are found in consumer electronics, electric vehicles, advanced electricity grids, solar rooftop etc. which are major battery consuming sectors and are expected to achieve robust growth in the near future.

In India, all the demand of the ACCs is currently being met through imports, thus there is negligible investment in ACCs manufacturing, along with value addition. This PLI scheme on ACCs is expected to reduce import dependence and facilitate setting up of ACC manufacturing companies as well as demand creation of battery storage in India. The ACC storage battery manufacturers will be selected through a transparent competitive bidding procedure and each of them should set up an ACC manufacturing facility of minimum 5 GWh capacity and ensure a minimum 60% domestic value addition at the Project level within a period of five years. This manufacturing facility would have to be commissioned within a period of two years and the fiscal incentives will be disbursed over a period of five years. The incentives awarded will be raised with increased specific energy density and cycles along with increased local value addition. Furthermore, the beneficiary firms will have to attain a domestic value addition of at least 25% and incur the mandatory investment INR 225 crore /GWh (EUR 25.5 million/GWh) within a span of 2 Years (at the Mother Unit Level) and increase it to 60% domestic value addition within a span of 5 Years, either at Mother Unit, in-case of an Integrated Unit, or at the Project Level, in-case of "Hub & Spoke" structure.

The major outcomes expected from the PLI scheme can be listed as follows:

- Setup a cumulative 50 GWh of ACC manufacturing facilities in India under the scheme.
- Direct investment of around INR 45,000 crore (EUR 5,108 Million) in ACC Battery storage manufacturing projects.
- Encourage battery storage demand creation in India.
- Support Make-In-India: Greater emphasis given to domestic value-capture and thereby reducing import dependence.
- Net savings of INR 2,00,000 crore (EUR 22.7 billion) to INR 2,50,000 crore (EUR 28.3 billion) on account of reduction of oil import bill during the time span of the scheme as ACCs manufactured under the scheme is expected to accelerate EV adoption across India.
- ACC manufacturing is expected to increase EV demand which will result in less pollution. As India is aiming at an ambitious renewable energy agenda, this PLI scheme will be a major factor to reduce India's Green House Gas (GHG) emissions which will be in line with India's promise to combat climate change.
- Import substitution of around INR 20,000 crore (EUR 2,271 Million) every year.
- Impetus to Research & Development to achieve higher specific energy density and cycles in ACC battery storage.
- Encourage newer and niche cell technologies.

4.4 Star labelling program for High-Energy Lithium-Ion Traction Battery packs and systems

To specify an energy-labelling requirement for high-energy Lithium-Ion based Battery packs and systems used in electrically propelled road vehicles, the Bureau of Energy Efficiency (BEE) released a schedule on 14th December 2021[39].

38 MHI, 'PLI Scheme for National Programme on Advanced Chemistry Cell (ACC) Battery Storage', 2022, https://heavyindustries.gov.in/UserView/index?mid=2487

39 Bureau of Energy Efficiency, "Standards and Labelling(S&L) Program for High-Energy Lithium-Ion Traction Battery Packs and Systems," December 14, 2021, https://www.beestarlabel.com/Content/Files/SCHEDULE_29.pdf.

This schedule covers high-energy Li-ion battery packs or modules with specific energy up to 350 Wh/kg and a Cycle life of up to 4,000 cycles. The star rating of such a high-energy Battery pack or module has been done based on its specific energy, the cycle life of the pack/module, and energy efficiency tested in accordance with the standard ISO 12405-4:2018 and as per the recommendation of a technical committee constituted by BEE for this purpose.

In order to define the rating plan/labelling plan, the high energy battery packs/modules are categorized as per Basic Matrix Group (BMG) as mentioned below in Table 4.6.

BEE or any of its designated agencies would pick up a battery pack and system samples (BEE registered) at random from the market and will be tested at a BEE empanelled NABL accredited Lab at the expense of BEE. During the testing, if the first sample fails, a second check testing would be carried out at the same lab. For the second check testing, again two similar battery packs/systems with the same rated efficiency would be picked up from the market randomly and both samples would have to meet the declared pack/system efficiency. Even if one sample fails to meet the declared pack/system efficiency during second check testing, the battery pack and systems and the related BMG will be treated as being in non-compliance with the prescribed BEE standards.

Table 4.6: Basic matrix group (BMG) matrix[40]

Cycle Life Range*		Specific Energy (Wh/kg)				
		A	B	C	D	E
		≥100	≥150	≥200	≥275	≥350
1	1000 to 1499	BMG A1	BMG B1	BMG C1	BMG D1	BMG E1
2	1500 to 1999	BMG A2	BMG B2	BMG C2	BMG D2	BMG E2
3	2000 to 3999	BMG A3	BMG B3	BMG C3	BMG D3	BMG E3
4	≥ 4000	BMG A4	BMG B4	BMG C4	BMG D4	BMG B4

**Subject to revision based upon availability of life cycle test data during the implementation of the program*

The star labelling scheme for Li-ion battery packs and systems is given in Table 4.7 below.

Table 4.7: Star rating matrix

Star Level	Overall battery pack efficiency (%)	
	Minimum	Maximum
1 star	85	88
2 star	>88	91
3 star	>91	95
4 star	>95	98
5 star	>98	

The family of battery packs is defined as battery packs/ modules and battery systems that lie under the same category of BMG and are equipped with the same Battery Management System (BMS) model type and cell type (e.g., Prismatic cell, cylindrical cells, etc.). In a family, the capacity (Ah) and model number of the battery pack/system may vary. Also, the battery pack/system within a family which has the highest rated capacity in Ah is termed as the parent battery pack/system and has to undergo complete cycle life testing. The battery packs/systems in a BMG shall be rated based on tested energy efficiency (η).

4.5 Auto Industry and Drone Industry to enhance India's manufacturing capabilities

Production Linked Incentive (PLI) Scheme or Automobile Industry and Drone Industry is part of the overall announcement of PLI Schemes for 13 sectors made earlier during the Indian Union Budget 2021-22. The Government has approved the PLI Scheme for Automobile Industry and Drone Industry with a budgetary outlay of INR 26,058 crore (EUR 3,017 Million) in September 2021 with a focus to incentivize emergence of Advanced Automotive Technology vehicles and products.

The PLI scheme foresees to overcome the cost disabilities to the industry for manufacture of Advanced Automotive Technology (AAT) products in the country. The incentive structure proposed under the scheme is expected to promote the industry to start fresh investments for indigenous global supply chain of AAT products. According to the estimations, this PLI Scheme for Automobile and Auto Components Industry will lead to fresh investment of over INR 42,500 crore (EUR 4,921 Million) and incremental production of over INR 2,30,000 crore (EUR 26,630

40 Bureau of Energy Efficiency.

Million) within a span of five years. Further, it is also expected to create additional employment opportunities of over 7.5 lakh jobs and will help to increase India's share in global automotive trade.

This PLI scheme for automotive sector combined with already launched PLI scheme for Advanced Chemistry Cell (ACC) and FAME phase II scheme will enable India to transition from its conventional fossil fuel based automobile sector to environmentally cleaner, greener, sustainable, more advanced and efficient Electric Vehicle transportation sector.

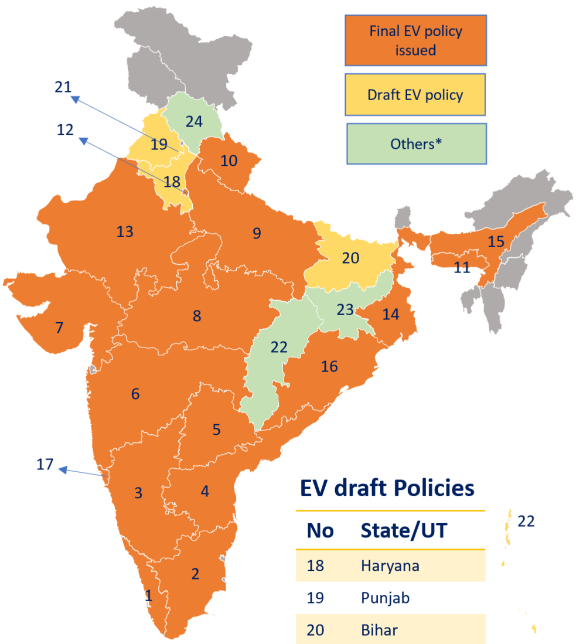
Another focus of the launched PLI Scheme is related to the Drones and Drone components industry which addresses the strategic, tactical and operational uses of this revolutionary technology. A product specific scheme for drones with specific targets for revenue and a clear focus on domestic value addition is important to making these key drivers of India's growth strategy. The PLI for Drones and Drone components industry, is expected to bring up investments worth INR 5,000 crore (EUR 567.6 Million) and increase in eligible sales of INR 1,500 crore (EUR 170.3 Million) over a period of three years. It also aims to create additional employment of about 10,000 jobs.

4.6 EV State Policies

Consequent to the government of India's push towards the paradigm shift from ICE to large EV penetration in country by 2030, several states in India have proposed and notified their EV policies aimed at promoting manufacturing and increasing demand of EVs in their respective states. The state governments have taken various initiatives to attract manufacturing and adoption of EV fleet and related technologies. Karnataka became the first state of the country to release its EV policy, and as of March 2022, a total of seventeen states/UTs have notified their final EV policies as shown in Figure 4.4 and five states/UTs released draft EV policies. These policies have included various incentives and subsidies to attract the consumers towards EV market as well as the manufacturers and private players to set up charging infrastructure.[41]

A number of important promotional measures have also been introduced in each state's Electric Vehicle policy such as, promotion of shared mobility in the state, the sources of different funding aspects, incentives for R&D opportunities, vehicle scrapping, skill development initiatives and battery recycling provisions etc. which is

No	State/UT	Title of Policy issued and year
1	Kerala	Kerala Electric Vehicle Policy 2019
2	Tamil Nadu	Tamil Nadu Electric Vehicle Policy 2019
3	Karnataka	Karnataka Electric Vehicle & Energy Storage Policy 2017
4	Andhra Pradesh	Andhra Pradesh Electric Mobility Policy 2018-23
5	Telangana	Telangana EV ESS Policy 2020-2030
6	Maharashtra	Maharashtra State Electric Vehicle Policy 2021
7	Gujarat	Gujarat State Electric Vehicle Policy 2021
8	Madhya Pradesh	Madhya Pradesh Electric Vehicle Policy 2019
9	Uttar Pradesh	Uttar Pradesh Electric Vehicle Policy 2019
10	Uttarakhand	Uttarakhand Electric Vehicle Policy 2018
11	Meghalaya	Meghalaya Electric Vehicle Policy 2021
12	Delhi	Delhi Electric Vehicle Policy 2019
13	Rajasthan	Rajasthan Electric Vehicle Policy *
14	West Bengal	West Bengal Electric Vehicle Policy 2021
15	Assam	Electric Vehicle Policy of Assam 2021
16	Odisha	Odisha Electric Vehicle Policy 2021
17	Goa	Goa Electric Mobility Promotion Policy 2021



EV draft Policies

No	State/UT
18	Haryana
19	Punjab
20	Bihar
21	Chandigarh
22	Andaman & Nicobar Islands

Figure 4.4: State and UTs with final issued and draft EV policies[40]

41 Others' category include the states which are promoting EVs through other related policies or are in the process of draft EV policy preparation. Rajasthan has not yet released a single comprehensive EV policy. But it released an incentive program providing subsidies on purchase of EVs, and a separate order on EV charging infrastructure requirements. Both together cover most aspects of an EV policy. Draft EV policy for Andaman & Nicobar Islands have been recently published in March 2022 and the draft policy preparation of Himachal Pradesh is at an advanced stage.

expected to enable development of an efficient ecosystem as mandated for larger uptake of e-mobility in individual states as well as in the country. These measures are listed in Table 4.8.

Table 4.8: Key Promotional Measures defined in State Policies

Funding Sources	Mention of various sources of funding such as incentives on motorized vehicles, green tax and incentives on stamp duty, funds received from industries to carry out social Responsibilities, apart from funds from the Central and State Government. E.g.: Rajasthan Transport Infrastructure Development Fund (RTIDF)
Promotion of Shared mobility	Indian customers are price sensitive and e-based shared mobility is cost-effective since, the operation cost is lower, and it is bringing down the overall cost of transportation for customers resulting in higher uptake. There is a growing need for last-mile connectivity with increase of shared mobility through Rail-Metro, Buses etc. Guidelines are given in policy to support and suggest various methods to improve the participation of electric based shared mobility in states.
R & D Aspects	Most of the state policies give significant focus on facilitating Research and Development aspects in their guidelines, since India is aiming to become manufacturer of EV and its associated components, rather than being a complete import dependent nation.
Skill development	State policy makers give importance to training-based certification and placement programs for skill development. With transition towards EV, it is crucial that the automobile workers get proper training and skill development on newer e-mobility technologies to improve the manpower as well as ensure job continuity.
Battery Recycling	Battery recycling is an efficient way to assure optimal utilization of rare elements along with meeting the rising demand. The negative environmental impact of disposal of batteries can be reduced using recycling along with reduction of overall cost of a battery and therefore EVs. Policy makers should consider providing financial assistance or incentives to high-quality recycling processes and promote creation of battery recycling industry in the country.
Vehicle scrapping Incentives	The scrappage policy is meant to flush out old cars running on the roads and phase-out these old vehicles, which will end up polluting the environment. Some of the policy guidelines consider providing incentives for vehicle scrapping in order to promote EV adoption by giving away old and unusable vehicles.
Retrofitting	Retrofitting in automobile sector is often a required step towards modernization and competitive boosting of market. It is nothing more than the introduction of new technology or features to older systems so as to improve its efficiency, add more functionalities or be compatible with the latest environmental demands. Policy guidelines are considering retrofitting options to promote EV adoption in states and in country.
EV Tariff	Dedicated electricity tariff encourages adoption of EV. Hence there is need to design a suitable electricity tariff structure that increases feasibility of operation of charging infrastructure facilities at even low asset utilization level. Most of the states in India have taken EV policy initiatives to specify tariff structure, still some states are yet to introduce EV specific tariffs for public and home charging.
Building bye-laws	Ministry of Housing and Urban Affairs has notified Amendments in Model Building By-Laws (MBBL) - 2016 for EV charging infrastructure in February 2019. Building by-laws helps to make charging infrastructure development an integral part of urban planning, development, and construction.
Home/ workplace EV charging	The range anxiety and limited availability of en-route charging stations are significant concerns that stop people from purchasing EVs. Thus, policies should provide sufficient focus on promotion of development of home charging/ workplace charging infrastructure that could potentially offer a convenient alternative to en-route charging infrastructure for EV users.
Promoting digital Payment	The promotion of different payment methods of electricity usage at charging stations are also considered in state policy framing. This includes, debit/credit card payments, mobile wallets, UPI options, QR code payment etc., that helps easy, fast, and secure payments by the customers.
Public Awareness	Public awareness is key in providing thrust to EV uptake. Since it helps to educate people to adopt EV. Their impactful role in making the environment clean, needs to be communicated to have wider participation. In order to raise the public awareness, different states issued different options in their policy guidelines such as launching test drives, competitions, celebrating e- mobility day etc.

4.6.1 DELHI

Delhi's EV policy is majorly focused on accelerating the pace of EV adoption in the state across different vehicle segments in order to reduce emissions from transport sector that contributes to air pollution experienced in the region. As a part of this initiative, several provisions are provided in the policy guidelines to discourage use of ICE vehicles such as pollution cess, increased road tax and congestion fee on aggregators and ride hailing services for all ICE based vehicles (existing and new). Another aspect in the policy related to removal of conventional automobiles is the scrappage and deregistration incentives applicable to a few ICE vehicle categories, which is applicable to consumers who plan to buy EV in the same financial year. The aim of the policy is to encourage EV adoption such that BEVs contribute to 25% of all new vehicle registrations by 2024. Delhi plans to add 50% of e-buses to its public transport by 2023. Moreover, various initiatives to increase the public awareness about the benefits of shifting towards e-mobility have been proposed in the EV policy. The Delhi EV policy offers support across all the different vehicle categories. Through purchase incentives, reduction in permit/registration fee, tax waiving schemes and exemptions under the government push in order to increase the EV adoption. Along with such fiscal attractions to capture attention of EV buyers, the policy also has a provision for various opportunities to improve the EV and its associated component manufacturing along with private and public charging infrastructure business. Delhi also provides dedicated electricity tariff structure for EV charging and mandates DISCOMS to coordinate with residential/commercial building owners to set up charging infrastructures to provide adequate power supply to the EV users. Delhi is planning to have public charging stations within 3 kms from anywhere in Delhi[42]. The policy remains valid for three years from the date of issue, 7 August 2020.

4.6.1.1 Key Objectives of Delhi Electric Vehicle Policy 2020

Measures to Enable EV charging on supply-side	
Elements	**Focus on State EV Policy**
Incentives for promoting the EV charging infrastructure	• Delhi government to provide a 100% subsidy for the purchase of charging equipment up to INR 6,000 (EUR 68.12) per charging point for the first 30,000 private charging points at residential and non-residential buildings. • 100% of net SGST will be provided as reimbursement to EOs for purchase of Advanced Batteries to be used at swapping stations. • A capital subsidy for the cost of charger installation expenses would also be provided to select Energy Operators.
Prioritization in terms of EV characteristics and social geography	• Providing accessible public charging / battery swapping facilities within 3 km travel from anywhere in Delhi is a key objective. • Changes would be made to building bye-laws in order to make all new home and workplace parking 'EV ready' with 20% of all vehicle holding capacity in the parking area.

42 GNCTD, "Delhi Electric Vehicles Policy, 2020," Department of Transport, Government of National Capital Territory of Delhi, 2020, https://transport.delhi.gov.in/sites/default/files/All-PDF/Delhi_Electric_Vehicles_Policy_2020.pdf.

Additional Measures for promotion of EV sector	
Elements	Focus on State EV Policy
EV Market Support services to promote EV adoption	• 2-wheelers: Purchase incentive of INR 5,000 (EUR 58) per kWh of battery capacity. Max incentive of INR 30,000 (EUR 347)per vehicle • 2-wheelers: Scrapping incentive of up to INR 5000 (EUR 58) to be offered subject to evidence of matching contribution from the dealer or OEM and confirmation of scrapping and de-registration of ICE vehicle. • All two-wheelers engaged in last-mile deliveries will be expected to transition 50% of their fleet to electric by 31st March 2023, and 100% of their fleet by 31st March 2025. • E-autos: Purchase Incentive of INR 30,000 (EUR 347) per vehicle. Eligibility: Advanced battery models and swappable battery models where battery is not sold with the vehicle.
Elements	Focus on State EV Policy
	• E-autos: Interest subvention of 5% on loans and/or hire purchase scheme for the purchase of an e-auto. • Scrapping incentive of up to INR 7,500 (EUR 87) for E-autos. • E-rickshaws and E carts: Purchase Incentive of INR 30,000 (EUR 347) per vehicle (also applicable for lead acid battery vehicles as well as swappable models where battery is not sold along with vehicle • Additional Interest subvention of 5% on loans and/or hire purchase scheme for advanced battery vehicles. • Advanced battery goods carriers to get a purchase incentive of INR 3,000 (EUR 35) for first 10,000 vehicles. • Interest subvention of 5% on loans and/or hire purchase scheme for goods carriers. • Goods Carriers will be completely exempt from the prohibition on plying and idle parking of lights goods vehicles on identified roads of NCT of Delhi during specified timings. • Purchase incentive of INR 10,000 (EUR 116) per kWh of battery capacity for first 1000 cars subject to a cap of INR 1,50,000 (EUR 1737) per vehicle for 4-wheelers • Scrapping incentive of up to INR 7,500 (EUR 87) for 4-wheelers. • All leased/hired cars used for commute of GNCTD officers will be transitioned to electric within a period of 12 months from the date of notification of this policy. • Subsidy as decided by GNCTD from time to time with a commitment that pure electric buses shall constitute at least 50% of all new buses (including smaller buses for last-mile connectivity) to be added to the city bus fleet, starting with an induction of pure e-buses by 2020. • Road tax and registration fees to be waived for all Battery Electric Vehicles during the period of this policy. • All financial incentives will be applicable for both fixed battery models and swappable battery models. If battery is not sold with the vehicle, 50% of the purchase incentive will be vehicle owner and rest to Energy Operators for defraying the cost of any deposit that may be required from end users for the use of a swappable battery.
Institutional framework for roll out of policies	Energy Operators' (EOs) will be invited to set up charging and battery swapping stations across Delhi. Government shall provide a capital subsidy for the cost of charger's installation.
Enhancement of EV value chain peripheral ecosystem	• Green number plates for EVs registered in Delhi. • All new home and workplace parking will need to be 'EV ready' with 20% of all; vehicle holding capacity/ parking required to be EV ready.
Promotion of Battery Recycling/ scrapping facilities	• The policy encourages reuse of EV batteries that have reached their end of life • Policy aims to set up recycling business in collaboration with EV and battery manufacturers which focus on urban mining of rare materials for reuse by battery manufacturers
Miscellaneous	• Ride hailing services allowed to use electric 2Ws. • Open permit system for e-autos on first come first serve basis.

4.6.1.2 Key Attributes targeted in Delhi EV Policy:

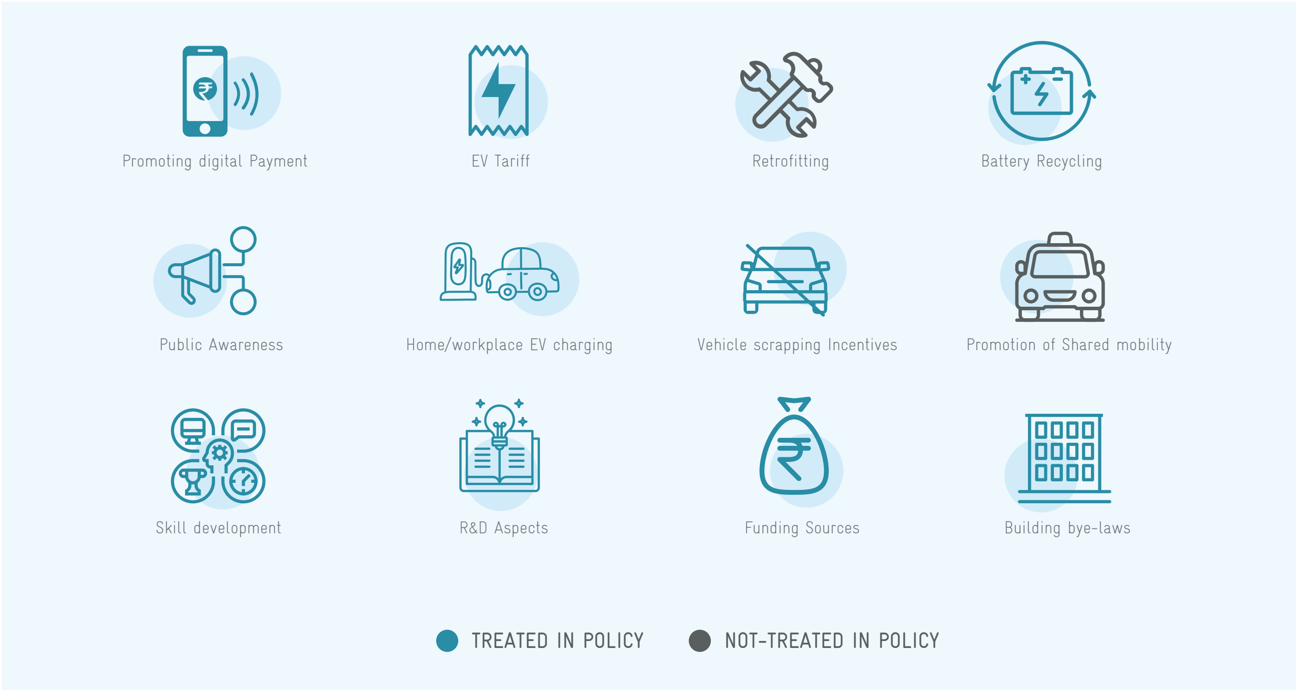


Figure 4.5: Key highlights in Delhi EV policy

For the improvement in network value chain in EV eco system, various provisions for payment towards energy supply are notified, such as enabling EOs and BSOs to accept multiple mode of payments including digital payment options through cash, card, mobile wallets, or UPI facilities. In order to make the entire system more user friendly and efficient, Delhi is planning to provide real-time information on EV charging details using an open, publicly owned database which includes location, numbers, type of swapping kiosks/chargers, queue lengths/ availability, pricing etc. The state transport department is the nodal agency for implementing the Delhi EV policy, and a dedicated EV cell is expected to be established soon within the nodal department for effective day-to-day review and follow up of the policy.

Limitations related to EV charging infrastructure in Delhi EV Policy:

a) DISCOMS are not mandated to invest in charging infrastructure development.
b) The major focus of EV charging infrastructure has been given to slow chargers so far. However, considering rapid growth of 4 wheelers with high-capacity batteries, fast chargers, particularly in public spaces need to be given a special focus to cater charging needs of the modern 4-wheeler EV segment.
c) No provision of dedicated help desk/single window clearance system for charging station developers.
d) No mention of utilization of V1G or V2X capabilities and integration of RE based sources in EV charging infrastructure .
e) Development of digital platforms for database management, setting up of facilities to address consumer complaints and specifications of payment methods are not considered.

EV Market of Delhi

Delhi has been one of the front runners in the EV market of India. To control the rising pollution levels, the Delhi government has an ambitious target of replacing 25% of the city's annual vehicles registrations to EVs by 2024. Delhi market for 4-wheelers, 2-wheelers and 3-wheelers by fuel type till February 2022 is shown in Figure 4.6, Figure 4.7 and Figure 4.8 (VAHANSEWA, 2021). In the 4-wheeler segment, there are only around 4871 registered BEVs, while the number of PHEVs is quite high at around 42,196 as of February 2022. The majority of the 4-wheelers (99%) are fuelled by conventional fuels. In the 2-wheeler segment, although the total number of BEVs is high at 15,952, however, compared to the total registered 2-wheelers in the city, this amount is negligible as can be observed in Figure 4.7. Nevertheless, BEV is the 2nd most popular 2-wheeler by fuel type. The situation however is quite different in case of 3-wheeler market segment, where BEV is one of the most popular fuel type with 1,13,677 registered 3-wheeler BEVs compared to 71,329 petrol fuelled 3-wheeler in Delhi as shown in Figure 4.8. However, in Delhi there is also a significantly large share of CNG fuelled 3W. In case of large and heavy-duty vehicles, such as, buses and trucks, only 31 BEVs and 0 PHEVs have been registered in Delhi.

The growth of the EV market will be significantly influenced by the availability of charging facilities among other factors. In this regard, the Delhi Government has laid down plans for extension of its public charging infrastructure.

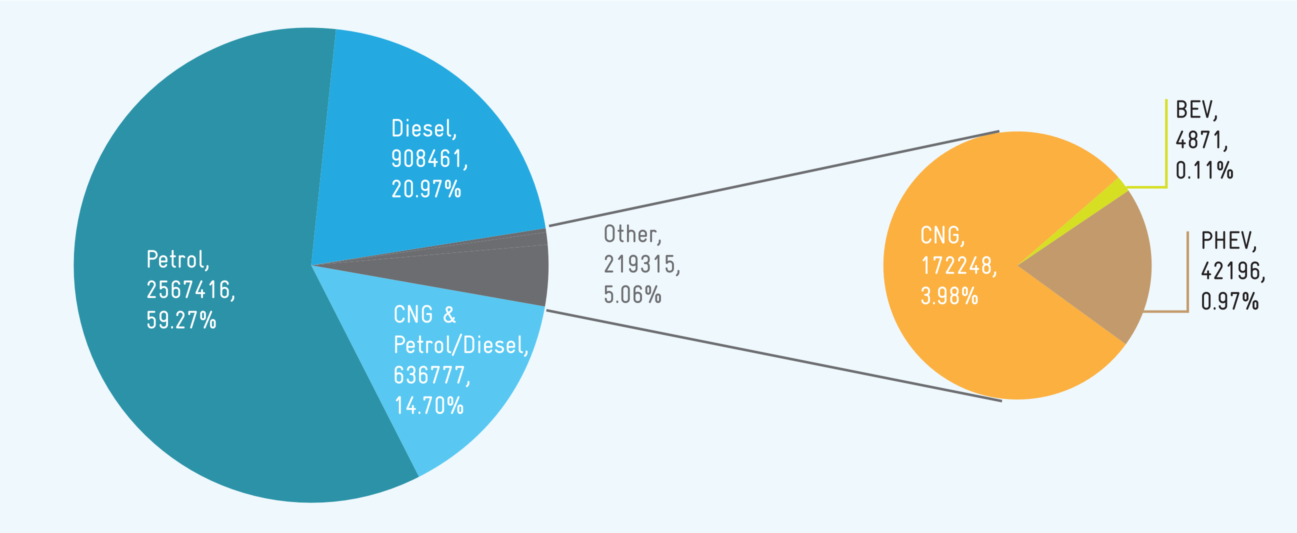


Figure 4.6: Share of total registered 4W in Delhi by fuel type (as of Feb 2022)[43]

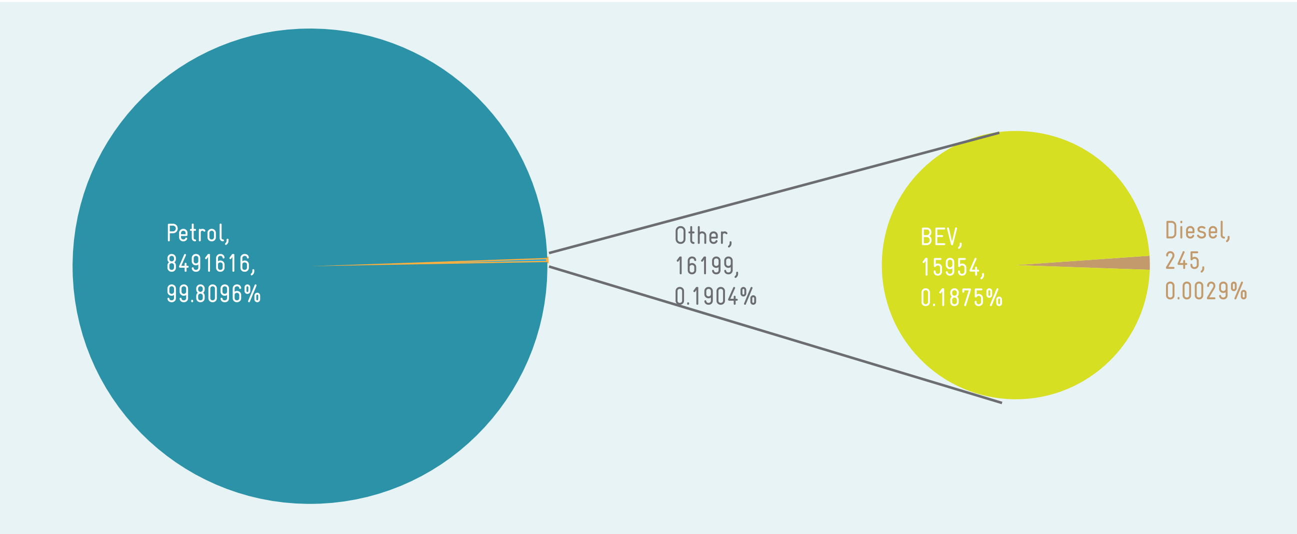


Figure 4.7: Share of total registered 2W in Delhi by fuel type (as of Feb 2022) [42]

43 Vahansewa, "Dashboard," Ministry of Road Transport & Highways, 2022, https://vahan.parivahan.gov.in/vahan4dashboard/vahan/view/reportview.xhtml.

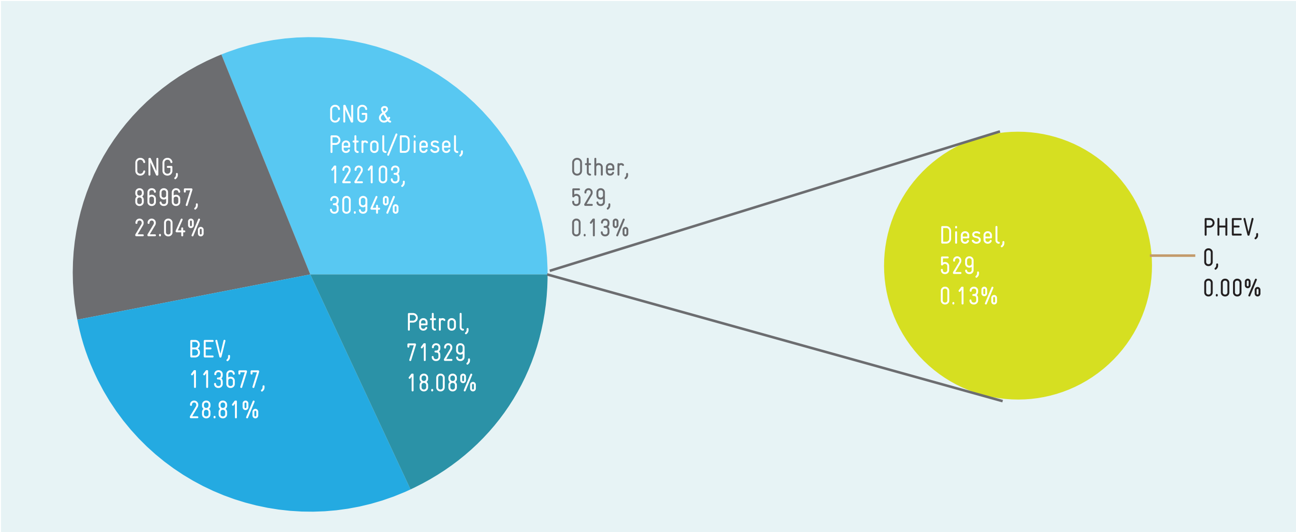
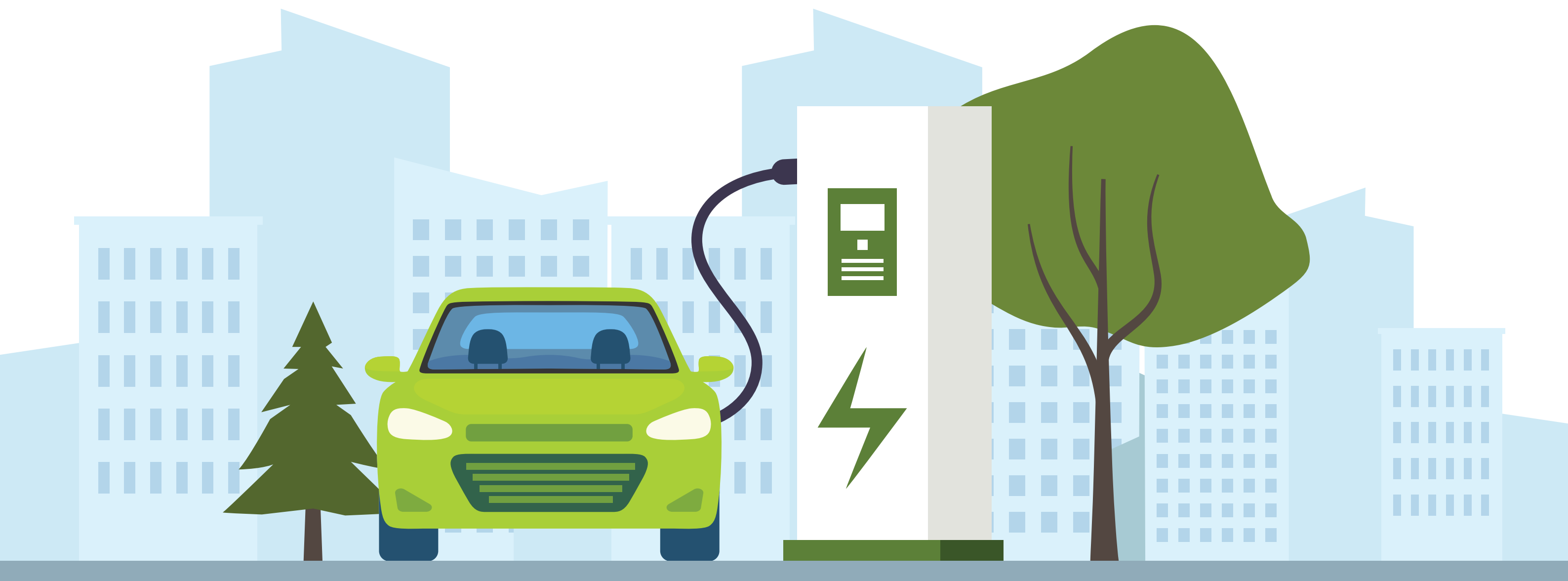
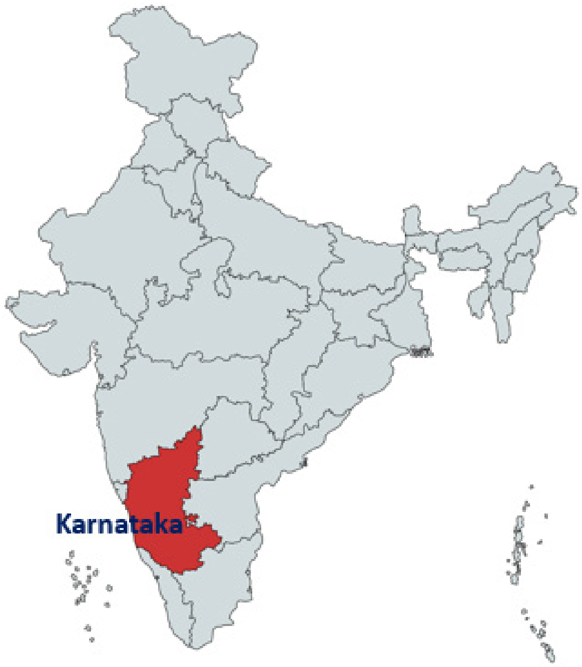


Figure 4.8: Share of total registered 3W in Delhi by fuel type (as of Feb 2022)[42]



4.6.2 KARNATAKA



Karnataka became the first state in India to officially release an EV policy under the various initiatives the Government of India had put forward to accelerate faster adoption of Electric Mobility in the country such as NEMMP and FAME schemes. Karnataka, with a vibrant automotive sector with large technical manpower pool, robust research and development capabilities and manufacturing expertise, was an obvious choice to initiate and utilize the e-mobility growth initiated at the national level[44]. However, the need for a comprehensive and well-designed policy push to enable the rapid growth of e-mobility sector in the state was essential. In this backdrop, the state notified 'Karnataka Electric Vehicle & Energy Storage policy' in 2017 which is focused to give the required impetus to EV sector in the state and also aims to attract investments towards EV manufacturing opportunities. The Department of Industries and Commerce of the state formulated the policy based broadly on the principles of Karnataka Industrial Policy 2014-19 and issued it with the concurrence of Finance department.

The state policy focuses on various aspects of Research & Development opportunities, and schemes to encourage local manufacturing of EV and its related components including production, services, and customer aspects. The policy also earmarked special packages of fiscal and non-fiscal incentives and concessions for ultra-mega and super mega EV enterprises which includes EV manufacturers, EV charging/swapping equipment manufacturers and lithium-ion battery manufacturers. The state is already providing incentives such as interest-free loans on the net SGST for EV manufacturing enterprises. The policy is valid for 5 years from its date of issue, 25 September 2017.

4.6.2.1 Key Objectives of Karnataka Electric Vehicle Policy 2017

Measures to Enable EV charging on supply-side	
Elements	**Focus on State EV Policy**
Definition of a fundamental market design framework to limit distortions and entry barriers	• Government of Karnataka will encourage private players to set up ARAI-compliant/BIS standard, EV charging systems/ infrastructure. • BMRCL, BMTC, KSRTC, BBMP will provide charging stations for 2-W at their parking stations to encourage EVs for last mile commute. • Encourage lease/pay-per-use business models with battery swapping station network, integrated payment, and tracking system in partnership with BMTC and other private players.

44 Govt. of Karnataka, "Karnataka Electric Vehicles & Energy Storage Policy - 2017" (Commerce & Industries Department, Govt. of Karnataka, 2017), https://kum.karnataka.gov.in/KUM/PDFS/KEVESPPolicyInsidepagesfinal.pdf.

Incentives for promoting the EV charging infrastructure	• Capital subsidy of 25% on the equipment/machinery subject to maximum of INR 10,00,000 (EUR 11,353) per station for the first 100 fast charging stations in the state. • Capital subsidy of 25% on the equipment/machinery subject to maximum of INR 3,00,000 (EUR 3,400) per station for the first 100 battery switching/swapping stations in the state. • Capital subsidy of 25% on the equipment/machinery subject to maximum of INR 5,00,000 (EUR 5,676) per station for the first 50 battery switching/swapping stations for electric cars in the state. • Capital subsidy of 25% on the equipment/machinery subject to maximum of INR 10,00,000 (EUR 11,353) per station for the first 50 battery switching/swapping stations for electric buses in the state. • Incentives to EV and EV charging and Charging infrastructure Manufacturing enterprises – Investment promotion subsidy of 25% of the value of Fixed assets (VFA) to micro enterprises up to INR 15,00,000 (EUR 17,000) ; 20% of VFA to small enterprise up to INR 40,00,000 (EUR 45,400) ; and INR 50,00,000 (EUR 56,700) to medium enterprises.
Prioritization in terms of EV characteristics and social geography	• To facilitate inter-city travel, fast charging stations/ battery swapping stations would be set up on prominent highways in the state at every 50 km. • For incorporation of charging infrastructure in all high rise buildings/ new Special Economic Zones/ Technology Park/ Apartments, amendments would be made to the building byelaws. • Bengaluru Metro Rail Corporation Ltd. (BMRCL)/ Bengaluru Metropolitan Transport Corporation (BMTC)/ Karnataka State Road Transport Corporation (KSRTC)/ Bruhat Bengaluru Mahanagara Palike (BBMP) would provide charging infrastructure for 2W at their parking stations. • Charging infrastructure for personal transport vehicles of Government employees would be made available at Vikasa Soudha basement/multistoried building parking area and covered parking areas in all Government buildings across the state. • Existing apartment associations will be encouraged to provide special dedicated plug/ charging station facilitating adoption of EVs by their members
Easing out administrative barriers for establishing charging stations	• ESCOMs will examine bringing in amendments to their policies and allow re-sale of power to encourage setting up of charging stations • Amendments will be made to building bye-laws for providing charging infrastructure for EVs in all high-rise buildings/new SEZ/Technology Park/Apartments in the state.
Focus on RE integration and EV charging	ESCOMs will examine permitting use of solar energy/renewable energy at low connection cost and offer zero wheeling charges by EV charging stations.
Measures to Enable EV charging on demand-side	
Elements	Focus on State EV Policy
Specification of the use of a wide range of payment methods	Encourage lease/pay-per-use business models with battery swapping station network, integrated payment, and tracking system in partnership with BMTC and other private players.

Additional Measures for promotion of EV sector	
Elements	Focus on State EV Policy
EV Market Support services to promote EV adoption	• Offer incentives to encourage manufacture of modular design Li-ion batteries with higher mileage per charge in the state • Exemption of taxes on all electric non-transport and transport vehicles including e-rickshaws and e-carts under Karnataka Motor vehicles Taxation Act 1957 with effect from 01-04-2016 • Existing auto rickshaws will be encouraged for retrofitting and move towards EV segment • The following segments of vehicles in Bengaluru will be encouraged to move towards EVs with an intention of 100% EV by 2030: Auto rickshaws, Cab aggregators, corporate fleets, School buses/vans • EV 3-W/4W mini goods vehicles, e-commerce and delivery companies' fleet in Bengaluru will be encouraged to move towards EV in a phased manner to achieve 100 % e-mobility by 2030 • Offer incentives to encourage manufacture of modular design Li-ion batteries with higher mileage per charge in the state • A venture capital fund will be set up for R&D in EV mobility • Incentives to EV and EV charging and Charging infrastructure Manufacturing enterprises - Investment promotion subsidy of 25% of the value of Fixed assets (VFA) to micro enterprises up to INR 15,00,000(EUR 17,000) ; 20% of VFA to small enterprise up to INR 40,00,000 (EUR 45,400) ; and INR 50,00,000 (EUR 56,700) to medium enterprises. • Concession to Manufacturing enterprises- for all loan documents, lease deeds and sale deeds the registration charges shall be at a concessional rate of INR 1 (EUR 0.011) per INR 1,000 (EUR 11.3) • 100 % exemption of stamp duty, reimbursement of land conversion fee, exemption from tax on electricity tariff, subsidy for setting up Effluent Treatment Plants and interest free loans on NET SGST: provided to support adoption of EVs and EV manufacturing in the state (subjected to terms and conditions specified in Appendix of the policy) • All large, mega, ultra-mega and Super mega Enterprises are provided with exemption from stamp duty, registration charges are available at a concession rate of INR 1,000 (EUR 11.3), reimbursement of land conversion fee, exemption from tax on electricity tariff, subsidy for setting up Effluent Treatment Plants and interest free loans on NET SGST.
Institutional framework for roll out of policies	• As a pilot project, BMTC will introduce "EV Vayu Vajra" services in select routes to Kempegowda International Airport by the end of 2018. • BMTC, KSRTC, NWKSRTC and NEKRTC will introduce 1,000 e-buses during policy period • To encourage adoption of EV in short route public transport, a flexible stage carrier permit policy for e-buses allowing multiple/variable routes outside the BMTC area will be examined. • Government of Karnataka will commission the 'Karnataka Electric Mobility Research and Innovation center' and extend necessary support to make it a world class research hub • A high-level inter departmental review committee will be constituted under the chairmanship of Chief Secretary to regularly review implementation of all provisions of the policy in achieving the targets and to suggest mid-course corrections. • A working sub-committee under chairmanship of commissioner for ID and Director of I&C will also be constituted in the Department of I&C to regularly monitor implementation of the policy.

Enhancement of EV value chain peripheral ecosystem	• Make industrial land available, preferably in clusters so that EV manufacturing zones can be created • Infrastructure in the form of readymade flatted factories with power, water, sewage, and testing facilities on a ready built basis to enable ancillaries to be set up through PPP mode • Encourage establishment of a dedicated testing track and facility for EVs and associated technologies, to make it easier for researchers and start-ups to test new technologies in a safe environment through PPP mode • To support short distance shared mobility, electric 2-wheeler taxis will be encouraged • Government of Karnataka will facilitate deploying used EV batteries for solar application, create a secondary market and provide battery disposal infrastructure in PPP mode • A start up incubation center will be set up: Start-ups will be encouraged to develop business models focused on EVs • Research program in collaboration with EV industry with a focus on battery innovation will be introduced in Engineering colleges/Universities • To encourage in-plant training provided by the EV manufacturers in the state by offering a stipend up to 50% of the cost of training subject to a limit of INR 10,000(EUR 113) per month per trainee. This incentive shall be available for maximum 50 trainees per company. The benefits shall be available for 1,000 candidates per annum
Promotion of Battery Recycling/ scrapping facilities	Facilitate deploying used EV batteries for solar application, create a secondary market and provide battery disposal infrastructure in PPP mode

4.6.2.2 Key Attributes targeted in Karnataka EV Policy

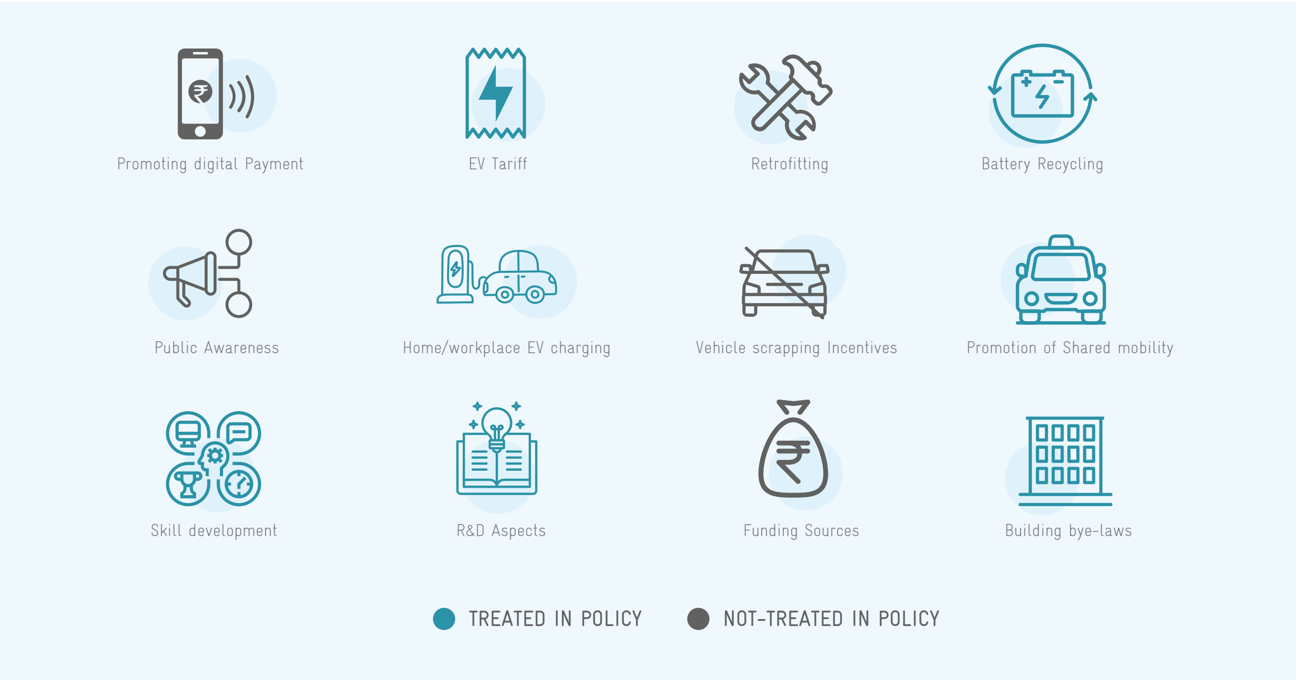


Figure 4.9: Key highlights in Karnataka EV policy

The requirement of a technical committee is mandated in the policy guidelines of the state, to define standards and certify products such as EV components (including battery) and EV manufacturing companies which are awarded with incentives and concessions under the state EV policy claim. Moreover, the policy promises capital subsidy for setting up Effluent Treatment Plants (ETP). One of the major focuses of the policy is battery storage plans and setting up a secondary market for the same. The policy has also focused on developing charging stations through commercially viable business models, which will attract private investment. By combining industry players with academia, the state will focus on designing the standards for battery manufacture and related technology developments closely associated with EV market along with the plan to issue promising capital funds to encourage e-mobility start-ups.

Limitations related to EV charging infrastructure in Karnataka EV Policy:

a) No mention of smart charging and bidirectional charging.

b) Development of digital platforms for database management and establishment of methods to address consumer complaints are not included.

c) No mention of utilization of V1G or V2X capabilities in EV charging infrastructure .

d) No provision of dedicated help desk/single window clearance system for charging station developers.

4.6.2.3 EV market of Karnataka

The market share of vehicles in Karnataka based on fuel type as of February 2022 has been shown in Figure 4.10. As can be seen, BEVs account for just 0.32% of all state registered vehicles, while PHEVs being just 0.14%

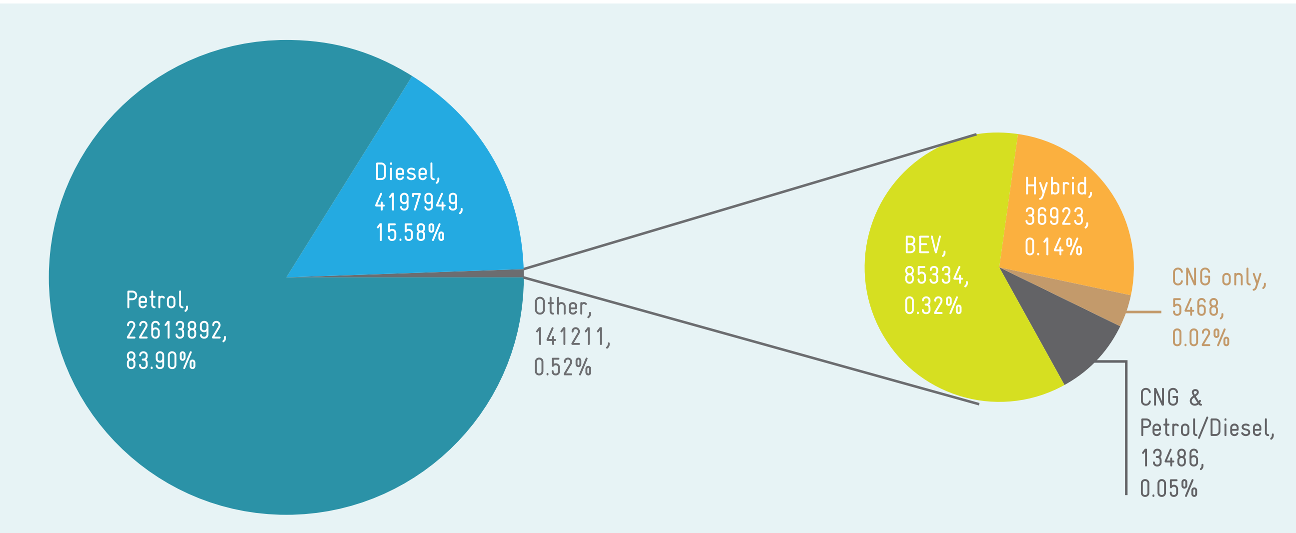


Figure 4.10: Share of total registered vehicles in Karnataka by fuel type (till Feb 2022)[42]

4.6.3 ANDHRA PRADESH

In the context of e-mobility becoming more economical day by day, driven by falling prices of Lithium-ion batteries, extensive research into fuel cells and cheaper RE sources, the Government of Andhra Pradesh aims to achieve its objectives by setting up an ambitious target, to be one of the leading states in India in e-mobility sector. The focus of the state is to become one of the three best states in EV adoption in India by 2022, the best state by 2029 and a leading global investment hub by 2050. Accordingly, the state Government has identified E-Mobility to be the fastest growing industry in the years to come, thus aims to be a frontrunner in developing a sustainable automobile and transportation infrastructure by promoting EV Ecosystem in the state. In view of these goals, the state government released 'Electric Mobility Policy 2018-23' after consultation with various stakeholders, industrial experts, and partners[45]. This policy is valid for 5 years from its date of issue, 8 June 2018.The policy aims to support every aspect of e-mobility with major emphasis given on the areas of,

- manufacturing of EV and its components,
- implementing charging infrastructure across the state,
- development of Hydrogen generation and Refuelling infrastructure,
- creation of demand for e-mobility, and
- Research and development

4.6.3.1 Key Objectives of Andhra Pradesh Electric mobility Policy 2018-23

Measures to Enable EV charging on supply-side	
Elements	Focus on State EV Policy
Definition of a fundamental market design framework to limit distortions and entry barriers	• The DISCOM will invest in setting up both slow and fast charging networks in government buildings and other public places. These charging points will be accessible to both government as well as private vehicles. • DISCOM will setup the charging infrastructure on its own or through third party operators using appropriate PPP models. Such costs can be recovered as part of ARR. • DISCOM shall release supply to charging/battery swapping stations within 48 hours of application. • A separate EV tariff category will be created. Time of day sale of power to BEVs will be considered to provide cheaper power during non-peak hours. • Third party EV charging infrastructure providers will be allowed to procure power from DISCOM at regulator determined tariff and will be allowed to provide the charging service to EVs.

45 Government of Andhra Pradesh, "Electric Mobility Policy 2018-23," 2018, http://www.ghmc.gov.in/tender pdfs/GOMsNo168.pdf.

Incentives for promoting the EV charging infrastructure	• DC Chargers (100 V and above): Capital Subsidy of 25% of the value of the charging station equipment/machinery for first 100 stations up to a Maximum subsidy of INR 10,00,000 (EUR 11,300) • DC Chargers (Below 100 V): Capital Subsidy of 25% of the value of the charging station equipment/ machinery for first 300 charging stations up to a Maximum subsidy of INR 30,000 (EUR 340) • Capital subsidy of 25% of Fixed Capital Investment (for eligible assets excluding cost of battery inventory) up to a maximum subsidy of 10,00,000 (EUR 11,300) for swapping stations for the first 50 stations. • 100% net SGST, accrued to the state, as reimbursement for purchase of fast chargers (DC chargers of capacity 100 V and above). • 100% net SGST, accrued to the state, as reimbursement for purchase of advanced batteries for BEV swapping stations. • Developers of Auto Clusters and Automotive Suppliers Manufacturing Centers (ASMC) specific to EVs shall be provided financial assistance of 50% of fixed capital investments in building and common infrastructure, up to a maximum of INR 20 crore (EUR 2.27 Million). • External Infrastructure Subsidy: All external infrastructure such as power supply, water supply, roads will be provided at the doorstep of the industrial unit, charging & battery swapping stations at 50% of the cost of the infrastructure with an overall limit of INR 2 crore (EUR 227,000) per project.
Prioritization in terms of EV characteristics and social geography	• Multiple government offices and public areas will be chosen for installing public charging equipment that can be used by all. • Existing private buildings such as malls and other commercial buildings will be incentivized to setup charging/battery swapping stations. • APSRTC depots, bus terminals and bus stops will have charging stations. • Public parking spaces will be mandated to have charging stations. • Government buildings will set a roadmap to setup charging or swapping stations in all of its parking spaces. • Facilities will be provided to setup swapping stations in the form of a kiosk to service 2 and 3 wheelers. • All new permits for commercial complexes, housing societies and residential townships with a built-up area 5,000 sq.mt and above will mandate charging stations.
Easing out administrative barriers for establishing charging stations	• The GoAP will allocate 500 to 1,000 acres of land for developing EV Parks with plug and play internal infrastructure, common facilities, and necessary external infrastructure. • Municipalities shall issue provisional permissions online immediately to setup charging/battery swapping stations. Any verification shall only be post sanction of provisional permission. • Land across major cities will be allocated for private developers for setting up charging or battery swapping stations in a form similar to a contemporary fuel station as per statutory clearances. • City codes will be modified for both public places and private buildings in order to make the infrastructural changes needed for charging/battery swapping infrastructure. • Urban local bodies, Municipality rules/regulations will be modified to allow charging and battery swapping stations to be setup within its limits as and when required.
Mandate on the utilization of V2X capabilities	APERC will issue regulations, defining tariff and related terms & conditions, for vehicle to grid (V2G) sale of power to meet the requirements of real time and ancillary services for DISCOM.
Focus on RE integration and EV charging	• Third party EV charging service providers will be allowed to procure power through open access route from renewable energy sources irrespective of the size of the demand. APERC will determine the appropriate process and charges related to open access. • Third party EV charging service providers can also setup their own renewable energy generating stations at their premises for charging EVs only.
Measures to Enable EV charging on demand-side	
Elements	Focus on State EV Policy
Specification of the use of a wide range of payment methods	Cloud charging features will be encouraged in order to have all metering and transactions done digitally with payment apps, NFC enabled devices, RFID tags etc. while keeping it flexible and customer friendly.
Harmonization of Intra/ interstate mobility of EVs	Charging infrastructure will be installed at least every 50 km on highways, other major roads etc.

Additional Measures for promotion of EV sector	
Elements	Focus on State EV Policy
EV Market Support services to promote EV adoption	**Capital subsidy of Fixed Capital Investment (FCI) in the following amounts:** • 25% of FCI up to a maximum of INR 15,00,000 (EUR 17,000) for Micro industries • 20% of FCI up to a maximum of INR 40,00,000 (EUR 45,400) for Small and INR 50,00,000 (EUR 58,000) for Medium Industries • 10% of FCI up to a maximum of INR 10 crore (EUR 1.13 Million) for first two units, under Large industries, in each segment of EV (2 wheelers, 3 wheelers, 4 wheelers, buses), battery and charging equipment, hydrogen storage & fueling equipment manufacturing. • 10% of FCI up to a maximum of INR 20 crore (EUR 2.27 Million) for first two units, under Mega category, in each segment of EV (2 wheelers, 3 wheelers, 4 wheelers, buses), battery and charging equipment, hydrogen storage & fueling equipment manufacturing. • Additionally, special incentives will be given according to their need for Mega, Mega Integrated automobile projects and Ultra-Mega battery manufacturing plants on a case-to-case basis. • For specific clean production measures, as certified by Andhra Pradesh Pollution Control Board (APPCB), 35% subsidy on cost of plant & machinery for MSMEs up to a maximum of INR 35,00,000 (EUR 39,000) and 10% subsidy on cost of plant & machinery for Large projects up to a maximum of INR 35,00,000 (EUR 39,000) . • 25% subsidy, for MSMEs and Large projects, for sustainable green measures on total FCI of the project (excluding cost of land, land development, preliminary and pre-operative expenses, and consultancy fees) with a ceiling of INR 50 crore (EUR 5.67 Million). **Stamp Duty:** • 100% of stamp duty and transfer duty paid by the industry on purchase or lease of land meant for industrial use will be reimbursed. • 100% of stamp duty for lease of land/shed/buildings, mortgages and hypothecations will be reimbursed. • Stamp duty will be reimbursed only one time on the land. Stamp duty will not be waived on subsequent transactions on the same land. • External Infrastructure Subsidy: All external infrastructure such as power supply, water supply, roads will be provided at the doorstep of the industrial unit, charging & battery swapping stations at 50% of the cost of the infrastructure with an overall limit of 2 crores per project. **Power:** • AP is one of the three states selected under the centrally sponsored "Power for All" scheme. GoAP is committed to supplying uninterrupted 24x7 quality power to all qualified EV related industries operating in the state. GoAP will provide dedicated feeders to all units involved in manufacturing components for EV as required. • GoAP will provide fixed power cost reimbursement at INR 1 per unit for a period of 5 years from the date of commencement of commercial production. The power cost reimbursement for certain specific sector/sub-sector may be higher. • The electricity duty will be reimbursed for a period of 5 years. • A dedicated line along with special discount for night-time/non-peak time usage will be offered for testing of BEV batteries based on requirements **Water:** • Water Supply will be made at 50% of the price of existing industrial supply tariff for the initial 3 years from the date of commencement of commercial production. • In order to provide quality water, the GoAP will reimburse 25% of the cost of water treatment plant wherever necessary, with a limit of INR 2 crore (EUR 232,000) on this subsidy. • Tax Incentives: 100% net SGST accrued to the state will be reimbursed for a period of 5 years for micro & small, 7 years for medium, 10 years for large industries. This reimbursement will be limited to 100% of capex or for the period stated, whichever is earlier. • Skill development incentives: Stipend of INR 10,000 (EUR 113) per employee per year to a maximum of first 50 employees for a single company for Micro, Small, Medium, and Large firms.

	• Marketing incentives: 50% of cost of participation with a maximum amount of 5,00,000 (EUR 6,000) to be reimbursed to a maximum of 10 MSME units per year for participating in international trade fairs. **Financial Incentives for Private Purchase and Use** • Reimbursement of registration charges and road tax on sale of EVs until 2024. • Phase wise/City wise, promotional discounted tariff will be offered for charging BEVs. • Time of use tariff for BEV to be introduced • Reimbursement of the Net SGST for services rendered, accrued to the state, for firms involved in services such as leasing of fleet of EVs, owning or operating EV fleets and providing charging/battery swapping/Hydrogen stations for recharging/ refueling EVs, until 2024.
Institutional framework for roll out of policies	• **Nodal Organization:** The government will setup a high-level committee consisting of stakeholders from all concerned departments. The government will issue new directives to the respective departments to include any support needed for furtherance of EV in their operational policy under ease of doing business. • **Smart Mobility Corporation:** to coordinate all associated departments in central Government as well as state Government to further the adoption of vehicles both for government as well as private use. It will also periodically review the incentives and suggest amendments as required. • **Land:** In case of Mega integrated projects, government will offer land to dependent ancillary units at the same rates as offered to respective Original Equipment Manufacturer (OEM) (wherever Government allocates land to OEM) up to a maximum of 50% of the land allocated to OEM. • **Water:** The GoAP will provide water supply and also facilitate/support setup of water treatment plants in/around major auto hubs in order to meet this requirement wherever necessary. • **Rail and Road Connectivity:** The GoAP shall strive to construct elevated expressways to decongest roads to the industrial areas and will also look to ensuring better road access to ports. • **Export Oriented Units:** For export focused units, the incentives as per the Export policy of the state shall be applicable, over and above what is made available under this policy. • Formation of Centre for Advanced automotive Research (CAAR) and Center for Advancement of Smart Mobility (CASM) to focus on R&D based objectives under the policy • In coordination with National automotive testing and R&D Infrastructure (NATRiP), GoAP shall strive to set-up quality testing center for EVs and these facilities would be accessible to all manufacturers in the sector.
Enhancement of EV value chain peripheral ecosystem	**Research & Development grants:** • A research grant of INR 500 crore (EUR 58 Million) will fund the most innovative solutions in the mobility space. Public or private research labs, incubators, start-ups that work on products and solutions in electric mobility space will also be provided land and office space to quickly setup their facility. • Research scholars who move to the state to work for research in electric mobility and its components will be offered one time grant and incentivized via accommodation and transportation benefits. • GoAP proposes to provide financial assistance towards expenses incurred for patent registration and for quality certifications. The financial assistance will be limited to 75% of the cost, subject to a maximum of 25,00,000 (EUR 29,000) for obtaining patent registration and 50% of all charges, subject to a maximum of 5,00,000 (EUR 6,000) paid for obtaining quality certification. This would be applicable only to MSME's. • State will identify required quantum of skilled manpower; map EV specific skill sets and provide courses at different levels of education – matriculation and above. Local Industrial Training Institutes (ITIs), employment exchange centers, technical institutes will be prepared to introduce EV courses & train technicians and engineers. • Additional subsidy on training and stipend will be provided for every company with a cap on employees per type of firm. • Test rides in collaboration with various vehicle manufacturers, green days in the capital region and other cities will be promoted to take the new technology to the common man.

Miscellaneous	**Model Electric Mobility Cities:** • 2018-19 shall be announced as the "Year of the Electric Vehicle" in AP • The cities of Vijayawada, Vishakhapatnam, Amaravati and Tirupati will be declared as model EM cities with phase-wise goals to adopt EVs, charging & hydrogen refueling infrastructure and new EV enabling building codes. Visakhapatnam will be the pilot city for all new initiatives • Model EM cities will have a deadline to convert 100% of all commercial & logistics fleets to electric fleet by 2024. These fleets can belong to any government organization, APSRTC, educational institutes, hospitals or corporates and other institutions. • DISCOM will plan to setup 100 DC public charging stations in each of these cities. • Smart city proposals to the central government will include support for charging infrastructure and hydrogen fueling stations. Identified areas will be designated as "Green zones" with entry only to non-fossil fuel-based vehicles. • These cities will develop specific goals of charging and Hydrogen refueling infrastructure density • Within a defined timeline linked to target for deployment of EVs. These cities will create mobility blueprints and make provision in infrastructure needs to support the charging stations and EV only zones. • One or more of higher registration, renewal, parking fees, congestion charges, taxes/cess on sale, and limitation of entry into city limits etc. will be levied on sale/usage of highly polluting vehicles in order to support the switch to environmentally friendly vehicles. • Multiple government offices and public areas will be chosen for installing public charging equipment that can be used by all. • GoAP will support CSR initiatives in the Electric mobility ecosystem, as per the guidelines of GOI • PPP models in public transport, using purely EVs, will be offered based on selected routes/EV Zones.

4.6.3.2 Key Attributes Defined in Andhra Pradesh EV Policy:

Figure 4.11: Key highlights in Andhra Pradesh EV policy

In the state policies, special attention is given to public transport sector which aims to convert all the public buses to e-buses by the end of 2029, starting with conversion of all buses in four major target cities in the state, to electric by 2024. The state policy guidelines also offer to create awareness among the people for facilitating growth of the EV market. In order to do this, test rides in collaboration with various manufacturers are also planned. The state also has plans to celebrate "green days" in its capital city as part of the EV promotion among its citizens.

Limitations related to EV charging infrastructure in Andhra Pradesh EV Policy:

a) No support for home/workplace charging infrastructure.

b) No provision of dedicated help desk/single window clearance system for charging station developers.

c) Development of digital platforms for database management and setting up of facilities to address consumer complaints are not considered.

4.6.3.3 EV Market of Andhra Pradesh

Andhra Pradesh also boasts of a significant number of e-2W compared to e-4W. As of December 2021, the state has more than 14,000 e-2w and 4,500 e-4W. The state also has around 2,500 e-3W[46].

46 Transport Department, Government of Andhra Pradesh.

4.6.4 KERALA

Kerala is popular for its environmental sensitiveness and biodiversity. Thus, the state wishes to maintain its green environment intact and plans to ensure sustainable development by transitioning the vehicle sector from fossil fuel based to e-mobility. The EV development and implementation must be integrated to the state's manufacturing eco system, particularly for the e-mobility components. Also, the infrastructure for electric vehicles must include adequately available power supply, charging facilities and favourable electricity tariffs.

Kerala Electric Vehicle Policy released in March 2019 aims at embracing e-Mobility as a tool to promote shared mobility and clean transportation which ensures environmental sustainability with reduced pollution and increased energy efficiency[47]. Another aspect of this policy is the inclusion of creating an opportunity to set up an efficient eco-system for manufacturing EV and its components in the state.

4.6.4.1 Key Objectives of Kerala Electric Vehicle Policy 2019

Measures to Enable EV charging on supply-side	
Elements	**Focus on State EV Policy**
Definition of a fundamental market design framework to limit distortions and entry barriers	• PCS and BSF shall be provided across the state in phased manner. • ToD tariff will be made applicable to all PCS/BSF
Incentives for promoting the EV charging infrastructure	• Capital subsidy of 25% of the value of the charging station equipment/machinery up to a maximum subsidy of INR 10,00,000 (EUR 11,578) for DC chargers (100 V and above) for first 100 stations and INR 30,000 (EUR 347) for DC chargers (below 100 V) for first 300 stations. • Capital subsidy of 25 % of fixed capital investment (for eligible assets excluding cost of battery inventory) up to a maximum subsidy of INR 10 lakhs (EUR 12,000) for swapping stations for the first 50 stations.
Prioritization in terms of EV characteristics and social geography	• In major cities, at least one charging station should be available in a grid of 3km ×3 km. • Existing buildings such as malls and other commercial properties would be incentivized to setup PCS/BSF. • All new permits for commercial properties/ housing societies/ residential townships with a built-up area of 5,000 sq. m. and above would mandate a PCS. • New and renovated non-residential buildings with more than 10 equivalent car spaces (ECS) for parking would need to have 20% of those to be EV ready, with conduits installed. • For residential complexes and colonies with more than 10 ECS parking spaces would need to have 100% of ECS EV ready.
Focus on RE integration and EV charging	• The charging infrastructures will have an option to meet their power requirement from renewables or conventional energy sources or from distribution companies within the state.

47 "Kerala Electric Vehicle Policy," 2019, https://mvd.kerala.gov.in/sites/default/files/Downloads/e_vehicle_policy_go_no24_19.pdf.

Additional Measures for promotion of EV sector	
Elements	• Focus on State EV Policy
EV Market Support services to promote EV adoption	• The road tax on the EVs may be fully exempted for the initial 3 years (for new registrations) • Capital subsidy of 25 % of fixed capital investment (for eligible assets excluding cost of battery inventory) up to a maximum subsidy of INR 10,00,000 (EUR 12,000) for swapping stations for the first 50 stations. • Incentives of INR 30,000 (EUR 347) or 25% of the EV whichever is lower for the 3-wheelers that are procured from the empaneled vendors (under the scheme for promotion of EVs) • Fiscal incentives on EVs such as state tax breaks, road tax exemptions and free permits to fleet drivers are proposed. • Non fiscal incentives such as exemption from toll charges, free parking etc. are also included in the support schemes of early EV adoption.
Institutional framework for roll out of policies	• The KSEBL, the state DISCOM shall be the state nodal agency for establishing the charging infrastructure in the state. • e-mobility State Level task force set up by the state government to initiate, develop and sustain e-mobility in the state. • e-mobility State Level task force defines policies and strategies for the development and growth of EV sector and shall also scrutinize the technology adoption and manufacturing proposals and give necessary recommendations to the Government • A high level inter-departmental steering committee is constituted for the smooth implementation of EV roadmap in the state. It shall review progress of plans and suggest necessary course corrections.
Enhancement of EV value chain peripheral ecosystem	• Government initiative to conduct electric vehicles expo to create awareness and familiarity among the public as well as to create a platform for EV manufacturers to showcase their products. • Selected regions such as tourist spots, technology hubs etc. will be converted to e-mobility zones to familiarize the public on the e-mobility aspects and usages. • Human capacity building and re-skilling facilities such as curriculum updates in schools and colleges, specific skilling program to deliver hands on learning for graduates and professionals and establishment of centers of innovation and excellence for EV technologies are also proposed

4.6.4.2 Key Attributes Targeted in Kerala EV Policy:

Figure 4.12: Key highlights in Kerala EV policy

Kerala has selected a few areas across the state such as tourist villages, technology hubs and Central Business Districts (CBDs) of major cities that are aimed to be developed into e-mobility demonstration hubs. It plans to build a robust infrastructure for EV market, with adequate power supply, favourable electricity tariff along with proper charging networks. The various goals for the state are the need to balance the power supply- demand of utilities, ensure good operational efficiency and increase savings for transport utility and the transport sector in general.

4.6.4.2 EV market of Kerala

Figure 4.13 shows the share of registered vehicles in Kerala as of February 2022 differentiated by the fuel type. Here too, the share of PHEVs is much higher than that of BEVS with PHEVs accounting for 0.21% of the state's vehicle population and BEVs accounting for just 0.1%.

Limitations related to EV charging infrastructure in Kerala EV Policy

a) No financial support for home/workplace charging infrastructure.

b) Lack of clarity in expense recovery for DISCOMS in setting up charging stations.

c) No mention of battery recycling, retrofitting, vehicle scrappage incentives, and promotion of shared mobility.

d) There is no mention of utilization of V1G or V2X capabilities.

e) Development of digital platforms for database management, setting up of facilities to address consumer complaints and specifications of payment methods are not considered.

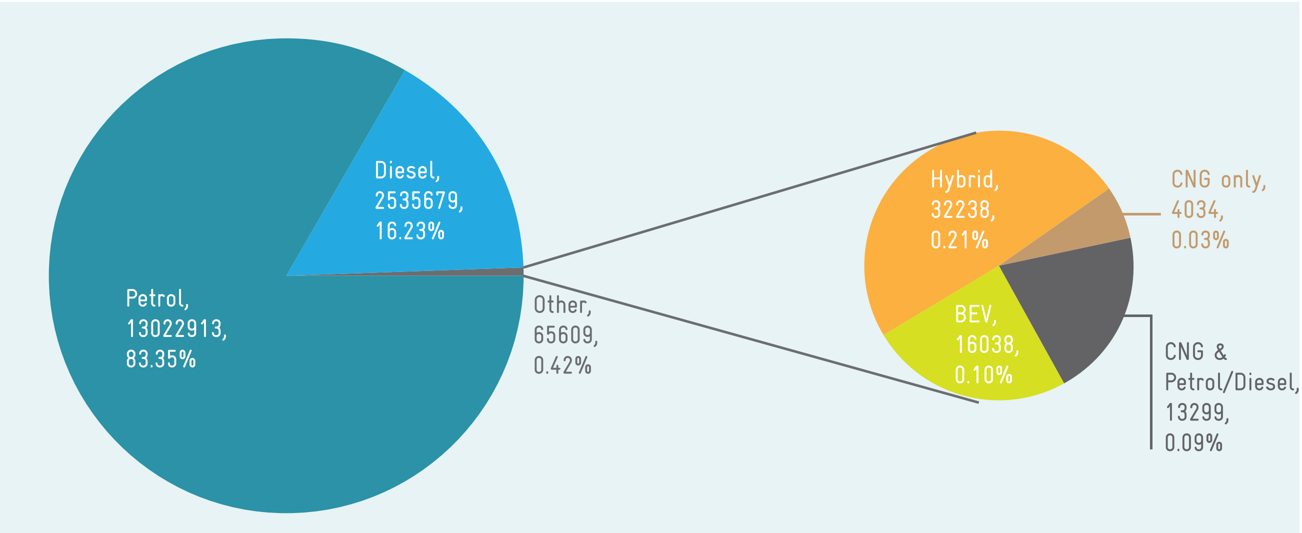


Figure 4.13: Share of total registered vehicles in Kerala by fuel type (till Feb 2022)[42]

4.6.5 UTTAR PRADESH

The Uttar Pradesh Electric Vehicles Manufacturing and Mobility Policy 2018 provides attractive fiscal and non-fiscal benefits to attract investments for promoting Electric mobility in the state[48]. The policy also promotes early adoption of EVs in the state as well as create demand in the sector. Therefore, the policy contains three components: -

(1) Manufacturing

(2) Charging infrastructure

(3) Demand Creation.

The EV policy complements the UP Industrial Investment and Employment Promotion Policy (UP IIEP), 2017. Besides the department of infrastructure & industrial development, department of transport, department of power and department of urban development play pivotal role in the implementation of this policy. This policy is valid for 5 years from its date of issue, 7th August, 2019.

4.6.5.1 Key Objectives of Uttar Pradesh Electric Vehicle Policy 2019

Measures to Enable EV charging on supply-side	
Elements	**Focus on State EV Policy**
Definition of a fundamental market design framework to limit distortions and entry barriers	• DISCOM will plan an investment to set up 100 DC public charging stations in each of the 10 model EM cities.
Incentives for promoting the EV charging infrastructure	• Capital Subsidy @25% on fixed capital investment (excluding land cost) to first 100 charging stations subject to maximum INR 6,00,000 (EUR 7,000) per charging station. • Government of Uttar Pradesh will provide incentives to the developers of private EV parks & clusters with plug and play facilities. • 50% Capital interest subsidy on fixed capital investment will be provided for setting up hydrogen generation and fueling plants in the form of reimbursement to first 10 units in UP, subject to maximum INR 50 lakh (EUR 58 Thousand) per unit over the period of this policy. • For manufacturing of alternate clean sources of fuel like hydrogen-based fuel cells will be supported in technology transfer: Anchor EBUs will be reimbursed 100% and 75% cost of technology transfer towards first and next 5 vendor units consecutively, up to INR 50,00,000 (EUR 58,000); Ultra mega Battery plant will be reimbursed 50% cost of technology transfer, up to INR 10,00,000 (EUR 12,000) per annum.
Prioritization in terms of EV characteristics and social geography	• Charging infrastructure to be developed and promoted in public places with provisions to set up charging outlets. • Fast charging stations, BSF at every 50 km would be prioritized for installation in prominent highways such as the Yamuna Expressway, Agra-Lucknow Expressway, and other upcoming expressways. • New apartments, technology parks would be encouraged to make provisions for EV charging infrastructure. • Permits for commercial complexes, housing societies and residential townships with a built-up area of 5000 sq.mt. and above would have mandated number of charging points.

48 "Uttar Pradesh Electric Vehicle Manufacturing and Mobility Policy 2019," 2020, http://investup.org.in/wp-content/uploads/2021/04/UP-EV_2019.pdf.

Easing out administrative barriers for establishing charging stations	• State will facilitate acquisition of land to such PSUs at concessional rates in designated areas to set up charging infrastructure. • All required approval and clearances for setting up of EV charging infrastructure would be made in a single window system.
Measures to Enable EV charging on demand-side	
Elements	**Focus on State EV Policy**
Harmonization of Intra/ interstate mobility of EVs	• Promote EV mobility on prominent highways, with heavy density of vehicles, fast charging stations, battery swapping infrastructure, at every 50 km.
Additional Measures for promotion of EV sector	
Elements	**Focus on State EV Policy**
EV Market Support services to promote EV adoption	• Government will promote hybrid electric vehicles and give incentives to boost demand of HEVs in the state. • Land Subsidy: Up to 25% of reimbursements will be provided on Mega Anchor Project and Ultra mega battery plant on land purchase. • The defined Large, Anchor EVMUs/EBUs and MSME units will be provided incentives including: - Capital interest subsidy, Infrastructure interest subsidy, Industrial quality subsidy, Stamp duty and electricity duty exemption, and SGST reimbursement. • First 1,00,000 buyers of Private EVs manufactured within the State of Uttar Pradesh over the period of this policy will be provided following exemptions: 100% exemption from Vehicle registration fees;100% exemption on road tax for 2-wheeler EVs and 75% road tax exemption for other EVs • For manufacturing of alternate clean sources of fuel like hydrogen-based fuel cells will be supported in technology transfer: Anchor EBUs will be reimbursed 100% and 75% cost of technology transfer towards first and next 5 vendor units consecutively, up to INR 50,00,000 (EUR 58,000); Ultra mega Battery plant will be reimbursed 50% cost of technology transfer, up to INR 10,00,000 (EUR 12,000) per annum
Institutional framework for roll out of policies	• To develop the state as an EV manufacturing hub Government is promoting quality infrastructure. • Various cities including Noida, Ghaziabad, etc. will be declared as model EM cities.
Enhancement of EV value chain peripheral ecosystem	• To promote EV vehicles in Public Transportation, 1000 EV buses will be introduced by the State by 2030. 25% in phase I by 2020, 35% in phase II by 2022. 40% in phase III by 2030. • All forms of government vehicles will be converted to electric vehicles by 2024. • Patent & quality certifications– Government will provide financial assistance limited to 75% towards patent and certifications. It will be subjected to a maximum of INR 25 lakhs (EUR 29 Thousand) for obtaining patent registration and 50% of all charges, subject to a maximum of INR 5 Lakhs (EUR 6 Thousand) paid for obtaining quality certification. • Government will set-up an accessible quality testing center for all manufacturers EVs.

4.6.5.2 Key Attributes Targeted in Uttar Pradesh EV Policy

The state provides different incentives for large, medium, small, and micro manufacturing units of EV in the state, such as, capital interest subsidy, infrastructure interest subsidy, and industrial quality subsidy, and offers exemption from stamp duty, electricity duty, SGST etc. It also provides subsidy on land purchased along with a reimbursement of up to 25% of the total cost of the land at the prevalent circle rate for EV and battery manufacturing units, however all the fiscal support is available to the vehicles and associated components which are manufactured in the state itself and not applicable to products from outside the state. The state also offers a single window system dedicated specially for all approvals required by EV and battery manufacturing units and is directly monitored by the Chief Minister's office of the state. UP plans to become a popular R&D hub for EV market, by targeted focus on next generation of EV related technologies such as (i) battery management systems, (ii) drivetrain components (iii) battery chemistry (iv) fuel cell and (v) intelligent transportation systems. Incubation centres and start up support funds are also provided by the state policy guidelines to encourage the growth of EV adoption in state. In addition to all these, more research facilities are promoted by tie up projects between government and various academic institutions and universities.

Figure 4.14: Key highlights in Uttar Pradesh EV policy

The state policy covers all possible aspects of EV market promotion such as encouraging R&D opportunities, facilitation of land acquisition for setting up charging stations in private buildings to technology parks and other major commercial places, management of EV batteries from the disposal aspects to its recycling facilities and so on. The EV policy also has provision for a subsidy of 50% on annual interest on loans taken in the form of reimbursement to deploy waste treatment plants.

4.6.5.3 Market Status

The share of vehicle types is Uttar Pradesh based on fuel type as of February 2022 has been shown in Figure 4.15. As shown, the number of BEVs in state is more than 2.8 lakh, however similar to Bihar, of these, 2.6 lakh are 3W BEVs and 18,800 are 2 wheelers (VAHANSEWA, 2021).

Limitations related to EV charging infrastructure in Uttar Pradesh EV Policy

a) No support for home/workplace charging infrastructure.

b) No mention of public awareness programs, retrofitting and vehicle scrappage incentives.

c) Development of digital platforms for database management, setting up of facilities to address consumer complaints and specifications of payment methods are not considered.

d) No mention of utilization of V1G or V2X capabilities and integration of RE based sources in EV charging infrastructure.

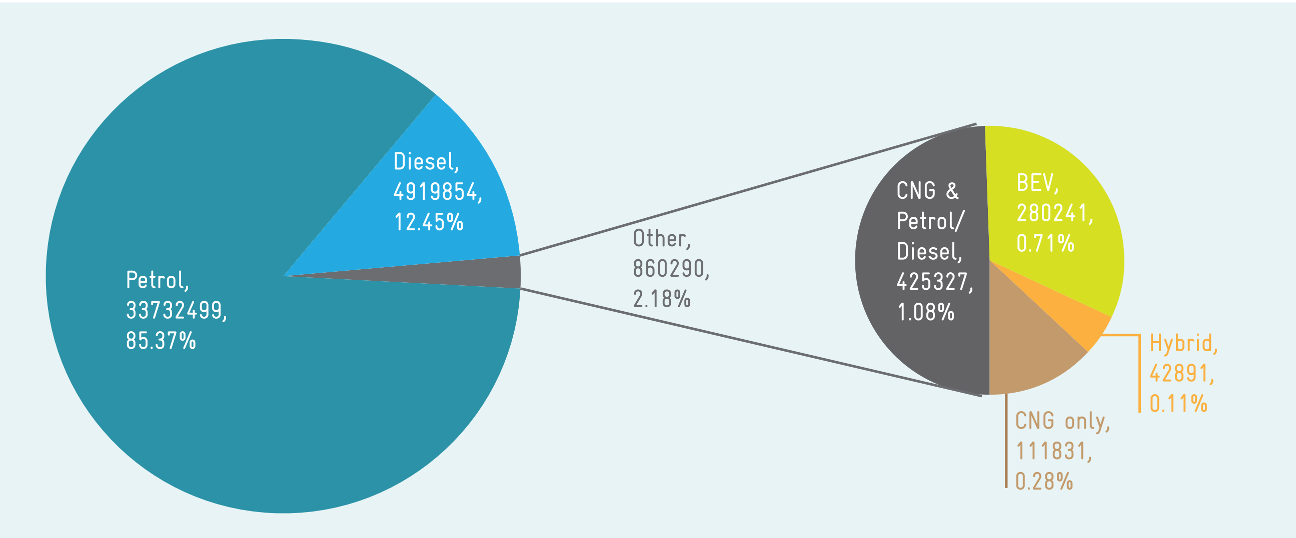
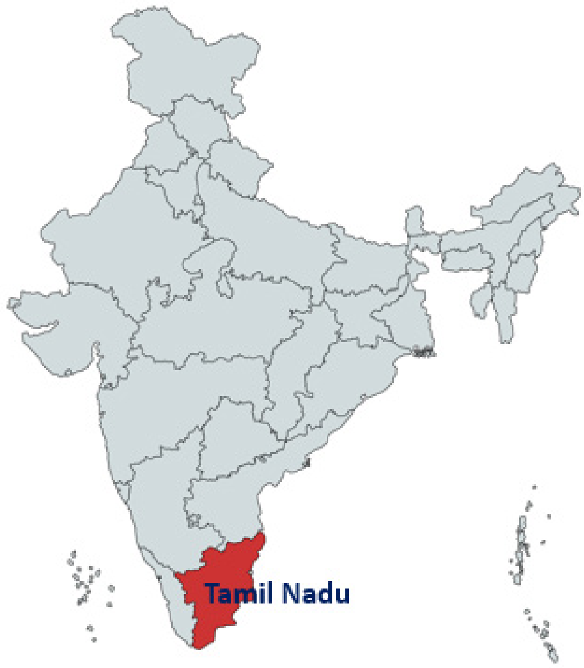


Figure 4.15: Share of total registered vehicles in Uttar Pradesh by fuel type (till Feb 2022)[42]

4.6.6 TAMIL NADU



Tamil Nadu is one of the most preferred investor's destinations in India with a highly developed industrial eco system, strong in sectors like auto mobiles and auto components. The state government is guided by the objective of making Tamil Nadu a manufacturing hub in consonance with the sustainable growth and development goals. The shift to clean transport such as electric mobility became one of the important investment options aligned with it. An important aspect that EV brings out is the low carbon power generation mix when electricity is generated using renewable energy sources such as wind and solar, which is relevant for the state since it is one of the renewable energy rich states in India with a remarkable installed capacity of 15,914 MW as of January 2022 .

Tamil Nadu being the second state with highest vehicle population in India, with 2.77 crore vehicles, its EV stock accounts for 6.4% of the national EV stock as of 2019. The state government thus notified Tamil Nadu Electric Vehicle Policy in 2019 to drive the visions set by the state in the wake of increasing EV penetration. A dedicated strategy is formulated to address various factors such as EV prices, implementation of charging infrastructures across the state and investment opportunities in the manufacturing of EV and related components in promoting EV growth[49]. This policy is valid for 10 years from its date of issue, i.e., 16 September 2019 or till a new policy is announced.

4.6.6.1 Key Objectives of Tamil Nadu Electric Vehicle Policy 2019

Measures to Enable EV charging on supply-side	
Elements	Focus on State EV Policy
Definition of a fundamental market design framework to limit distortions and entry barriers	• The Energy department will ensure public and private charging stations are provided with all necessary facilities and incentives. • The state will invest in setting up charging stations with active participation of public sector units including TANGEDCO and private players. • TANGEDCO will set up the charging infrastructure on its own or through private operators using appropriate public-private partnership models. • Adequate policy support will be provided for the development of charging infrastructure in cities and other places. • The tariff applicable for domestic consumption shall be applicable for private charging station at home: slow charging or overnight charging for EV (2-W,3-W, and small 4-W) may be included in this tariff scheme • Private charging in case of offices, malls, gated community etc. can be done in the common supply with LT tariff -V of TANGEDCO • Tariff for Public Charging stations will be determined by TNERC, and it will be endeavored to fix the tariff as not more than 15% above average cost of supply

Incentives for promoting the EV charging infrastructure	• The Government will develop schemes with appropriate capital subsidy to enable private operators to set up public charging stations. • In the case of intermediate products used in the manufacturing of EV and charging infrastructure, where SGST reimbursement is not applicable, a capital subsidy of 15% will be given on eligible investments over 10 years till 31-12-2025. • EV related and charging infrastructure manufacturing industries in the State will be provided 100% exemption on electricity tax till 31-12-2025. • EV related and charging infrastructure manufacturing industries in the State that obtain land by sale or lease shall be entitled to 100% exemption on stamp duty for transactions till 31-12-2022. • EV related and charging infrastructure manufacturing industries in the State that obtain land from SIPCOT, SIDCO or other Governmental agencies will be provided a 15% subsidy on the cost of land and will be provided 50% subsidy if the investment is in Southern districts till 31-12-2022. • EV related and charging infrastructure manufacturing units will be provided an employment incentive in the form of the reimbursement of employer's contribution to the EPF for all new jobs created till 31-12-2025. This incentive shall be paid for a period of one year and shall not exceed INR 48,000 (EUR 556) per employee. • For EV component and charging infrastructure manufacturing firms falling under the Medium Industries category that avail loans from Tamil Nadu Industrial Investment Corporation, 6% interest subvention will be provided as against 3% under the existing scheme till 31-12-2025
Prioritization in terms of EV characteristics and social geography	• The Government will take effort to set up 3×3 grid charging stations in Chennai, Coimbatore, Trichy, Madurai, Salem, and Tirunelveli. • TANGEDCO will invest in setting up both slow and fast charging networks in Government buildings and public places. • One slow charging unit for every electric bus and one fast charging station for every 10 electric buses shall be provided. • Charging points will be provided in the Government office parking lots in Chennai, Coimbatore, Trichy, Madurai, Salem, and Tirunelveli and other places based on requirements. • All existing apartment associations with 50+ families will be encouraged to provide charging points in parking lots. • Existing residential townships with 500+ families will be encouraged to install charging stations. • At least 10% of parking space will be earmarked for setting up Charging stations in commercial buildings such as hotels, shopping malls, cinema halls, apartments etc.
Easing out administrative barriers for establishing charging stations	• Amendment to building and construction laws will be made to ensure that charging infrastructure is integrated at the planning stage itself for all new constructions and apartments in cities • All investment proposals under the EV sector will be provided the necessary facilitation through the Single Window Clearance facility.
Focus on RE integration and EV charging	• EV charging service providers can also setup their own RE based generating stations at their premises for charging of EVs. • Supply of Renewable Energy will be ensured on preferential basis for EV charging stations with zero connection cost.
Measures to Enable EV charging on demand-side	
Elements	**Focus on State EV Policy**
Harmonization of Intra/ interstate mobility of EVs	One charging station will be set up at 25 km intervals on both sides of NHAI and State highways

Additional Measures for promotion of EV sector	
Elements	Focus on State EV Policy
EV Market Support services to promote EV adoption	• 100 % road tax exemption to all 2-wheelers, e-autos, e-transport vehicles, e-carriers till 30-12-2022 • Road tax exemption will be enhanced from 50% to 100 % for private e-cars till 30-12-2022 • Waiver on registration charges/fees will be done for all e-vehicles as per GoI's notification • Auto-rickshaw/taxi permit fees will be waived for e-autos/e-transport vehicles till 30-12-2022 • There will be no requirement of permit for the 3-W goods, e-carriers as well as electric light goods carrier • 100% of the SGST paid on the sale of EVs manufactured, sold, and registered for use in the State will be reimbursed to the manufacturing companies till 31-12-2030 • In the case of intermediate products used in the manufacture of EV and charging infrastructure, where SGST reimbursement is not applicable, a capital subsidy of 15% will be given on eligible investments over 10 years till 31-12-2025 • The Government will provide higher capital subsidy of 20% of the eligible investment over 20 years in cases where manufacturing units are engaged in EV battery manufacturing. Such units shall also be provided land at 20% subsidy and at 50% subsidy in Southern districts. The special package will be applicable for investments made till 31-12-2025 • An additional capital subsidy of 20% will be offered over and above the eligibility limit for capital subsidy under the existing capital subsidy scheme to MSME units that are engaged in EV component or charging infrastructure manufacturer
Institutional framework for roll out of policies	• The Industries Department will be the nodal department for implementation of manufacturing related incentives under EV policy in TN • The Transport Department shall be the nodal department for issuing guidelines to achieve the transport related objectives of the policy • State Transport Undertakings (STUs) will strive to replace around 5% of the buses as EV every year and around 1000 EV buses maybe introduced every year • Private bus operators will also be encouraged to transition to EV buses. • Buses operated to pilgrimage centers, tourist places, national parks etc. will be converted to EVs • Institutional vehicles (school /college) buses will be encouraged to transition to EVs completely • Proposed conversion of all auto rickshaws in six major cities- Chennai, Coimbatore, Trichy, Madurai, Salem, and Tirunelveli to EVs within a span of 10 years and will be extended to other cities gradually • Proposed conversion of all taxis/cabs and app-based transport operators and aggregators in the six major cities (mentioned before) to EVs within a span of 10 years • E-commerce and delivery companies in the state will be encouraged to transition to e-mobility • the Government will develop exclusive EV parks in major auto manufacturing hubs and also in areas which have potential to attract EV investments • The Government will also promote Logistic Parks and Free Trade Warehousing Zones for better inventory management • The respective Industrial Guidance Bureaus for Large industries and MSME sector shall provide the necessary handholding services for E-vehicle related investments in state
Enhancement of EV value chain peripheral ecosystem	• Tamil Nadu Skill Development Corporation (TNSDC) to provide EV based skill training approved by NSDC to required industries and graduates, technical professional etc. • Promotion of conversion of 2-W and electric cars to EVs through fiscal concessions and creation of charging network. • Plug and Play manufacturing facilities will be created where vendors and OEMs can commence production with minimal capital investment in land and building. • With a view to assisting existing investors to transition into the EV manufacturing system, the principle of maintaining base volume production for expansion projects will not be applicable for EV manufacturers • Existing automobile manufacturing companies will be provided a one-time re-skilling allowance for every existing employee in the production line.
Promotion of Battery Recycling/ scrapping facilities	Recycle and reuse used batteries and dispose the rejected batteries in an eco-friendly manner to reduce pollution

4.6.6.2 Key Attributes Targeted in Tamil Nadu EV Policy

Figure 4.16: Key highlights in Tamil Nadu EV policy

In order to exploit the state's position as an 'automobile manufacturing hub', by being home to a large number of major manufacturing companies, the state has developed an "EV Special Manufacturing Package" with fiscal incentives and concessions to strengthen the supply side environment. Also, with a focus to initiate and encourage start-ups in the e-mobility sector, TN is setting up venture capital and business incubation centre.

4.6.6.2 Market Status

The market share of vehicles in Tamil Nadu by fuel type as of February 2022 is shown in Figure 4.17. Here, unlike Bihar and Uttar Pradesh, the number of electric 4W LMVs is comparatively higher at around 4,049, while the majority still comprises of electric 2W with a population count of 46,257 as of February 2022. Further, almost all the hybrid vehicles are 4W LMVs (VAHANSEWA, 2021).

Limitations related to EV charging infrastructure in Tamil Nadu EV Policy:

a) Lack of clarity in expense recovery for DISCOMS in setting up charging stations.

b) No support for home/workplace charging infrastructure.

c) No mention of public awareness programs, retrofitting and vehicle scrappage incentives.

d) Development of digital platforms for database management, setting up of facilities to address consumer complaints and specifications of payment methods are not considered.

e) No mention of utilization of V1G or V2X capabilities.

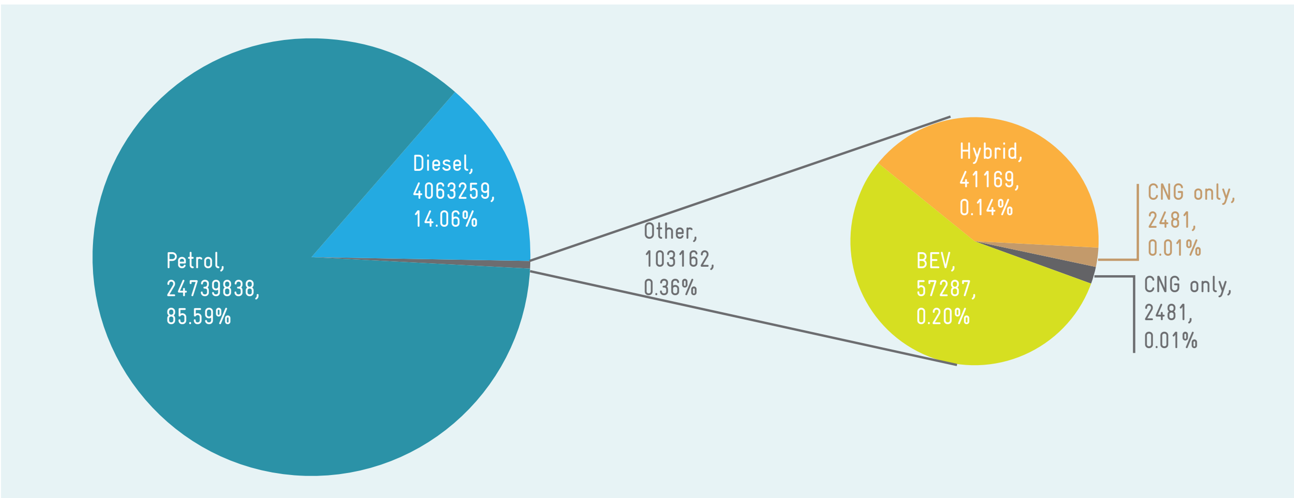


Figure 4.17: Share of total registered vehicles in Tamil Nadu by fuel type (as of Feb 2022) [42]

4.6.7 MADHYA PRADESH

The Urban Development and Housing department (UDHD) of Madhya Pradesh has formulated "Madhya Pradesh Electric Vehicle Policy 2019" to accomplish the objectives of 'Electric Vehicle Initiative (EVI)', which is dedicated to accelerating the growth and development of e-mobility in the state. There are a wide range of goals under the deployment of EV: better air quality and reduced pollution and greenhouse gas emissions, enhanced energy security combined with low carbon power generation mix. The policy shall act as a guiding document to prioritize and direct proper implementation measures of EVs across all the areas of the state. This policy will apply exclusively to battery electric vehicles, whereas mild hybrid, strong hybrid, and plug-in hybrid EVs will not be covered under this policy .

The primary objective of Madhya Pradesh Electric Vehicle Policy 2019 is to promote e-mobility and bring about the sustainable development in greener transport sector of the state. The policy will seek to drive rapid deployment of EVs in such a way that, EVs will contribute 25% of all new public transport vehicle registrations by 2026. The policy also aimed at enabling adoption of safe, reliable, easily accessible, and affordable public charging infrastructure across the state provided with renewable energy sources. Another aspect of the policy is to put in place support to create opportunities for manufacturing of EVs and its associated components[50]. This policy is valid for 5 years from its date of issue, 1st November 2019.

4.6.7.1 Key Objectives of Madhya Pradesh Electric Vehicle Policy 2019

Measures to Enable EV charging on supply-side	
Elements	Focus on State EV Policy
Definition of a fundamental market design framework to limit distortions and entry barriers	• The location and lands will be identified by the authority for setting up of public charging station on government land. These public charging stations can be small, medium, large category charging stations. Energy Operators' (EOs) will be invited to bid to set up charging stations along with battery swapping facility at each of the identified location. • Revenue from appropriate public amenities installed at charging stations like cafeteria, public toilets, and outdoor media devices etc., will be collected by the Energy Operators (EOs).
Incentives for promoting the EV charging infrastructure	• On small Charging stations: Capital Subsidy of 25% of the value of the charging equipment/machinery for first 300 charging stations up to a Maximum subsidy of INR 1,50,000 (EUR 1,737) • On medium charging stations: Capital Subsidy of 25% of the value of the charging equipment/machinery for first 100 stations up to a Maximum subsidy of INR 2,00,000 (EUR 2,316). • On large charging stations: Capital Subsidy of 25% of the value of the charging equipment/machinery for first 100 stations up to a Maximum subsidy of INR 10,00,000(EUR 12,000).

50 Urban Development & Housing Department, "Madhya Pradesh Electric Vehicle (EV) Policy 2019," November 1, 2019, http://mpurban.gov.in/Uploaded%20Document/guidelines/1-MPEVP2019.pdf.

Prioritization in terms of EV characteristics and social geography	• Charging stations along with battery swapping facility will be carved out from existing public parking zones, bus depots and terminals, and locations such that they offer easy entry and exit. Charging stations will also be set up at various bus depots and citizens can also use the charging stations by paying applicable tariff. • The city and building codes would be modified for both public and private buildings in order to make the necessary changes for EV charging infrastructure addition. • Existing private buildings such as malls and other commercial buildings will be incentivised to setup charging/battery swapping stations • All new permits for commercial complexes, housing societies and residential townships with a built-up area 5,000 sq.mt and above will mandatorily have a charging stations.
Mandate on user data sharing and privacy	• Share charging station data with DISCOM and to maintain appropriate protocols as prescribed by DISCOM for this purpose. The UDHD shall have access to this database.
Mandate on the utilization of V2X capabilities	• The Madhya Pradesh Electricity Regulatory Commission would release regulations and tariffs for V2G. • With release of due regulations V2G may be used for real time power balancing and provision of ancillary services. • Sale of power from BSF to the grid have been considered as V2G as per this policy.
Focus on RE integration and EV charging	• Open access for purchase of electricity from any other vendor would be allowed with the condition of having a contract demand of at least 1 MW. • EOs and BSFs with RE infrastructure would be provided with net metering facilities • Third party EV charging service providers would be allowed to procure power through open access from RE sources irrespective of the size of the demand.
Measures to Enable EV charging on demand-side	
Elements	• Focus on State EV Policy
Specification of minimum facilities to be provided at the charging stations	• Every Large and Medium Public Charging Station (PCS)[51] shall have minimum infrastructure as prescribed in the Guidelines and Standards notified by Ministry of Power, dated 14 December 2018 for "Charging Infrastructure for EVs." • The guidelines for the minimum chargers/charging infrastructure for vehicles at each category (small, medium, and large) of charging stations shall be separately issued by UDHD.
Additional Measures for promotion of EV sector	
Elements	Focus on State EV Policy
EV Market Support services to promote EV adoption	• The first 15000 electric two-wheelers or total electric two-wheelers in 5 years whichever is less, will be charged 1% motor vehicle tax. • Vehicle registration fees will be exempted for 22,500 electric two-wheelers or total electric two-wheelers in 5 years, whichever is less. • The first 5,000 Shared E-Rickshaws/electric auto-rickshaws or total Shared E-Rickshaws/ electric auto-rickshaws in 5 years, whichever is less, will be charged 1% (One Percent) motor vehicle tax. • Vehicle registration fees will be exempted for 7,500 Shared E-Rickshaws/ electric auto-rickshaws or total Shared E-Rickshaws/ electric auto-rickshaws in 5 years, whichever is less. • If permit requires for operations of electric Shared Rickshaws (SR)/ electric auto-rickshaws, then first 5,000 Shared E-Rickshaws/ electric auto-rickshaws or total Shared E-Rickshaws/ electric auto-rickshaws in 5 years, whichever is less, will be exempted by transport department. • The first 2,000 Electric Three-Wheeler Goods Carrier or total electric three-wheeler goods Carrier in 5 years, whichever is less, will be charged 1% motor vehicle tax.

51 Definition of charging station types as per Madhya Pradesh EV Policy

Charging Station Type	Vehicle Category Serviceable	Location applicability
Small Charging Station	2W and 3W	City
Medium Charging Station	2W, 3W and cars	City and highways
Large Charging Station	2W, 3W, Cars and Heavy vehicles	City and highways

	• Vehicle registration fees will be exempted for 3,000 Electric three-wheeler goods Carrier or total Electric three-wheeler goods Carrier in 5 years, whichever is less. • If permit requires for operations of Electric Three-Wheeler Goods Carrier, then first 2,000 Electric Three-Wheeler Goods Carrier or total Electric Three-Wheeler Goods Carrier in 5 years, whichever is less, will be exempted by transport department. • The first 6,000 electric cars or total electric cars in 5 years, whichever is less, will be charged 1% motor vehicle tax. • Vehicle registration fees will be exempted for 9,000 electric cars or total electric cars in 5 years, whichever is less. • The first 1,500 electric buses or total electric buses in 5 years, whichever is less, will be charged 1% motor vehicle tax. • Vehicle registration fees will be exempted for 2,250 electric buses or total electric buses in 5 years, whichever is less. • If permit requires for operations of Electric Buses, then first 1,500 Electric Buses or total Electric Buses in 5 years, whichever is less, will be exempted by transport department. • Parking Cost: All EVs will be provided a 100% waiver on parking charges at any ULB run parking facility for an initial period of 5 years.
Institutional framework for roll out of policies	• UDHD and GoMP will be the nodal department for implementation of MPEV Policy 2019. • The GoMP will setup a high-level committee consisting of stakeholders from all concerned departments. The government will issue new directives to the respective departments to include any support needed for furtherance of EV in their operational policy under ease of doing business.

4.6.7.2 Key Attributes Targeted in Madhya Pradesh EV Policy

Figure 4.18: Key highlights in Madhya Pradesh EV policy

The state's EV policy does not provide sufficient push at the supply as well as demand side of EV Market. The policy provides guidelines for land at concessional rates to promote EV manufacturing facilities along with providing grants for R&D opportunities in the state. One of the key scheme mentioned in the policy is the permission for third party EV service providers to purchase power using open access from RE generating plants irrespective of the size of the demand. It also includes promotion of recycling of batteries and provides incentives for vehicle scrappage.

Limitations related to EV charging infrastructure in Madhya Pradesh EV Policy:

a) No support for home/workplace charging infrastructure.

b) No mention of retrofitting.

4.6.8 UTTARAKHAND

Government of Uttarakhand released 'The Uttarakhand EV Manufacturing and Usage Promotion and Related Services Infrastructure Policy 2018' with the focus of making Uttarakhand a major E-Mobility hub in India. This policy is mainly aimed at making the state a preferred destination for and laying out EV manufacturing investment opportunities along with radical transformation of mobility sector.

It is important to note that the state already is an important automobile manufacturing hub in Northern India with Haridwar and Pantnagar evolved as cities with good base of automobile and auto-component manufacturers such as Tata Motors, Mahindra, Ashok Leyland etc[52].

4.6.8.1 Key Objectives of Uttarakhand Electric Vehicle Policy 2019

Additional Measures for EV sector promotion	
Elements	Focus on State EV Policy
EV Market Support services to promote EV adoption	• For investment between INR 10-50 crore (EUR 1-6 Million), interest subsidy at 5% up to a maximum INR 3,00,000 (EUR 3,473) will be applicable form term loans • For investment above INR 50 crore (EUR 6 Million) , interest subsidy at 7% up to a maximum of INR 25,00,000 (EUR 29,000) for large units, INR 30 crore (EUR 3.4 Million) for Mega units and INR 50,00,000 (EUR 58,000) for Ultra-Mega units • 50 % exemption on stamp duty is given for investment between INR 10-50 crore (EUR 1-6 Million) and above INR 50 crore (EUR 6 Million). • Rebate of 15% 25% and 35% on SIDCUL prevailing land rate for investment above INR 50 crore (EUR 6 Million). • For investment between INR 10-50 crore (EUR 1-6 Million), payment provision is (i) 50% at time of allotment and balance 50% within 2 years in 2 instalments (ii) 100 % payment at the time of allotment will be eligible for 5 % rebate • Power incentive: 100 % exemption on electricity duty for 5 years from the date of commercial production • For MSME and Large Units (investment up to INR 50 crore (EUR 6 Million)) SGST reimbursement at 30% for 5 years after adjustment of input tax credit. • For investment above INR 50 crore (EUR 6 Million), SGST reimbursement at 50 % for 5 years • 100 % exemption of stage carriage permit for commercial vehicles for 5 years from the date of registration for first 100,000 customers • 100 % exemption from paying Motor Vehicle Tax for 5 years from the date of registration for first 100,000 customers
Enhancement of EV value chain peripheral ecosystem	• Land allocated for setting up EV manufacturing or EV component manufacturing units cannot be utilized for any other purpose for 15 years from the grant • Up to 50 % EPF reimbursement for 10 years with ceiling of INR 2 crore (EUR 232,000) for units employing 100 or more skilled labor on full time basis • For imparting training in EV/HEV component manufacturing, the organization will be entitled for training reimbursement at INR 1,000 (EUR 12) per month for 50 trainees
Miscellaneous	To avail incentives under the program of external infrastructure subsidy, firms need to employ 70% of their workforce from citizens residing in Uttarakhand

52 "The Uttarakhand EV Manufacturing and Usage Promotion and Related Services Infrastructure Policy" (State Infrastructure and Industrial Development Department, Government of Uttarakhand, December 2, 2019), https://www.siidcul.com/programs/25830_electric1576487934.pdf.

4.6.8.2 Key Attributes Targeted in Uttarakhand EV Policy

Figure 4.19: Key highlights in Uttarakhand EV policy

Limitations related to EV charging infrastructure in Uttarakhand EV Policy

a) No mention of incentives for Charging/ battery swapping stations.

b) No mention of battery recycling, electricity tariff, public awareness, R&D aspects, building bye-laws, retrofitting, vehicle scrappage incentives, promotion of shared mobility, and funding sources.

c) Development of digital platforms for database management, setting up of facilities to address consumer complaints and specifications of payment methods are not considered.

d) No mention of utilization of V1G or V2X capabilities and integration of RE based sources in EV charging infrastructure.

4.6.8.3 EV Market of Uttarakhand

The majority of the vehicles registered in Uttarakhand are still conventional fuel vehicles with BEVs and PHEVs comprising of only 0.92% of the total registered vehicles.

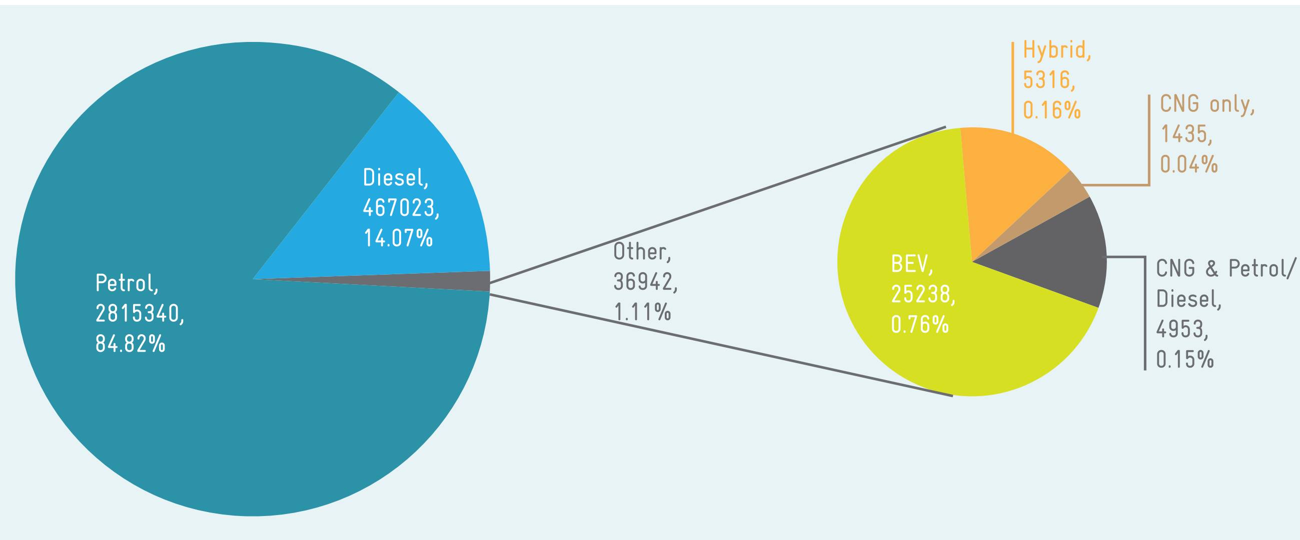


Figure 4.20: Share of total registered vehicles in Uttarakhand by fuel type (till Feb 2022)[42]

4.6.9 TELANGANA

The 'Telangana Electric Vehicle & Energy Storage Policy 2020-2030' builds upon FAME II scheme implemented since April 2019 by Department of Heavy Industries, Government of India. The policy released by Telangana is focused on not only making Electrical mobility as economically viable and sustainable solution for transforming vehicular technology, but also committed to provide facilities for energy storage solutions. Under National Mission on "Transformative Mobility and Energy Storage" launched by GoI in March 2019, the state is interested in developing a complete ecosystem domestically around EVs, which includes manufacturing of batteries and all other associated components to make Electric Mobility and Energy Storage Solutions (ESS) sector competitive in the near future. The major missions proposed by Telangana state under this policy includes, making the State an attractive investment destination for both EV and ESS sector combined with manufacturing and R&D facilities. It also aims to promote the faster adoption of both EV and ESS technologies in state, which can support a world class infrastructure in order to achieve substantial reduction in total cost of transportation for personal and commercial purposes[53]. This policy is valid for 10 years from its date of issue, October 2020.

4.6.9.1 Key Objectives of Telangana EV ESS Policy 2020-2030

Measures to Enable EV charging on supply-side	
Elements	Focus on State EV Policy
Definition of a fundamental market design framework to limit distortions and entry barriers	• TSREDCO (State Nodal Agency) shall evaluate to establish public charging stations directly or under licensee/franchise/PPP model. Various public places such as airports, railway/ metro stations, parking lots, bus depots, markets, petrol stations, malls & electric poles shall be examined for the same. • Government shall facilitate setting of up initial batch of fast charging stations in Hyderabad and other towns in a phased manner, by state entities and private players. • Government shall develop Night-time community parking with charging facility in PPP mode for e- Autos, Shared mobility taxis and public transport vehicles within Industrial zones. • Telangana State Electricity Regulatory Commission shall provide special Power Tariff category for Electric Vehicle Charging Stations.
Incentives for promoting the EV charging infrastructure	Incentives shall be provided for charging infrastructure.
Prioritization in terms of EV characteristics and social geography	• Existing Residential Townships with 1000+ families shall be encouraged to develop charging stations lots. • Preferential parking slots with required charging infrastructure shall be made available for Electric Vehicles. • HMR stations and TSRTC Bus depots (across the state) shall provide reserved parking and charging points for two-wheelers in their parking zones to encourage EVs for last mile commute

53 "Telangana Electric Vehicle and Energy Storage Policy" (Government of Telangana, 2020), https://cef.ceew.in/system/policies/policy_pdfs/000/000/076/original/telangana.pdf?1616142085.

Focus on RE integration and EV charging	TSREDCO (State Nodal Agency) in coordination with State DISCOMS shall ensure Supply of Renewable energy for EV charging stations & setting up of solar rooftop plants as per net metering policy and captive power plants shall be encouraged as per the TSREC Guidelines.
Measures to Enable EV charging on demand-side	
Elements	**Focus on State EV Policy**
Harmonization of Intra/ interstate mobility of EVs	Charging/ swapping station for every 50 km within state boundaries on highway to cities like Bengaluru, Mumbai, and Chennai, followed by other national/state highways shall be encouraged.
Additional Measures for promotion of EV sector	
Elements	**Focus on State EV Policy**
EV Market Support services to promote EV adoption	• Incentives shall be made available for Manufacturing of Electric Vehicles, Energy Storage Systems & related components in Telangana. Incentives shall include Capital Subsidies, SGST reimbursements, power tariff subsidies, etc. • Incentives shall be made available for 2 & 3 Wheelers, 4 wheelers, Light Commercial Vehicles, Shared Transport & Public Transport. The incentives shall include waiver on Road Tax & Registration Charges • Existing state self-employment schemes shall be extended to provide financial assistance for purchase of Electric Vehicles for commercial purposes. • EV & ESS sectors shall be incentivized as per the subsidies and incentives available under the Electronics Policy 2016.
Institutional framework for roll out of policies	• State Government shall facilitate in dovetailing with Govt. of India (GoI) schemes and encourage state stakeholders to avail benefits available under GoI schemes. • Adoption of EVs at Institutional Level shall be promoted starting with Government entities.
Enhancement of EV value chain peripheral ecosystem	• Battery operated feeder shuttle services at all Hyderabad Metro Stations for last mile connectivity shall be made available. • Government shall encourage EV adoption in Shared Mobility, Public Transport, Institutional Transport, Logistics & Delivery Services. • Government shall facilitate aggregators involved in public transportation with regulatory support to enable them to convert their fleet to EVs. • Government shall extend tailor-made benefits to Mega and Strategic Projects on case-to-case basis. Investment of more than INR 200 crore (EUR 23 Million) in plant and machinery or providing employment to more than 1000 persons shall be categorized as mega project.
Promotion of Battery Recycling/ scrapping facilities	• A battery disposal infrastructure model shall be created to facilitate deployment of used EV batteries. • Urban Mining of rare materials and cell/ battery recycling shall be incentivized on par with EV & ancillary manufacturing.

4.6.9.2 Key Attributes Targeted in Telangana EV Policy

Figure 4.21: Key highlights in Telangana EV policy

Telangana State EV ESS Policy 2020-2030 strives to formulate an effective policy framework for the accelerated deployment of EV and ESS technologies in their respective ecosystems. It comprehensively assesses gaps in both supply side and demand side as well as lays significant emphasis on development of EV charging infrastructure and implementation aspects of its various technologies. It also aims to provide balanced support to all EV value chain players as well as encourages manufacturing firms to set up their plants by providing land and plug and play facilities. The EV consumers and buyers in the state are awarded with various incentives along with exemption from paying road tax. Also, the charging infrastructure facility providers gets their reward in terms of capital subsidy and SGST rebate in the state. This policy is designed to make Telangana State the EV capital and Manufacturing hub of ESS in India.

4.6.9.3 EV Market in Telangana

As of February 2022, Telangana has around 16,000 BEVs and 4,700 PHEVs in the state which corresponds to around 0.26% and 0.08% respectively as shown in Figure 4.22. The majority of its vehicles are still conventional fuel vehicles.

Limitations related to EV charging infrastructure in Telangana EV Policy:

a) No support for home/workplace charging infrastructure.

b) No mention of avenues to arrange funds for implementation of policy guidelines.

c) No focus on power grid upgradations with respect to additional EV loads.

d) No mandate for DISCOMS to set up charging stations in state.

e) No mention of public awareness, retrofitting, vehicle scrappage incentives, promotion of shared mobility, and funding sources.

f) Development of digital platforms for database management, setting up of facilities to address consumer complaints and specifications of payment methods are not considered.

g) No mention of utilization of V1G or V2X capabilities.

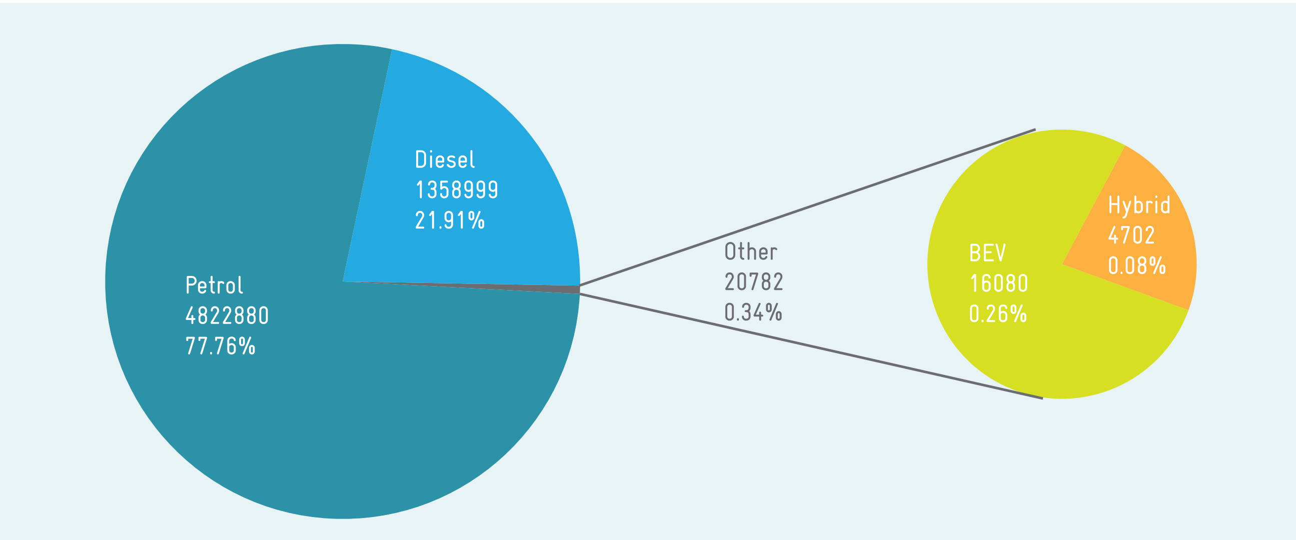


Figure 4.22: Share of total registered vehicles in Telangana by fuel type (till Feb 2022)[54]

54 Telangana Open Data Portal, "Regional Transport Authority Vehicle Registrations Data", https://data.telangana.gov.in/dataset/regional-transport-authority-vehicle-registrations-data

4.6.10 MEGHALAYA

The government of Meghalaya focuses on providing requisite impetus towards, adoption of a minimum of 15% EVs in the coming 5 years in the state, by giving incentives to a limited number of first EV adopters. The state aims at facilitating registration of around 20,000 EVs during the policy period, which will result in savings on 50 Lakh litres of fuel and about 10,000 kg reduction of CO2 per day (more than 36.5 lakh kg of CO2 per year). The state is working towards this objective to contribute to clean and green environment and an energy secure India, by facilitating increased and faster adoption of EVs and the required momentum for this is obtained through Meghalaya Electric Vehicle Policy 2021[55]. This policy is valid for 5 years from its date of issue, Feb 2021.

4.6.10.1 Key Objectives of Meghalaya Electric Vehicle Policy 2021

Measures to Enable EV charging on supply-side	
Elements	**Focus on State EV Policy**
Definition of a fundamental market design framework to limit distortions and entry barriers	• To create an enabling environment to provide charging infrastructure for EVs in the State. • To support the setting up of robust infrastructure for EVs including adequate power supply, network of charging points with favorable power tariff and adequate service centers
Prioritization in terms of EV characteristics and social geography	• Through the policy, the State would facilitate installation of charging stations at several key locations such as Meghalaya Transport Corporation's depots, Inter State Bus Terminus, Deputy Commissioner's offices, Secretariat, State Central Library, Urban Affairs Department's parking lots, and other government facilities and commercial buildings like, hotels, shopping malls, etc. • Government land wherever available, would be provided free of cost for installation of EV charging infrastructure, to government agencies/ PSUs/ private agencies under PPP.
Additional Measures for promotion of EV sector	
Elements	**Focus on State EV Policy**
EV Market Support services to promote EV adoption	• To provide support towards adoption of EVs by providing purchase incentives for early adoption of EVs based on the energy capacity in kWh of battery. • To replace the Meghalaya Transport Corporation buses with battery electric vehicles in a phased manner. • Registration fees and road tax shall be waived for all types of electric vehicles purchased during policy period.
Institutional framework for roll out of policies	• To facilitate adoption of at least 15% EVs in the State by 2025 • To mandate adoption of EVs in the Government and its Boards, Corporations, Government undertakings, Development Authorities, Municipalities in a phased manner.

55 "Meghalaya Electric Vehicle Policy – 2021" (Transport Department, Government of Meghalaya, 2021), https://www.meghalaya.gov.in/sites/default/files/documents/Meghalaya_Electric_vehicle_policy_2021.pdf.

Enhancement of EV value chain peripheral ecosystem	• To promote innovation in EVs for automotive and shared mobility by providing the requisite ecosystem and infrastructure • To create a pool of skilled workforce for the EVs industry in collaboration with technical institutions available in the State, encourage entrepreneurship and create new jobs in the EVs industry. • To provide a clean and green environment at tourist spots. • Priority registration will be provided to EVs over ICE vehicles by the respective RTOs in the State. • In case the Government decides to implement Odd-Even system for plying of vehicles in order to curb pollution, the EVs shall be exempted from such arrangement. • In order to support the EV ecosystem, the Government will undertake appropriate steps to reserve parking slots for EVs at key locations.
Promotion of Battery Recycling/ scrapping facilities	To facilitate in creating an ecosystem for recycling and reuse batteries and disposal of rejected batteries in an environment friendly manner to avoid environmental pollution.

4.6.10.2 Summary of Incentives for various EV categories

A	B	C	D	E	F=D*E	G=C*F	Remarks
Sr	Type of Electric Vehicle	Nos. in 5 yrs.	Approx. capacity (in KWH)	Incentive per KWH in INR (EUR)	Incentive per vehicle in INR (EUR)	Total Incentive in 5 Years (in INR (EUR))	Maximum ex-factory price to avail incentive (INR (EUR))
1	2 wheelers	3500	2	10,000 (113.5)	20,000 (227.07)	7 crore (0.8 mil)	1.5 Lakhs (1,703)
2	3 wheelers	200	5	4,000 (45.41)	20,000 (227.07)	0.40 crore (0.045 mil)	5 Lakhs (5,676)
3	4 wheelers	2500	15	4,000 (45.41)	60,000 (681.2)	15.00 crore (1.7 mil)	15 Lakhs (17,029)
4	Strong Hybrid 4 wheelers	30	1.3	4,000 (45.41)	5,200 (59.04)	0.02 crore (2270)	15 Lakhs (17,029)
5	Buses	30	250	4,000 (45.41)	10,00,000 (11,353)	3.00 crore (0.34 mil)	2 crores (0.23 mil)
					TOTAL	**INR 25.42 crores (2.88 million)**	

4.6.10.3 Key Attributes Targeted in Meghalaya EV Policy

Figure 4.23: Key highlights in Meghalaya EV policy

The nodal agency will be the sole commissionerate for implementation of various provisions described under the notified policy. To make the Meghalaya Electric Vehicle Policy 2021 financially self-sustainable, the nodal agency will set up Meghalaya Electric Vehicle Adoption Fund (MEVAF), which will be non-lapsable by consulting the state finance department.

4.6.10.4 EV Market in Meghalaya

Meghalaya has an almost non-existent EV market with only 36 BEVs and 548 PHEVs registered as of February 2022.

Limitations related to EV charging infrastructure in Meghalaya EV Policy:

a) No mention of avenues to arrange funds for implementation of policy guidelines

b) No mention of public awareness, electricity tariff, R&D aspects, retrofitting, vehicle scrappage incentives, building bye-laws, and funding sources.

c) Development of digital platforms for database management, setting up of facilities to address consumer complaints and specifications of payment methods are not considered

d) No mention of utilization of V1G or V2X capabilities and integration of RE based sources in EV charging infrastructure

4.6.11 WEST BENGAL

West Bengal is the first Asian state that introduced electrified public transportation. Currently the state has low percentage of e-mobility of 0.4% with 47,595 electric vehicles out of 10.34 million of vehicles. To increase the share of e-mobility in the state and harmonise with the EV adoption policy of Government of India, Power Department of West Bengal issued an 'Electric Vehicle Policy' in 2021[56]. The West Bengal state government's EV policy provides a strategic direction to an emerging EV sector. It is envisioned to make the state as a 'model state' in India for e-mobility. Considering the FAME India Guidelines, West Bengal government has a vision to leverage its history on mobility ecosystem and became leading state in future Indian electric mobility sector. Understanding the need of electric mobility and transformation in transportation sector, Power department, Government of West Bengal aims to become a leader in establishing sustainable transportation network by promoting electric mobility ecosystem and encouraging sustainability and energy efficiency. For achieving this aim, the policy is focused on promoting funds and grants for research in next generation battery technology, fuel cell technology, EV power train, and EV electronics to the research institutes, start-ups, incubation centres. It boosts investment in EV charging, battery swapping infrastructure, and hydrogen generation. In addition to focusing on funds and investment, policy encourages EV adoption to become an environmentally friendly and sustainable cities. The policy constitutes of strategy for the growth of charging infrastructure, demand creation of EV, and Research & development. It has fixed an ambitious target to be in top three states for EV penetration till the end of FAME II, 2022 and further to become best state by 2030. More specifically, government aims to include 10 lakh EVs during policy implementation and establish 1 lakh public and semi-public charging infrastructure till the policy duration. It also aims to create robust and adequate infrastructure for power supply and charging with favourable tariff structure which ensures EVs to charging station ratio of 8 during the policy period. Recycling, clean disposal of EV waste is addressed in the policy. It has introduced 'EV Accelerator Cell' as a nodal entity to the roll out of electric mobility implementation program within state. The cell will also facilitate inter-departmental coordination on framing regulatory mechanisms and progressive policies to enhance uptake.

The policy is applicable for 5 years from the date of implementation (from June 2021) or till substituted by new policy. It introduces monitoring committee that is formed to periodically review the policy and make necessary changes towards aim of the policy.

56 "Electric Vehicle Policy 2021" (Power Department, Government of West Bengal, June 3, 2021), https://wbpower.gov.in/wp-content/uploads/Electric%20Vehicle%20Policy%202021%20(Kolkata%20Gazette%20Notification).pdf.

4.6.11.1 Key Objectives of West Bengal State Electric Vehicle Policy 2021

Measures to Enable EV charging on supply-side	
Elements	**Focus on State EV Policy**
Definition of a fundamental market design framework to limit distortions and entry barriers	• Charge Point Operator (CPO) will get land at 'concessional location' with minimum lease price at existing public parking zones and other locations. • Encourages DISCOM to set charging stations in their premises, highways corridors, and express ways • Tariff for public charging station should be nearly equal to INR 6/kWh (EUR 0.681/kWh) for the first two years to attract EV customers. • Kolkata, Asansol, Darjeeling, and Howrah are declared as model cities to phase-wise implement EV mobility for EV charging, hydrogen station, and EV building infrastructure. • DISCOM should provide power supply immediately within 48 hr for charging and swapping stations. • Third party EV charging participant is allowed to purchase power at a tariff determined by regulator. • Private participants are allowed to establish hydrogen station. • Electric kiosk/booth for 2-Wheeler (W) and 3W is provided for establishing battery swapping station
Incentives for promoting the EV charging infrastructure	• Existing private building such malls and other building will get incentivized for setting a charging or swapping station in their premises. • 100% reimbursement of net SGST is given to private hydrogen stations and refueling station for the purchase of machinery. • Revenue earned through public charging station should be given to customers in terms of tariff reduction.
Prioritization in terms of EV characteristics and social geography	• Framework for residential charging, workplace charging, and EV ready parking will be developed. • Implement building bye law 2016 issued from Ministry of Housing and Urban Affairs and Urban region plan guideline 2014 for establishing EV ready building infrastructure. • Charging stations should be installed at government offices and public area which will be accessible to all EV users • EV charging infrastructure working group will roll-out the list of 'concession land' for first phase of policy implementation.
Easing out administrative barriers for establishing charging stations	• Set up the charging infrastructure working group under Cell for rapid building of charging point • Few of the first hydrogen generation and refueling station must be developed by government.
Mandate on the utilization of V2X capabilities	Encourages to explore smart charging management system for smart charging (V2G) and integration of renewable generations.
Focus on RE integration and EV charging	Encourages locally powered Renewable energy (RE) power and RE power purchase through power purchase agreement.
Measures to Enable EV charging on demand-side	
Elements	**Focus on State EV Policy**
The mandate for the development of digital platforms and database management systems	Publicly owned data base or state point registry owned big data will be developed to get real time public charging information.
Specification of the use of a wide range of payment methods	• Encourages cloud charging features as online payment for all digital metering and transactions to ease the charging experience of customer. • State level charging point platform will be created to access from in-vehicle system or app. In addition, unified payment interface will also be created for easy utilization of EV charging services, it can be further developed as state level smart mobility card.
Harmonization of Intra/ interstate mobility of EVs	• Promote inter-city green routes with fast chargers at 25 km for managing heavy duty electric vehicles • State level charging point platform will be created to access from in-vehicle system or app. In addition, unified payment interface will also be created for easy utilization of EV charging services, it can be further developed as state level smart mobility card.

Additional Measures for promotion of EV sector	
Elements	Focus on State EV Policy
Institutional framework for roll out of policies	• EV Accelerator Cell should develop regulatory mechanism and progressive policies to increase EV adoption • EV Accelerator Cell should facilitate ICE vehicle phasing out plan across all vehicle segments using 'State EV funds' • Create 'EV forum' under accelerator cell accompanying all the EV related stakeholders • Host an EV awareness programs, web portal, and mobile app for focusing and increasing awareness regarding benefits of EV adoption, driving benefits of EV and highlights of state EV policy • Focus and perform pilot projects like zero-emission vehicle zone, clean street testbed, EV wireless charging, smart and clean green energy management, Pop-up chargers, innovative e-mobility, storage through IoT, etc. in COVID times. • Encourage city twinning for sharing of knowledge, best practices, and research collaboration • Host and introduce challenges and Hackathons to scale up most affordable and innovative ideas. • Allot funds for research on electric mobility solutions • Allocate land and office spaces for research and incubation center to set up their labs and facilities. • In addition to central level testing and quality assurance agencies as National Automotive Testing and R&D Infrastructure (NATRiP), Government of West Bengal will introduce state level EV quality testing center. • Build Intelligent Mobility Skilled Centre for providing training and creating jobs in EV sector. • ITI courses will be offered to train EV drives, mechanics, Charging station staff and EV entrepreneur
Enhancement of EV value chain peripheral ecosystem	• Government of West Bengal will provide all the safety standards that are to be strictly followed by hydrogen stations in coordination with central government. • In addition to model cities, New Town Kolkata is declared as pilot city for EV adoption and development. • Some area will be declared as "Green Zone" which allows non-fossil fuel-based vehicles only. • Accompany skilled professionals for any EV related matter with EV Accelerator Cell • Research scholar working in the state on electric mobility and its components will get one-time grant and incentive in terms of accommodation and transportation facilities. • Train group of women for the driving of 3w and last mile connectivity • Encourage to have international student exchange program for EV skilling.
Promotion of Battery Recycling/ scrapping facilities	• EV innovation Center for industry focused research on battery technology and management, reuse of battery, charging infrastructure, power train, and efficient controller will get established. • Establish "Battery Industrialization Hub" for the development of battery technology.

4.6.11.2 Key Attributes Targeted in West Bengal EV Policy

As per the new policy, the state government plans to have one million EVs combined across all segments during the policy implementation period. The government is also aiming to establish a total of 100,000 charging stations during this time frame. An EV innovation centre will be set up which will focus on industry-oriented research on battery technology development, recycling and re-use of batteries, battery management system, charging infrastructure, efficient controllers, and powertrains. In addition to this, the government will develop first few hydrogen generation and refuelling stations. Kolkata, Asansol, Darjeeling, and Howrah will be declared as model electric mobility cities with goals to adopt EVs, charging and hydrogen refuelling infrastructure, and new EV enabling building codes.

Figure 4.24: Key highlights in West Bengal EV policy

4.6.11.3 EV Market of West Bengal

The market share of vehicles in West Bengal by fuel type as of February 2022 is shown in Figure 4.17. Here too, of the total 47,432 BEVs in the state, the 3W market makes a significant contribution with almost 41,000 electric 3W.

Limitations related to EV charging infrastructure in West Bengal EV Policy:

a) No mention of incentives for Charging/ battery swapping stations.

b) No mention of retrofitting.

c) Facilities to address consumer complaints and specifications of minimum facilities to be provided at charging stations are not considered.

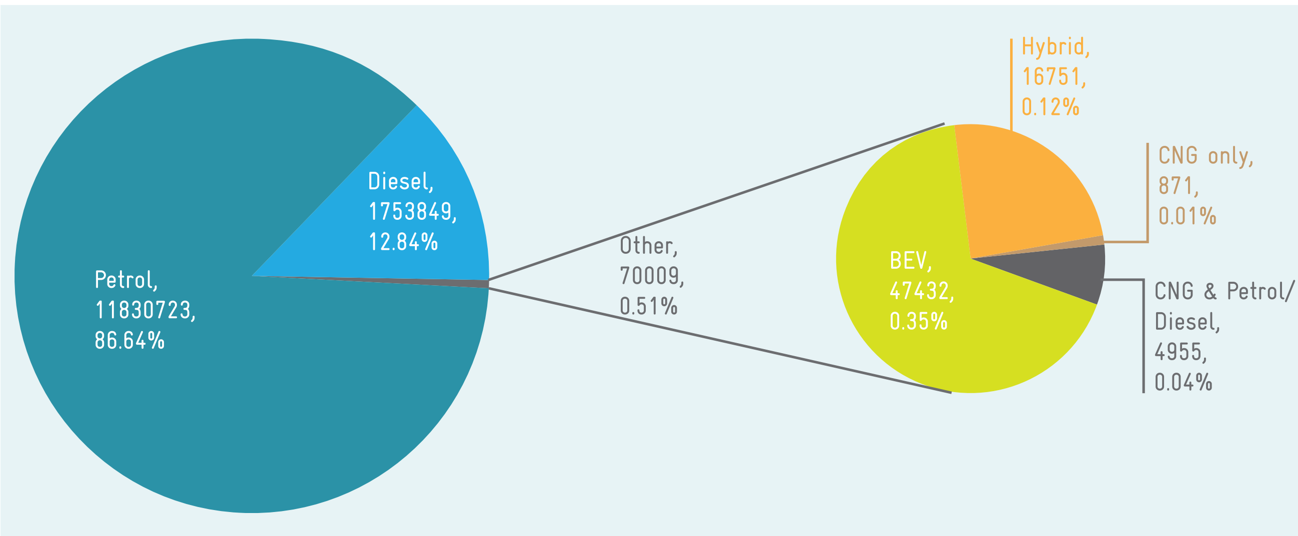


Figure 4.25: Share of total registered vehicles in West Bengal by fuel type (till Feb 2022)

4.6.12 GUJARAT

The vision of Gujarat EV policy 2021 is to position the state as a leader in the faster adoption of Electric Mobility as well as to establish an effective EV ecosystem support for encouraging consumers, manufacturers, and other investors in actively participating in the development and growth of EV market[57]. The issued policy will be valid for a period of four years commencing from 1 July 2021.

The state targets support for deployment of the first two lakh electric vehicles either under individual use or commercial use during the policy period. The segment wise policy targets are as follows: 10,000 2-Ws, 70,000 3-Ws, and 20,000 private and commercial 4-Ws.

4.6.12.1 Key Objectives of Gujarat State Electric Vehicle Policy 2021

Measures to Enable EV charging on supply-side	
Elements	Focus on State EV Policy
Definition of a fundamental market design framework to limit distortions and entry barriers	• Existing petrol pumps will be allowed to set up EV charging station subject to their areas qualifying fire & safety standard norms of relevant authorities under relevant acts/rules. • The State Distribution Licensees (DISCOMs) shall allow charging of EVs from the existing connection of a Consumer at the existing electricity tariff, except from agriculture connection.
Incentives for promoting the EV charging infrastructure	• The incentives for establishing charging station shall be applicable to charging stations meeting the guidelines and standards of the MoP Circular, dated 1st October 2019 and any amendments thereafter. • Commercial public EV charging stations for 2Ws, 3Ws, 4Ws will be eligible for 25% capital subsidy on equipment/machinery (limited up to INR 10,00,000 (EUR 12,000) per station) for the first 250 commercial public EVCS • The State Government shall exempt 100% electricity duty of EVCS during the policy period.
Prioritization in terms of EV characteristics and social geography	• Charging points to be provided in Government office parking areas. • Housing and commercial establishments shall give a 'No Objection Certificate' (NOC) to residents/ tenants to install charging stations at their designated parking spaces.
Easing out administrative barriers for establishing charging stations	Municipal corporations to promote last-mile connectivity by providing reserved parking/charging facility for EVs
Additional Measures for promotion of EV sector	
Elements	Focus on State EV Policy
EV Market Support services to promote EV adoption	• State nodal agency, GEDA has been independently running EV subsidy scheme for students. Under this successful scheme a total of 4,000 students availed benefits • School, and college students to get INR 12,000 (EUR 139) subsidy from government on E-2 wheelers. • Rickshaw drivers and self-employed persons to get INR 48,000 (EUR 556) subsidy from government on E-3 wheelers.

57 Gujarat Energy Research and Management Institute (GERMI), "Gujarat State Draft EV Policy 2019," 2019, 1–12.

	Summary of incentive across all segments under the policy period: • 2-W: state subsidy amount is INR 10,000 (EUR 116) /kWh with INR 1,50,000 (EUR 1,737) maximum ex-factory price to avail incentive • 3-W: state subsidy amount is INR 10,000 (EUR 116) /kWh with INR 5,00,000 (EUR 6,000) maximum ex-factory price to avail incentive • 4-W: state subsidy amount is INR 10,000 (EUR 116) /kWh with INR 15,00,000 (EUR 17,000) maximum ex-factory price to avail incentive The maximum amount of subsidy should not be more than the 40% of the ex. factory price of the vehicle.
Institutional framework for roll out of policies	• Energy and Petrochemicals Department, Government of Gujarat shall be the nodal agency for charging stations and subsidies related to it. • Gujarat Energy Research & Management Institute (GERMI) will be the nodal Institute for research, training, incubation, and other activities by providing a platform for various stakeholders including innovators, researchers, academia, industries, and the government.
Enhancement of EV value chain peripheral ecosystem	State is exploring possibility of EV manufacturing and battery developments by forming a specific manufacturing zone at Dholera smart city.
Miscellaneous	All provisions of the Gujarat Industrial Policy-2020, subsequent applicable policies and government resolutions, as amended from time to time, shall be applicable to parties intending to set up or upgrade their facilities for EV manufacturing sector

4.6.12.2 Key Attributes Targeted in Gujarat State Electric Vehicle Policy

Figure 4.26: Key highlights in Gujarat EV policy

In June 2018, Exide Industries had announced the signing of a pact with Leclanche SA for setting up a joint venture company, Exide Leclanche Energy Pvt Ltd. This JV Company's production plant to be located in Gujarat is the first such indigenous facility in the country, to manufacture lithium-ion batteries and provide energy storage systems for India's electric vehicle market, with the push towards promoting electric mobility . The major focus area of this facility will be e-transport sector including stationary energy storage systems and specialty storage markets. This venture will work on fleet of vehicles such as e-buses, electric 2-wheelers, and e-rickshaws.

Limitations related to EV charging infrastructure in Gujarat EV Policy:

a) No mention of incentives for battery swapping stations.

b) No mention of public awareness, battery recycling, building bye-laws, retrofitting, vehicle scrappage incentives, and funding sources.

c) Development of digital platforms for database management, setting up of facilities to address consumer complaints and specifications of payment methods are not considered.

d) No mention of utilization of V1G or V2X capabilities and integration of RE based sources in EV charging infrastructure.

4.6.12.3 EV market of Gujarat

In Gujarat there is close to 19,300 EVs till February 2022 as given in Figure 4.27. Of this the majority, i.e., 15,000 are electric 2W, while there are 1660 e4w and 1926 e3W. Gujarat also has a very well established CNG market as is evident from Figure 4.27.

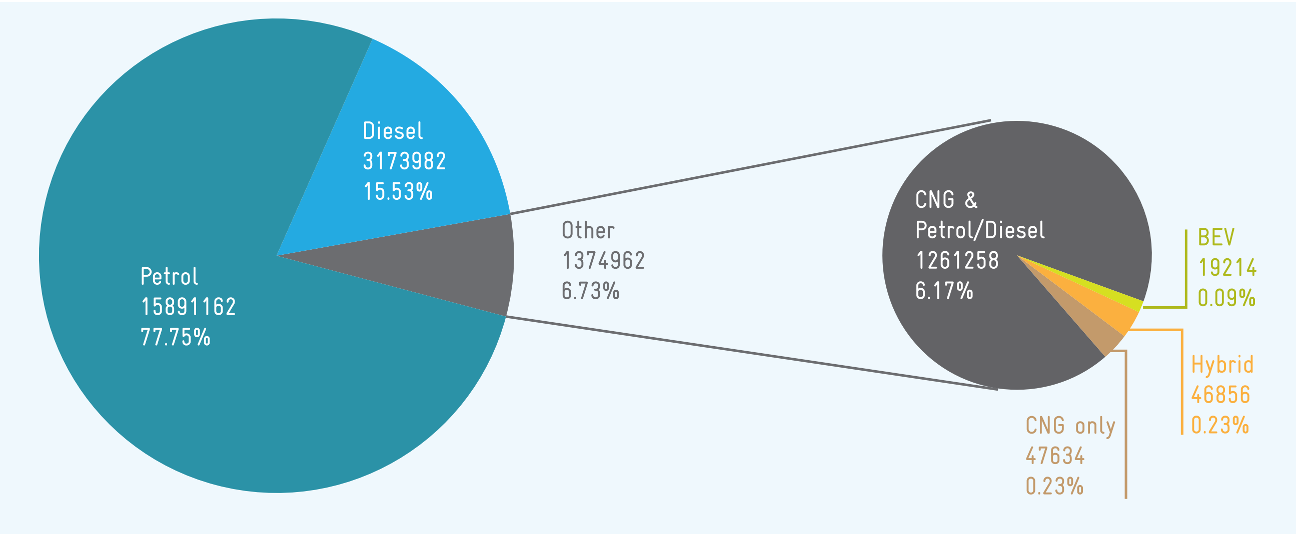


Figure 4.27: Share of total registered vehicles in Gujarat by fuel type (till Feb 2022)[42]

4.6.13 MAHARASHTRA

Based on the recent techno-economic developments happening in EV sector all over the country to make India an 'Electric Vehicle Nation' by 2030, Government of Maharashtra formulated a policy, 'Maharashtra's Electric Vehicle Policy 2021', for promotion of the EV mobility sector in Maharashtra state[58]. The Maharashtra Electric Vehicle Policy was first issued in February 2018 which included fiscal and non-fiscal incentives for EV adoption. The Electric Vehicle policy of Maharashtra released in 2021 aims to make the state a globally competitive candidate in the EV sector by maximizing adoption of EVs in the state. The policy will be valid from 23 July 2021 till 31st March 2025. It envisions to build the state as a model state in EV economy, retain the state's leadership in automotive manufacturing in India and to transform it into a leading state in terms of EV adoption in the country. Further, EV sector is expected to create a huge opportunity for job creation in manufacturing as well as service providing sectors[59].

The present policy plans to accelerate adoption of Battery Electric Vehicles (BEVs) in Maharashtra so that they contribute to 10% of new vehicle registrations by 2025. This policy shall apply exclusively to BEVs sold and registered in the state and excludes Mild Hybrid, Strong Hybrid, and Plugin Hybrid Electric Vehicles. The policy also envisions to place the state as one of the most preferred investment destinations for attracting global as well as domestic investors through various promotional strategies combined with developing a competitive and sustainable investment environment, thereby making it as one of the most favoured economic market and centre of attraction for EV ecosystem. This policy is valid for 4 years from its date of issue, 23rd July 2021.

4.6.13.1 Key Objectives of Maharashtra Electric Vehicle Policy 2021

Measures to Enable EV charging on supply-side	
Elements	Focus on State EV Policy
Definition of a fundamental market design framework to limit distortions and entry barriers	• Petrol pumps will be allowed to setup charging station freely subject to charging station areas qualifying fire & safety standard norms of relevant authorities under relevant acts/rules. • As per requirement facility of Robotic Battery Swapping Arm will be created at public bus stations. • A separate tariff category for EV charging loads.
Incentives for promoting the EV charging infrastructure	• The incentives for construction, eligible for public and semipublic charging stations are as follows: – Slow PCS/semi-public charging stations (SPCS): Incentive is 60% of the cost of charging station (excluding land and any ancillary costs) up to a maximum amount of INR 10,000 (EUR 116) per PCS/SPCS to a maximum of 15,000 PCS/SPCS. – Moderate/Fast PCS/SPCS: Incentive is 50% of the cost of charging station (excluding land and any ancillary costs) up to a maximum amount of INR 5 Lakhs (EUR 6 Thousand) per PCS/SPCS to a maximum of 500 PCS/SPCS. • Urban local bodies would provide property tax rebates to residential owners for installation of private charging infrastructure within their premises.

58 Maharashtra initially launched its EV policy in February 2018, which provided different fiscal and non-fiscal incentives for adopting and manufacturing of EVs in Maharashtra. To accelerate the growth of EV sector in the state, the State Government revisited the EV policy and launched the updated EV policy in 2021.

59 "Maharashtra State Electric Vehicle Policy - 2021" (Government of Maharashtra, 2021), https://cef.ceew.in/system/policies/policy_pdfs/000/000/069/original/MH-EV-Policy-2021.pdf?1629267930.

Prioritization in terms of EV characteristics and social geography	• By 2025, city-wise targets of public and semi-public charging stations are as listed below: – Greater Mumbai UA – 1500 – Pune UA – 500 – Nagpur UA – 150 – Nashik UA – 100 – Aurangabad UA – 75 – Amravati – 30 – Solapur – 20 • Setup at-least one public charging station in a 3 km x 3 km grid, or a minimum of 50 charging stations per million population, whichever is higher. • Make following four highways/expressways fully EV ready by 2025: – Hindu Hurudaysamrat Balasaheb Thackeray Samruddhi Highway –(Mumbai-Nagpur) – Yashwantrao Chavan Expressway – (Mumbai-Pune) – Mumbai Nashik – Nashik Pune – Setup public charging stations on highways at 25 km distance (on both sides of the highways). – New residential buildings would be mandated to have at least 20% of the total parking spaces to be EV ready., of which 30% would be in common parking spaces. – Institutional and commercial complexes should have at least 25% of total parking spaces EV ready by 2023 – Government office complexes should make 100% of their parking spaces EV ready by 2025
Easing out administrative barriers for establishing charging stations	• A time bound, single-window process is to be employed for installation of EV charging infrastructure. • Building byelaws would be amended in line with the model building byelaws as released by MoHUA in 2019. • Charging infrastructure service providers will be allowed to install charging stations in the state as per their business plans.
Measures to Enable EV charging on demand-side	
Elements	Focus on State EV Policy
The mandate for the development of digital platforms and database management systems	Charging service providers will be encouraged to provide centralized EVCS management system portal and user application (Android, iOS and/or other) to ensure information accessibility of all PCS and its live usage status in public domain.
Specification of the use of a wide range of payment methods	Charging service providers will be encouraged to provide centralized EVCS management system with various cashless payment options. Energy department and SNAs should take initiative regarding this

<table>
<tr><th colspan="2">Additional Measures for promotion of EV sector</th></tr>
<tr><th>Elements</th><th>Focus on State EV Policy</th></tr>
<tr><td>EV Market Support services to promote EV adoption</td><td>Incentives for only Battery Electric Vehicle (BEV)

Demand incentives for electric vehicles
<table>
<tr><th>Vehicle segment</th><th>Incentive available</th><th>No. of vehicles to be incentivized</th><th>Max. incentive per vehicle (INR)</th></tr>
<tr><td>e-2W</td><td>INR 5000/kWh (EUR 56.7/kWh)</td><td>1,00,000</td><td>10,000 (EUR 113.5)</td></tr>
<tr><td>e-3W autos</td><td>INR 5000/kWh (EUR 56.7/kWh)</td><td>15,000</td><td>30,000 (EUR 340.6)</td></tr>
<tr><td>e-3W goods carrier</td><td>INR 5000/kWh (EUR 56.7/kWh)</td><td>10,000</td><td>30,000 (EUR 340.6)</td></tr>
<tr><td>e-4W cars</td><td>INR 5000/kWh (EUR 56.7/kWh)</td><td>10,000</td><td>1,50,000 (EUR 1703)</td></tr>
<tr><td>e-4W goods carrier</td><td>INR 5000/kWh (EUR 56.7/kWh)</td><td>10,000</td><td>1,00,000 (EUR 1135)</td></tr>
<tr><td>e-buses[60]</td><td>10% of vehicle cost[61]</td><td>1,000</td><td>20,00,000 (EUR 22,706)</td></tr>
</table>

An early bird discount of additional INR 5000/kWh (EUR 56.76/kWh) capped at INR 1,00,000 (EUR 1135)would be provided for EVs (except e-buses) purchased before 31st December, 2021.
For vehicles sold without battery, 50% incentive amount shall be provided to the vehicle OEM and the remaining incentive amount shall be provided to the BSF. The OEMs are required to pass on all the incentives to the EV buyers.
Exemption from payment of fees for issue and renewal of registration certificate.
Exemption from road tax and registration fees for Electric Vehicles.
</td></tr>
<tr><td>Institutional framework for roll out of policies</td><td>A High-Power Committee will be constituted at the state level to monitor the implementation of this Policy and develop procedures and modalities where required.</td></tr>
<tr><td>Enhancement of EV value chain peripheral ecosystem</td><td>The Maharashtra State Board of Technical Education (MSBTE), Maharashtra State Skill Development Society (MSSDS) and other agencies will institute training-based certification and placement programs. They would collaborate with National Automotive Board (NAB) and other associations to understand their human resource requirements. Based on these requirements, a merit based, defined certification and placement procedure shall be instituted so that appropriate manpower is created for the EV industry.</td></tr>
<tr><td>Miscellaneous</td><td>Initially Government of Maharashtra to promote EV in public transport in six cities i.e.: - Mumbai, Pune, Aurangabad, Thane, Nagpur, and Nashik.</td></tr>
</table>

4.6.13.2 Key Attributes Targeted in Maharashtra EV Policy:

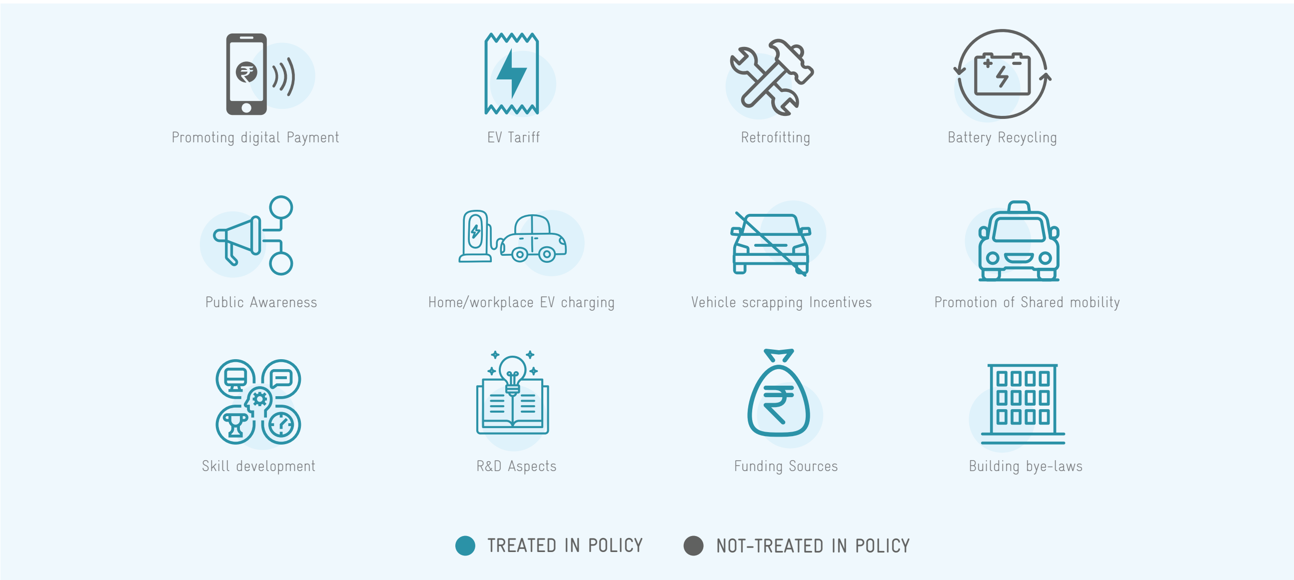


Figure 4.28: Key highlights in Maharashtra EV policy

60 Incentive only for State Transport Undertaking (STU) buses.
61 Ex-factory cost

According to the EV value chain, there are various provisions in the state policy specifically aiming at introducing e-mobility based curriculum in boards so as to upgrade technical and skill development opportunities and also to set up R&D centres, Centre of excellence etc. On the other hand, at EV and related manufacturing front, the state has formulated a number of incentive schemes for micro, small and medium enterprises (MSMEs) and large manufacturing units. A high-power commission will be formed to properly coordinate the disbursing of such incentives for manufacturing units of different scales. The fiscal incentives vary according to their nature such as, promotion incentives, purchase incentives and demand incentives in all vehicle segments 2Ws, 3Ws, 4Ws and e-buses. The exemption of road tax and registration fees are another attraction to increase the EV adoption in the state. Regarding the deployment of charging infrastructure across the state, policy enlists numerous benefits for its customers as well as the public investors interested in setting up charging stations. To provide charging points in residential/non-residential buildings, amendments are introduced in building/property rules to encourage them to invest in the public charging facilities which will also be awarded with 25% capital subsidy .

Limitations related to EV charging infrastructure in Maharashtra EV Policy:

a) No mention of incentives for battery swapping stations.

b) No mention of public awareness, battery recycling, building bye-laws, retrofitting, vehicle scrappage incentives, and funding sources.

c) Development of digital platforms for database management, setting up of facilities to address consumer complaints and specifications of payment methods are not considered.

d) No mention of utilization of V1G or V2X capabilities and integration of RE based sources in EV charging infrastructure.

4.6.13.3 EV market of Maharashtra

Figure 4.29 shows the share of registered vehicles in Maharashtra as of February 2022, differentiated by the fuel type. Here, hybrid electric vehicles are more popular than BEVs with HEVs accounting for 0.27% and BEVs only 0.22% of the total vehicles registered in Maharashtra. Among BEVs there are around 6500 e4W, while the number of e2W is more than 54,000. There are also 609 eBuses registered in Maharashtra till February 2022.

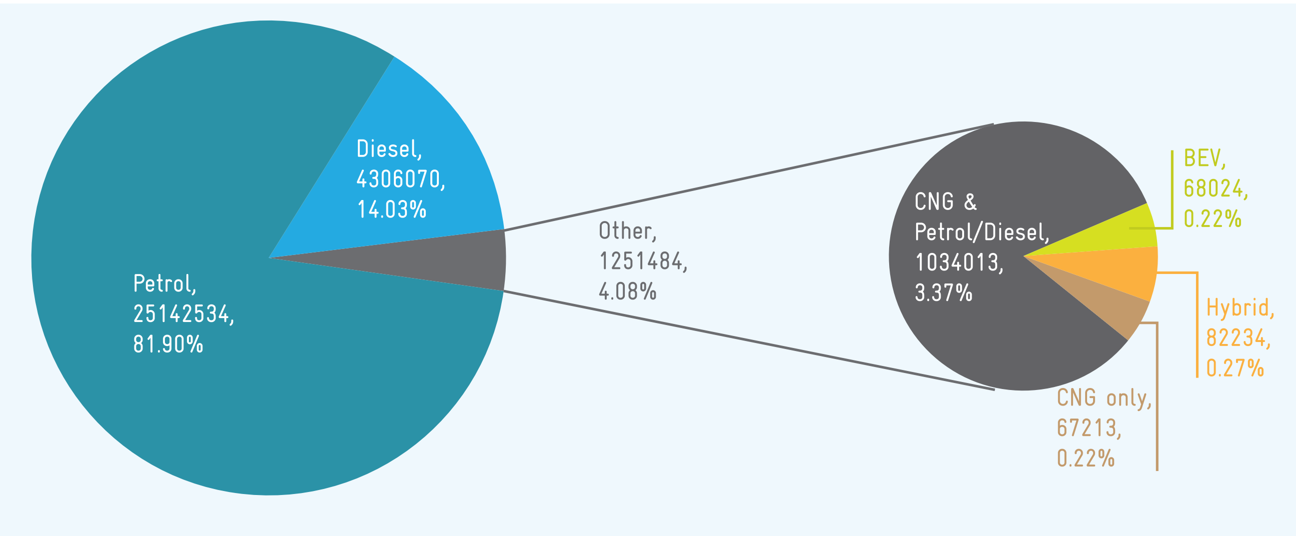


Figure 4.29: Share of total registered vehicles in Maharashtra by fuel type (till Feb 2022)[42]

4.6.14 RAJASTHAN

The low EV penetration level in Rajasthan as compared to other states in India, has necessitated a dedicated policy framework and regulations to accelerate EV adoption in the state. Rajasthan Transport Department released an official document providing incentives to purchase of different categories of EVs, while the state electricity regulatory commission released an order, directing the roles and actions of the state DISCOMs on how to efficiently integrate the EV charging load into the grid.

The availability of EV charging infrastructure is a key factor for pushing more EVs on road, as easy access to fast and efficient charging facilities significantly reduces downtime for EV users. At present, successful EV adoption in the state is limited by lack of sufficient charging infrastructure. The major roadblock that discourages people from shifting to EV from ICE is the limited number of EV charging facilities in the state. Therefore, lack of adequate charging infrastructure, needs to be tackled by properly setting up policy guidelines and regulatory frameworks. Moreover, it is essential to set up adequate electricity tariff structure to attract both EV consumers and private investors to enter EV charging business. Rajasthan Electricity Regulatory Commission (RERC) issued its latest tariff order which specifies EV tariff for the consumers. According to this new order, consumers can charge EV at the same rate which is applicable to the consumer category as per the tariff order, i.e., a residential consumer can pay residential rate for EV charging while a commercial consumer should pay commercial rates to EV charging and so on[62].

4.6.14.1 Key Objectives of Rajasthan's EV policy 2021

Measures to Enable EV charging on supply-side	
Elements	Focus on State EV Policy
Definition of a fundamental market design framework to limit distortions and entry barriers	• In short term initiatives, promotional tariff for EV charging stations would be specified and ToD Tariff may be introduced for public charging stations. The infrastructure development cost may be considered as a part of Investment plan. • In the long term, ToD Tariff may be introduced for all consumers including residential category and capital cost may be allowed to Distribution licensee to create a robust network to cater to EV loads.
Incentives for promoting EV charging infrastructure	• PCS would be allowed to purchase power from any source through open access route in accordance with the terms and conditions of the Rajasthan Open Access Regulations, 2016. • A concessional EV tariff has been introduced along with ToD rebates for EV loads.

62 Rajasthan has not yet released a single comprehensive EV policy. But it released an incentive program providing subsidies on purchase of EVs, and a separate order on EV charging infrastructure requirements. Both together cover most aspects of an EV policy.

Mandate on user data sharing and privacy	• A publicly accessible database on all the PCS in the DISOCM license area would be maintained by the DISCOM, which would include information on location of PCS/ types of chargers/availability of chargers/ rated voltage/ connector type/ number of charging points. • The DISCOM shall also develop a mobile app, where the real time status of the EV charging stations would be available. • Smart meter installation at every PCS
Mandate on the utilization of V2X capabilities	The DISCOMs shall conduct detailed study regarding smart charging features with respect to V2G and G2V
Focus on RE integration and EV charging	• Purchase of power though Open Access has been allowed. • Exemption of 100% Intra State transmission charges and wheeling charges for Solar Power Project set up before 31/03/2023 for supplying power to PCS under captive route or open access.
Additional Measures for promotion of EV sector	
Elements	**Focus on State EV Policy**
EV Market Support services to promote EV adoption	• The policy would also encourage EV manufacturers and respective OEMs by providing various fiscal and non-fiscal incentives in terms of land acquisition or input cost or tax exemptions etc. to drive EV adoption • Various initiatives such as waiver from toll tax, road tax, parking charges etc. may also be introduced by the nodal agencies for all EV categories in the state • there will be policies/guidelines that would help supply side to have required platform to match with the existing ICE manufacturers • there will be short term (1-3 years) and long term (4-10 years) initiatives to be taken by state regulator

4.6.14.2 Key Attributes Targeted in Rajasthan EV Policy:

The Rajasthan EV policy has well laid out plans for connection of EV charging infrastructure to its distribution grid. There policy spells out that the Rajasthan Electricity Regulatory Commission would work on implementation of smart charging as well as RE integration for EV charging.

Limitations related to EV charging infrastructure in Maharashtra EV Policy:

a) No support for home/workplace charging infrastructure.

b) No provision of land allotment for charging infrastructure business.

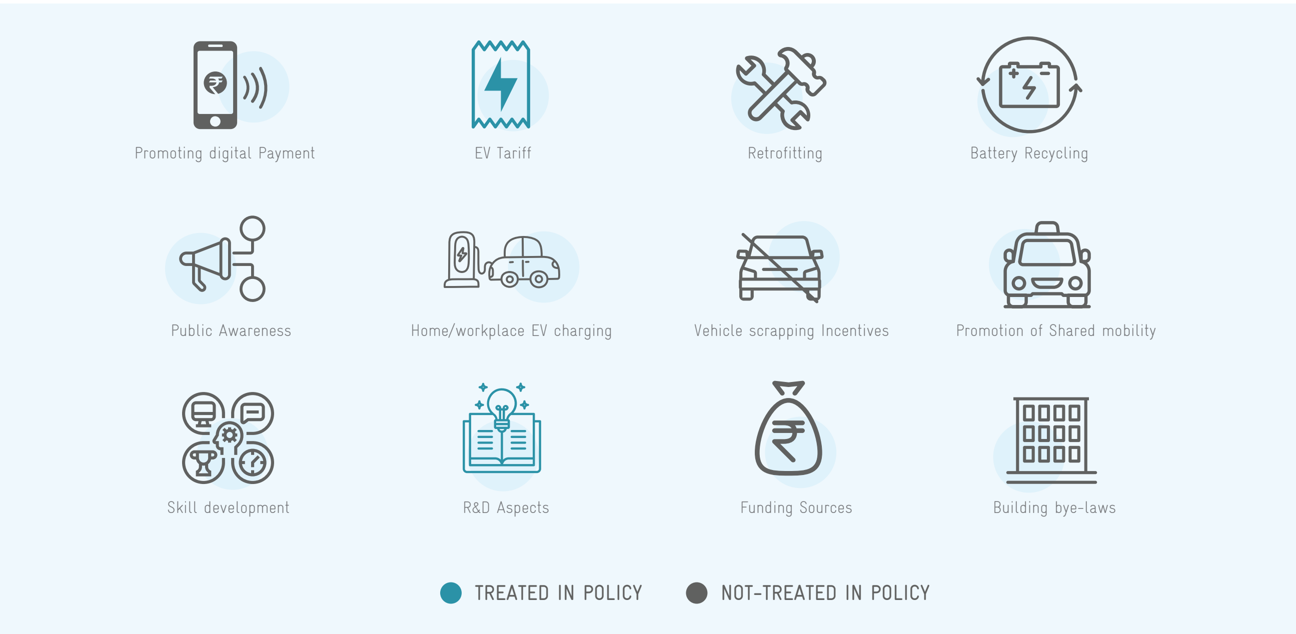


Figure 4.30: Key highlights in Rajasthan EV policy

4.6.14.3 EV Market of Rajasthan

The EV segment in Rajasthan mainly comprises of electric 3W and 2W, with 30,200 and 24,450 vehicles, respectively till February 2022. Comparatively, only 900 electric 4W LMV have been registered in the state. The PHEV segment which accounts for 0.12% of all state registered vehicles (Figure 4.31), however is almost completely 4W LMVs.

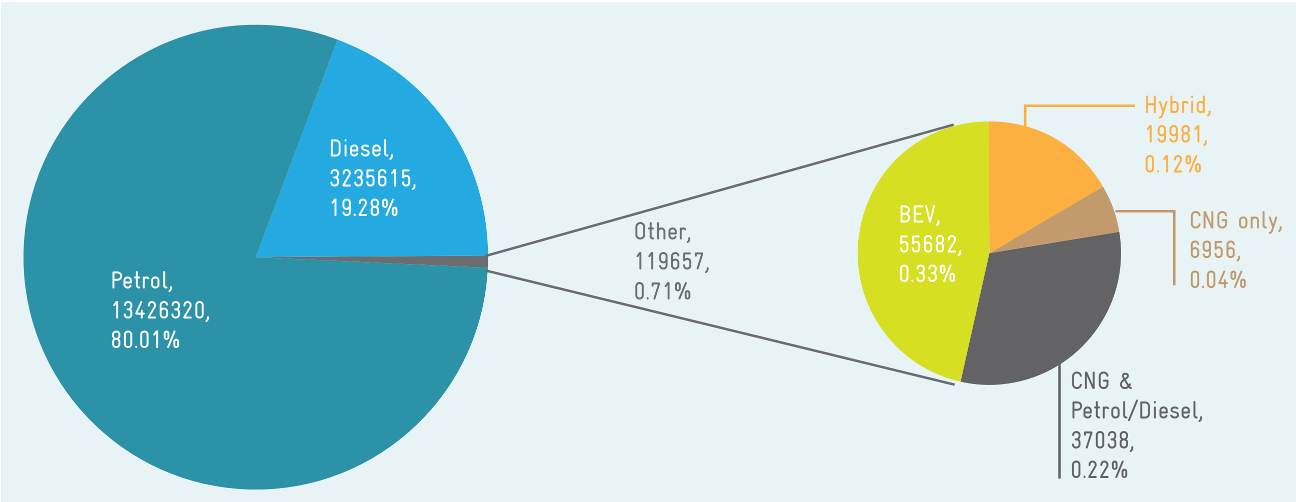
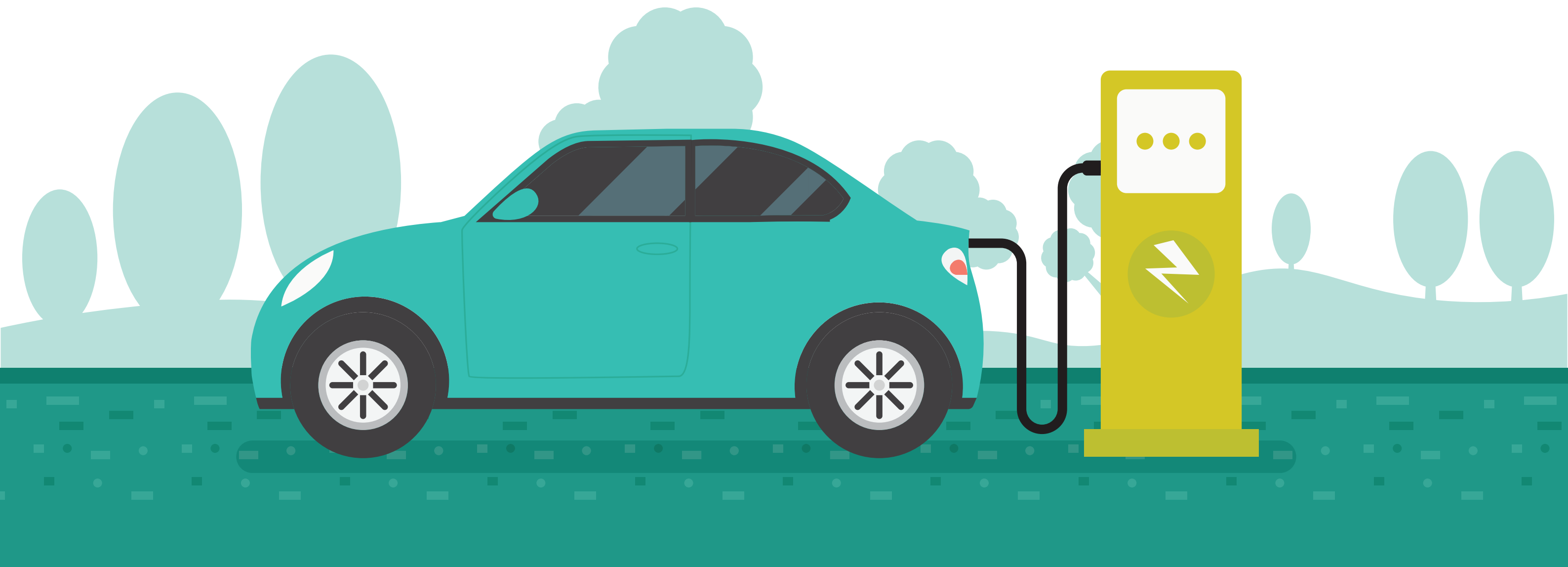


Figure 4.31: Share of total registered vehicles in Rajasthan by fuel type (till Feb 2022)[42]



4.6.15 ASSAM

The government of Assam through its EV policy in aims for 25% EV penetration in all vehicle registrations by 2026. The major focus of the policy is to add two lakhs electric vehicles which includes 100,000 electric two-wheelers (E2Ws); 75,000 electric three-wheelers (E3Ws); and 25,000 electric four-wheelers (E4Ws) either for individual or commercial use during the next five years of its duration[63]. The government has also set a target to convert 100% of its public transport bus fleet to e-buses (BEV) by 2030 besides all Government vehicles to be converted to EVs by 2030. As per the policy, after 2025, only EVs would be sold in the state as it intends to phase out all fossil fuel-based commercial and logistics vehicles in all cities by 2030. It also exempts registration charges and road tax on E2Ws, E3Ws, and E4Ws, coupled with a full waiver on parking charges for all EVs until 2026.

The policy came into effect from 4 September 2021, for five years (2026) or until the announcement of a new or revised policy, whichever is earlier. The implementation strategy of the State EV policy is as follows:

- Promotion of EV technology adoption: this stage aims to increase the viability of e-vehicles by way of providing various fiscal and non-fiscal incentives.
- Creation of dedicated EV charging infrastructure: This stage focuses on promoting Charging infrastructure creation through investment subsidization.
- Encouraging R&D and Innovation: Through this stage, the establishment of various R&D Centers and Center of Excellence across the State are promoted.

4.6.14.1 Key Objectives of Electric Vehicle Policy of Assam 2021

Measures to Enable EV charging on supply-side	
Elements	Focus on State EV Policy
Definition of a fundamental market design framework to limit distortions and entry barriers	• The State Government will promote EV charging infrastructure of different capacities/ technologies and support variety of business models viz. Privately-owned, DISCOM-owned and Investor-owned EV charging and battery swapping stations. • Petrol Pumps will be allowed to set up EV charging stations subject to qualifying fire & safety standards issued by the respective authorities.
Incentives for promoting the EV charging infrastructure	• Commercial public EVCS for 2-W, 3-W, and 4-W will be eligible for 25 % capital subsidy on equipment/machinery subject to maximum limit of INR 10 lakhs (EUR 12 Thousand) per station. This incentive will be applicable to first 500 commercial public EVCS. • The subsidy for EVCS shall only be given to those developers, individuals or entities which have not availed any similar subsidies under any policy/scheme of the State Government unless it is specifically prescribed under this policy. • The State Govt. shall exempt 90% electricity duty of EVCS. • The tariff for new third-party owned EVCS shall be as per the AERC tariff order for utilities.
Mandate on the utilization of V2X capabilities	All EV charging stations shall adhere to the charging guidelines and standards defined by the Ministry of Power, Government of India and Power (E) Department, Government of Assam.
Focus on RE integration and EV charging	• The batteries purchased by state nodal agency from the charging points and battery swapping stations will then be re-used as 'power banks' to store renewable energy. • Batteries procured in such manner will be auctioned to renewable generators within and outside Assam.

63 Industries and Commerce Department, Government of Assam, "Electric Vehicle Policy of Assam 2021," 2021, https://industries.assam.gov.in/sites/default/files/swf_utility_folder/departments/industries_com_oid_4/portlet/level_2/ilovepdf_merged.pdf.

Additional Measures for promotion of EV sector	
Elements	Focus on State EV Policy
EV Market Support services to promote EV adoption	• The Demand Incentive from the State shall be over and above any subsidies that are available from the Central Govt. through its promotional policies/schemes • The incentives for all types of electric vehicles shall be based on the electric vehicle battery capacity (i.e energy content measured in KWH) as indicated below: – 2-W: Battery size-2 kWh, State subsidy amount-INR 10,000 (EUR 116) /kWh, total state subsidy = INR 20,000 (EUR 232) , Maximum ex-factory price to avail incentive – INR 1,50,000 (EUR 1737) – 3-W: Battery size-5 kWh, State subsidy amount- INR 10,000 (EUR 116) /kWh, total state subsidy=INR 50,000 (EUR 579) , Maximum ex-factory price to avail incentive – INR 5,00,000 (EUR 6 Thousand) – 4-W: Battery size-15 kWh, State subsidy amount-INR 10,000 (EUR 116) /kWh, total state subsidy=INR 1,50,000 (EUR 1737) , Maximum ex-factory price to avail incentive – INR 15,00,000 (EUR 17 Thousand) • The beneficiary will be allowed to avail similar subsidy from only one scheme of State Govt. However, there will not be any bar to get any subsidy or incentive from any scheme of GoI. • The maximum subsidy amount should not exceed 40% of the ex-factory price of the e-vehicle. • Exemption of registration charges and road tax on 2, 3 & 4 Wheeler Electric Vehicles for 5 years • 100% Waiver on parking charges for EV for 5 years • Retro-fitment incentive @ 15% up to INR 15,000 (EUR 174) for 3-Seater auto rickshaws. • In addition to the 30% Capital Investment Subsidy available under NEIDS,2017 or any subsequent policy from Govt. of India/State Govt., units manufacturing EV or their components will be eligible for the following additional incentives: – @ 20% of cost of Plant & Machinery up to INR 15,00,000 (EUR 17,000) for Micro Units – @ 20% of cost of Plant & Machinery up to INR 50,00,000 (EUR 58,000) for Small Units – @ 20% of cost of Plant & Machinery up to INR 1 crore (EUR 116,000) for Medium Units – @ 10% of cost of Plant & Machinery up to INR 10 Crore. (EUR 1 Million) for Large Units • In addition to the 3% Interest Subsidy on Working Capital Loan available under NEIDS, 2017 or any subsequent policy from GoI/State Govt., EV manufacturing units or their components will be eligible for additional Interest Subsidy @ 2% on Working Capital Loan.
Institutional framework for roll out of policies	• All provisions of the Industrial & Investment Policy of Assam, 2019 or provisions under any subsequent Industrial Policies declared by Assam State Govt. shall be applicable to enterprises intending to set up EV manufacturing facilities. • All provisions of the North East Industrial Development Scheme (NEIDS), 2017 or provisions under any subsequent industrial policies for North Eastern Region declared by the Central Govt. shall be applicable to enterprises intending to set up EV manufacturing facilities. • A nodal agency will be appointed to act as an aggregator to purchase EV batteries that are at least 70% of rated capacity. The nodal agency shall publish purchase price of end of life batteries every month based on auction prices achieved and a margin for itself and the charging points and battery swapping stations. • State Govt. shall partner with premier Technical Institutes for establishing Centers of Excellence for conducting market-focused research on Battery Technologies, Battery Management, Motors and Controllers. • Government shall offer financial support to Start-ups for R&D and innovation in EV & Battery Technologies
Enhancement of EV value chain peripheral ecosystem	• Convert 100% of public transport bus fleet into electric buses (BEV) by 2030. • All Govt. vehicles to be converted to EV by 2030. After 2025, only EVs will be allowed to purchase. • By 2030, Phase out all fossil fuel based commercial fleets and logistics vehicles in all cities.
Promotion of Battery Recycling/ scrapping facilities	• EV batteries typically need to be replaced once they have degraded to operating at 70- 80% of their capacities. EVs are therefore going to outlive the batteries powering them, with a vehicle requiring change of batteries twice in a 10-year life span. • Re-use of EV batteries that have reached the end of their life will be encouraged and setting up of recycling businesses in collaboration with battery and EV manufacturers that focus on 'Urban Mining' of rare materials within the battery for re-use by battery manufacturers will be promoted. • EV owners can deposit vehicle batteries that have reached their end of life at any charging point or swapping station landfills and in return get a remunerative price for the battery. Disposal of EV batteries in any other manner – e.g., in or as scrap, will not be allowed.

4.6.14.2 Key Attributes Targeted in Assam EV Policy:

Figure 4.32: Key highlights in Assam EV policy

The population of over four million vehicles on the roads in Assam along with large numbers of vehicles plying from the neighbouring states as well as from other parts of the country has made mobility a challenge by increasing vehicular population resulting in road accidents and air pollution. Thus, adoption of Electric Vehicles (EVs) for road transport contributes to a wide range of goals such as improved air quality, reduced noise pollution, better energy security in combination with a low carbon power generation mix and reduced greenhouse emissions. Through the policy, the government of Assam focuses on a dedicated strategy to address price of EVs, public charging infrastructure and investment in EV manufacturing and charging infrastructure which are essential to promote EV adoption in the state. Government plans to ensure a robust infrastructure for EVs that includes adequate power availability, network of charging points and favourable power tariff structures.

Limitations related to EV charging infrastructure in Assam EV Policy:

a) No support for home/workplace charging infrastructure

b) No mention of public awareness, vehicle scrappage incentives, building bye-laws, skill development aspects, promotion of shared mobility and funding sources.

c) Development of digital platforms for database management, setting up of facilities to address consumer complaints and specifications of payment methods are not considered.

d) No mention of utilization of V1G or V2X capabilities and integration of RE based sources in EV charging infrastructure.

4.6.14.3 EV Market in Assam

The vehicle sector of Assam has been shown in Figure 4.33, which shows that till February 2022 Assam had close to 50,000 BEVs with the majority of them being 3W (around 48,000). Around 1.26% of its total vehicle sector has been electrified with petrol still being the dominant fuel type.

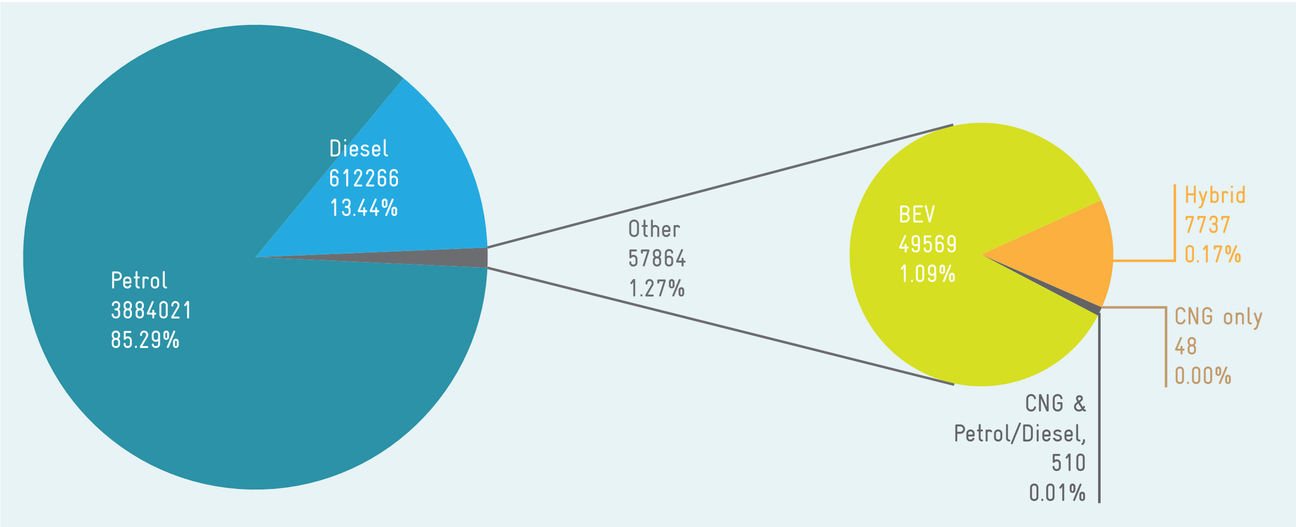


Figure 4.33: Share of total registered vehicles in Assam by fuel type (till Feb 2022)[42]

4.6.16 ODISHA

Government of Odisha has framed the 'Odisha Electric Vehicle Policy 2021', mainly focused to build Odisha as a model State in promotion of e-mobility through accelerating EV adoption, adaptation, research and development apart from facilitating growth in employment for circulation among the stake holders and general public. The policy also aims to bring up Battery Electric Vehicles to contribute as a substantial percentage of all new vehicle registrations in the coming years thereby improving the air quality in the state in general and all major cities in particular. The Odisha Electric Vehicle Policy, 2021 shall remain valid for a period of five years from the date of notification of the policy, i.e. August 2021[64].

The key objectives in the policy are as given below:

- Promote use of EVs across state in all vehicle segments among public by facilitating appropriate ecosystem. The policy aims to achieve adoption of 20% BEV in all vehicle registrations by 2025.
- Promotion of EV and its related components manufacturing including battery in the State.
- Encourage Innovation and facilitate Research & Development in the areas relating to EV and Battery.
- Put in various measures to aid job creation in driving, selling, financing, servicing, manufacturing and charging of EVs.

4.6.16.1 Key Objectives of Odisha Electric Vehicle Policy 2021

Measures to Enable EV charging on supply-side	
Elements	Focus on State EV Policy
Definition of a fundamental market design framework to limit distortions and entry barriers	• The customers under all the Electricity Distribution Companies in the State shall purchase Private Charging points with the grant supplied by Govt. and request the DISCOMS to install the same in their premises. The installation charge as approved by Government may be collected through electricity bills. • Energy Operators shall be invited to set up charging and battery swapping stations across all the cities and along the NH & SH in phases by porting and providing locations at bare minimum rental lease. • Highway re-fueling stations will be encouraged to set up fast charging stations for top up charging • Electricity tariff as applicable for charging stations shall be notified by the OERC. All the public charging station operators shall be encouraged to use low cost and renewable sources of power through OERC. • Electricity tariff applicable for all Public and Captive charging stations for commercial use (i.e., charging facilities used by fleet owners) shall be as notified by OERC. Government shall endeavor to work out special tariff for EV charging.

64 Commerce & Transport Department and Commerce and Transport Department,Government of Odisha, "Odisha Electric Vehicle Policy,2021," 2021, https://ct.odisha.gov.in/news/odisha-electric-vehicle-policy2021.

Incentives for promoting the EV charging infrastructure	• Government will provide grant for purchase of charging equipment up to INR 5000 (EUR 58) /- for the first 20,000 private charging points which will be installed within the premises of existing residential and non-residential buildings. • Government shall provide capital subsidy of 25% to the selected Energy Operators for the charger installation expenses. Such subsidy will be available within one year of allocation of locations. • Special subsidy shall be allowed for first 500 Charging Stations. • Govt. will also provide 100% SGST reimbursement to the Energy Operators for purchase of batteries to be used in swapping stations.
Prioritization in terms of EV characteristics and social geography	• Municipal authorities will provide subsidized parking for all personal EVs. Individual Towns/Cities will prepare city parking plan to encourage provisions for on- street parking places for EVs with subsidized fees and EVCS. • Building bye-laws shall be made for all new home and workplace to make it EV friendly with additional power load equivalent to the power required for all charging points with all safety factors adhering to the guidelines and standards as issued by MoP, GoI from time to time. • Government will explore the charging facility at bus stands/ stops for e-buses to reduce the battery size
Easing out administrative barriers for establishing charging stations	• Corporate Offices/ Educational Institutes/ ULBs/ OSRTC/ Housing Societies/ Govt. Buildings will be encouraged to set up charging infrastructure in their premises to meet the social responsibility and necessary incentives shall be extended to them. • The Energy Distribution Companies may take lead role in setting up charging points/ stations than other private parties. The number of charging points to be established will be maintained by the Energy Distribution Companies.
Additional Measures for promotion of EV sector	
Elements	**Focus on State EV Policy**
EV Market Support services to promote EV adoption	• The Policy focuses attention on incentivizing the purchase and use of EVs particularly in 2-wheelers, public/shared vehicles and goods carriers segments. • The following incentives are proposed: – 2-W: 15% subsidy with a maximum subsidy amount of INR 5,000 (EUR 58) – 3-W: 15% subsidy with a maximum subsidy amount of INR 12,000 (EUR 139) – 4-W: 15% subsidy with a maximum subsidy amount of INR 1,00,000 (EUR 1158) – e-bus: 10% subsidy with a maximum subsidy amount of INR 20,00,000 (EUR 23,000) – Individual and fleet owners shall be given purchase incentive of INR 30,000 (EUR 347) /- to the first 5000 electric goods carriers to be registered in the State • There shall be open permit for autos (3-Ws) • 100% interest free loans would be made available to State Govt. employees for purchase of EVs • 100% SGST on the sale of electric buses and electric goods carriages sold and registered in the State will be reimbursed during policy period. • Govt. Depts. / Offices and PSUs will give preference to hire EVs for Official use and the proposed purchase incentives will be applicable for the private owners to purchase these vehicles. Govt. Depts. / Offices/ PSUs will purchase EVs when such purchase is necessary and is allowed. • Govt. of Odisha will provide appropriate incentives and other support to ensure that pure e-buses constitute at least 50% of all new stage carriages procured for the city buses in next five years.

Institutional framework for roll out of policies	• A state level task force is formed to monitor and ensure timely release of relevant Orders/ Government Resolutions/Government Notifications and required amendments • A steering committee is formed for implementation of the decisions of the State Level Task Force to streamline the EV adoption in the State • E.I.C., Electricity will be the Nodal Agency for setting up & monitoring of charging stations.
Enhancement of EV value chain peripheral ecosystem	• Provision of mobile charging vans to provide on-road assistance for EV users who run out of charge shall be explored so that they can reach the nearest charging station with minimum travel.
Promotion of Battery Recycling/ scrapping facilities	• The policy shall encourage the reuse of EV batteries that have reached the end of life and setting up of recycling business in collaboration with battery manufactures. • EV Battery Manufacturers will set up schemes for the collection of waste batteries and shall not charge end users for collection. • Bench mark labels of materials to be recycled from batteries will be set up to encourage better recycling technique. • A well-defined policy for encouraging Recyclers shall be notified by Industries Department in consultation with Forest & Environment Department and State Pollution Control Board.

4.6.16.2 Key Attributes Targeted in Odisha EV Policy:

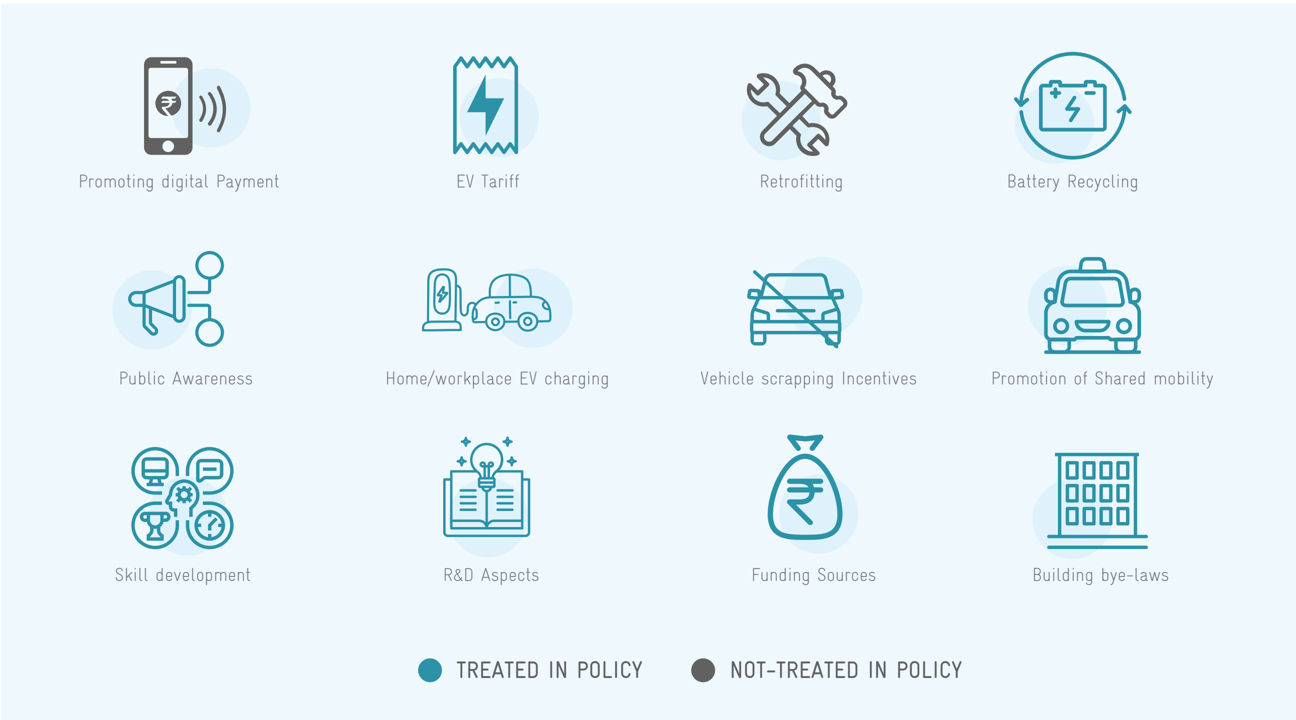


Figure 4.34: Key highlights in Odisha EV policy

The Odisha EV policy proposes various fiscal incentives directed towards manufacturing of EV and associated products, EV purchases particularly in the segments of e-2W, e-3W, and e-4W (light vehicles), and scrapping of old fuel based vehicles. Interest subvention in loans, road tax, and registration fee waivers will also be provided as notified in the policy guidelines. Incentives will also be available for start-ups. The state would also provide a 100% interest-free loan to government employees to purchase EVs. Similarly, government departments, offices, and public sector undertakings would encourage and prioritize hiring and purchasing EVs for their official use. The Transport Department will act as the nodal department and a dedicated "EV Cell" will be established for effective day-to-day policy implementation.

Limitations related to EV charging infrastructure in Odisha EV Policy:

a) No mention of retrofitting and promotion of digital payment options

b) Development of digital platforms for database management, setting up of facilities to address consumer complaints and specifications of payment methods are not considered

c) No mention of utilization of V1G or V2X capabilities in EV charging infrastructure.

4.6.16.3 EV Market in Odisha

The vehicle sector statistics in Odisha till February 2022 is depicted in Figure 4.35, from which it can be seen that, the number of BEVs in the state account for 0.13% of all vehicles and PHEVs account for 0.12%. The majority of the BEVs in the state are 2W, with more than 10,000 e2W registered till February 2022.

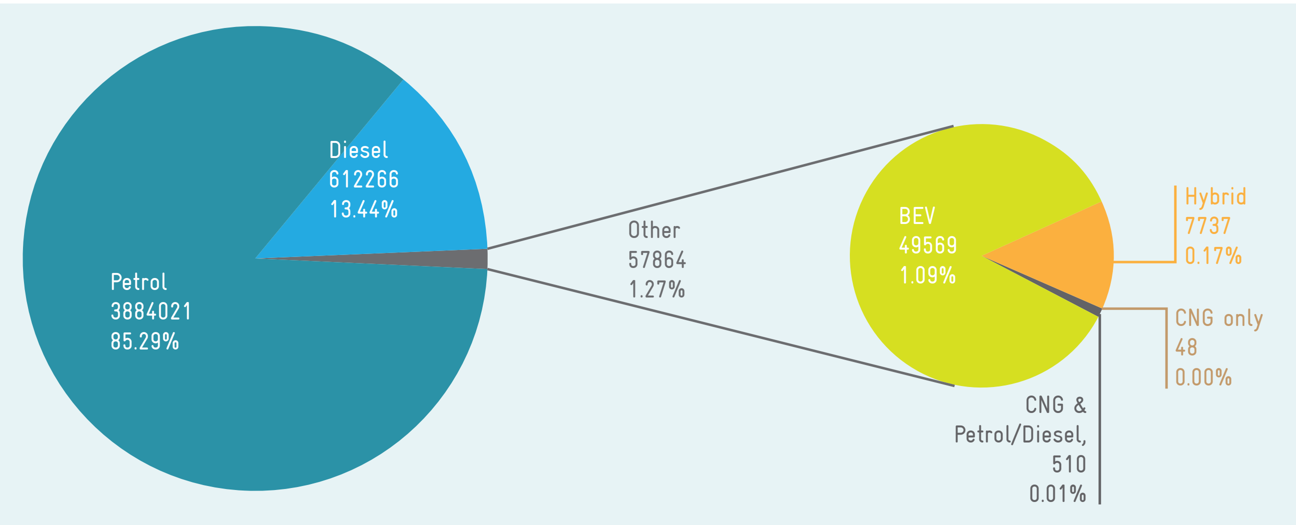


Figure 4.35: Share of total registered vehicles in Odisha by fuel type[42]

4.6.17 GOA

The state of Goa is planning to set an example by emerging as a frontrunner in EV sector having International Standards for Electric Vehicle adoption across passenger and commercial segments, supported by a world-class charging infrastructure and eco-system. This vision would be achieved by active incorporation of all sustainable initiatives such as smart-city development, energy conservation promotion and creation of integrated transport mechanisms. The state has ambitious plans such as 30% of vehicle registered annually to be electric starting from 2025, 50% of all ferries to be converted to electric by 2025 etc. Besides, the state also focuses on creating a total of 10,000 direct and indirect job opportunities in the EV sector. Therefore, the Government of Goa has issued the Goa Electric Mobility Promotion policy in 2021[65]. The operative period of the policy is 5 years, from the date of its notification (from December 2021) and is applicable to all classes of EVs including 2-W, 3-W, passenger cars and commercial light/heavy vehicles that are registered and operated in Goa. The policy also covers Battery Electric Vehicles (BEV), Hybrid Vehicles and Plug-in Hybrid Electric Vehicles (PHEV), as per FAME-II notifications and provisions.

Another key focus of the state policy is to promote establishment of new start-ups and attract more investments in the e-mobility market and related sectors such as mobility as a service (MaaS), autonomous vehicles, data analytics and information technology. It also aims to cater to various EV support services including battery repair and maintenance stations, promotion of R&D infrastructure, innovation, and skill development within the e-mobility sector, provision of various financial incentives like Purchase incentives, Scrapping incentives, Interest subvention on loans, provision of waiver on road tax and registration fees. The policy also targets the establishment of a wide network of EVCS and battery swapping stations and develop publicly owned database of the same.

4.6.17.1 Key Objectives of Goa Electric Mobility Promotion Policy 2021

Measures to Enable EV charging on supply-side	
Elements	Focus on State EV Policy
Definition of a fundamental market design framework to limit distortions and entry barriers	• Power distribution companies (DISCOMS) will work with owners of residential and non-residential buildings, RWAs and Co-op Group Housing Societies to ensure adequate supply infrastructure is made available for the installation of charging points. • Installation of first 50 charging stations in the state – at selected Kadamba Transport Corporation Ltd. (KTCL) bus depots. • Installation of 5 fast-charging stations at the international airport. • Installation of 10 slow charging stations at Central Secretariat in Panaji. • Electricity tariff, applicable for all Public and Captive charging stations for commercial use (i.e., charging facilities used by fleet owners) shall be as notified by Joint Electricity Regulatory Commission (JERC). • Battery swapping and fast charges would also be promoted

65 Government of Goa, "Goa Electric Mobility Promotion Policy 2021," 2021.

Incentives for promoting the EV charging infrastructure	• Additional duties on electricity shall be waived for all housing and commercial buildings, which register, with Goa Electricity Department for installing charging stations in their parking areas. • The State Government will incur all electricity infrastructure cost, up to INR 8,00,000 (EUR 9,040) associated with installation of EVSEs and charging stations. • Capital subsidy for cost of chargers installation shall be applicable for chargers installed within one year of the allocation of a Concessional Location. • In the case of solar-powered charging stations, the state shall provide a 20% capital subsidy for installation. • Regulators should also be recommended to waive off Fixed Demand Charges during the policy term.
Prioritization in terms of EV characteristics and social geography	• The Government plans to have charging stations every 25 km on highways and every 3 km within city limits. • All new and renovated non-residential buildings, individual and other residential buildings, Co.OP. grouping Housing Societies and colonies managed by Residents Welfare Associations (RWAs),etc. with parking demarcated for more than 10 equivalent car spaces(ECS) will need to have at least 20% 'EV ready' ECS spots with installed conduits.
Easing out administrative barriers for establishing charging stations	• All housing and commercial buildings shall compulsorily register with Goa Electricity Department to install EV charging stations with designated parking spaces. • Govt. of Goa through Department of New and Renewable Energy will provide Concessional Locations for charging station at bare minimum lease rentals. • The Charging Infrastructure Working Group shall identify a list of Concessional Locations for the first phase of EVCS roll out within 2 months of policy notification. Locations to include but not limited to industrial estates, tech parks, petrol pumps, existing auto/bus stands
Focus on RE integration and EV charging	• Solar powered charging stations will be given top priority and encouragement in the case of both private and public charging stations as part of government's green initiative. • The government would endeavor to provide open access without the condition of having minimum 1 MW contract demand for PCS in consultation with Joint Electricity Regulatory Commission (JERC). • The Charger Operators who set up captive renewable energy facilities shall be given power-banking facilities with Goa Electricity Department for operating in Goa over a period of one year. This shall encourage generation and use of renewable power.
Measures to Enable EV charging on demand-side	
Elements	**Focus on State EV Policy**
The mandate for the development of digital platforms and database management systems	• An open, publicly owned database shall be developed by Department of New and Renewable Energy along with Convergence Energy Services Ltd. offering historical and real time information on public charging infrastructure • The data include the following: kWh, session length, vehicle type if available, number of events, location (latitude, longitude) of the charger, number of chargers at site, site classification, payment amount, pay structure (by hour, or by kWh, or by session), as well as payment rate. • The Charger Operators shall have to provide data to this public database. The database can be used free of charge by in- vehicle navigation systems and charging apps and maps
Specification of the use of a wide range of payment methods	• The Charger Operators shall be expected to accept payments through multiple modes such as cash, cards, mobile wallets and UPI. Option for payments through the common mobility card payment system shall also need to be offered.
Specification of minimum facilities to be provided at the charging stations	• All EV charging stations, both private and public, shall adhere to the protocols approved by the Government of India, as updated on October 2019(Bharat AC charger AC-001 and Bharat EV charger DC-001) and any other protocols as and when notified.

Additional Measures for promotion of EV sector	
Elements	Focus on State EV Policy
EV Market Support services to promote EV adoption	• Pioneer, Mega and Ultra-Mega units manufacturing Electric Vehicles and associated components shall be given the following incentives: – Capital subsidy of up to 20% of Fixed Capital Investment (FCI). – 100 % net SGST reimbursement for 5 years. – 100 % stamp duty exemption. • Incentives for micro units manufacturing Electric Vehicles and associated components are as follows: – Capital subsidy of 30% of the cost of capital provided the subsidy on building/office is restricted to INR 5,00,000 (EUR 5,676). – 100 % net SGST reimbursement for 5 years. – 100 % stamp duty exemption • Incentives for small and medium units manufacturing Electric Vehicles and associated components are as follows: – A capital subsidy of 30% of the cost of capital provided the subsidy on building/office is restricted to INR 10,00,000 (EUR 11,353). – 100 % net SGST reimbursement for 5 years. – 100 % stamp duty exemption. – Price preference at the rate of 15% on the purchase made by the Government Departments is available to the registered Small- Scale Units. • Incentives for utilities: – 100 % electricity duty reimbursement for5 years. – Support in construction of effluent treatment plant (ETP) with 50% capital subsidy • Incentive for 2-W: A purchase incentive of INR 10,000 (EUR 1,135) per kWh of battery capacity shall be provided per vehicle to the registered owner and subject to maximum incentive of INR 30,000 (EUR 340) per vehicle. • Incentive for e-auto: Purchase Incentive of INR 10,000 (EUR 1135) per kWh of battery capacity per vehicle subject to a maximum incentive of INR 30,000 (EUR 340) per vehicle shall be provided by Govt. of Goa to the registered owner of the e-auto • Incentive for e-rickshaws/e-karts: A Purchase Incentive of INR 30,000 (EUR 340) per vehicle shall be provided to the registered owner for the purchase of one E-rickshaw or one E-cart per individual. This incentive shall apply to all E-rickshaws and E-carts, including the models with Lithium ion batteries and swappable models, where batteries not sold with the vehicle. • Incentive for e-cars (4W): A Purchase Incentive of INR 10,000 (EUR 1,135) per kWh of battery capacity shall be provided per electric 4-W subject to a maximum incentive of INR 1,50,000 (EUR 1,703) per vehicle to the registered owners of e-cars in Goa. • For purchase of e-autos/e-rickshaws/e-karts with advanced batteries, Convergence Energy Services Limited shall provide interest subvention on loans and/or hire purchase schemes. • The Govt. of Goa commits to provide appropriate incentives and other supports required to ensure that pure e-buses constitute at least 50% of all new stage- carriage buses, with a target of 500 pure e-buses by 2025. • Individuals and fleet owners shall be encouraged to adopt electric goods carriers ('e- Carriers') by providing a Purchase Incentive of INR 30,000 (EUR 340) per e-Carrier registered in Goa. • Convergence Energy Services Limited shall provide interest subvention of 5% on loans and/or hire purchase scheme for purchase of e-carriers. • The following scrapping incentives are provided to the owners of old ICE vehicles, subject to evidence of matching contribution from the dealer or OEM, and confirmation of scrapping and de-registration of the ICE vehicle: – 2-W: Department of New and renewable Energy Govt. of Goa shall reimburse Up to INR 5,000 (EUR 57) of the incentive to the registered owner. – E-auto: Department of New and renewable Energy Govt. of Goa shall reimburse Up to INR 10,000 (EUR 113) of the incentive to the registered owner. – E-carriers (goods): Department of New and renewable Energy Govt. of Goa shall reimburse Up to INR 10,000 (EUR 113) of the incentive to the registered owner.

	• Road Tax and registration fees shall be waived for all Battery Electric Vehicles during the period of this policy. • If the battery is not sold with EV, 50% of the Purchase Incentive shall be provided to the vehicle owner & the remaining amount of up to 50% would be provided to Energy Operators for defraying the cost of any deposit that may be required from the end users for use of a swappable battery. • The interest subvention of 5% being offered in the vehicle categories of e-autos, e- rickshaws, e-carts and e-carriers would be applicable, only if the loan is availed from the Convergence Energy Services Limited (CESL)
Institutional framework for roll out of policies	• State Electric Vehicle Board constituted with officials from Department of New and Renewable Energy, Department of Transport, Goa Electricity Department, Goa Energy Development Authority & Convergence Energy Services Limited (CESL), will be the Nodal Authority for the implementation of the Goa Electric Vehicle Promotion Policy. • The Investment promotion Board will give single-window clearance for all types of investments in the state with a special focus on EV Manufacturing. • Through the single window portal, the Government will also provide a channel for the units to provide policy inputs to the Government. • Through the single window system, all decisions regarding incentive approvals and payments will be provided within 90 working days, subject to due compliance of all procedures by the applicant.
Enhancement of EV value chain peripheral ecosystem	• Pollution Cess on the sale of diesel and petrol is proposed to be applicable in the state of Goa at 75 paisa per litre. The amount collected shall be transferred to State EV Fund on a monthly basis. • Road Tax called "Green Tax" levied on registration of diesel and petrol vehicles shall contribute to State EV Fund. • Congestion Fee shall be levied on all trips originating or terminating within Goa and taken using cab aggregator and ride hailing services. This tax shall be waived for rides taken in e-two wheeler, e-auto or e-cab. • Skill development courses in EV maintenance and component assembly will be started in ITIs and Polytechnic institutes to skill the workforce to augment the labor required for the EV promotion and maintenance. • A stipend of up to 50% of the cost of course fee subject to a limit of INR 10,000 (EUR 113) per year per student in all skill development and re-skilling courses affiliated to Board of Technical Education and State Council for Vocational Training shall be offered. • Specific areas to be identified like – Panjim Smart City, Heritage Zones, Tourist Zones, Airport and Railway stations etc. which will move towards 100% mandatory electric vehicles by 2025
Promotion of Battery Recycling/scrapping facilities	• The reuse of EV batteries that have reached the end of their life is encouraged, by setting up recycling businesses in collaboration with battery and EV manufacturers that focus on 'urban mining' of rare materials within the battery for re-use by battery manufacturers. • Convergence Energy Services Limited to develop a use case for second life of electric vehicle batteries since even after degrading to 70% of their capacity, they can be used for energy storage

4.6.17.2 Goa EV Concessional Charging Infrastructure Policy 2021

In addition to the Electric Vehicle policy issued by the state government, the state government of Goa launched 'The Goa Electric Vehicle Concessional Charging infrastructure policy 2021 on 4th December 2021 to install charging stations at 50 locations initially identified by the state within three months[66]. The charging stations would be provided with a 20% subsidy.

The government will appoint Goa Energy Development Agency (GEDA) as the nodal authority to grant licenses and permissions for setting up charging stations in public and private properties. The agency will also advertise a list of concessional EV charging locations against which the applications will be received. In cases of multiple applications received for a particular location, GEDA will allot the concessional location to the applicant who offers a maximum fixed monthly contribution to Goa Decarbonisation Fund during the period of allotment.

The guidelines for installation of EV charging stations as mentioned in the EV Concessional Charging infrastructure policy 2021 are listed below:

- The applications should be submitted to GEDA and in case an application is not complete, an opportunity to submit a revised application or document(s) rectifying the defects within 15 days will be given to the applicants
- no application shall be rejected unless the applicant has been given an opportunity of being heard on the reasons for such action
- GEDA shall issue the permit or license to the applicant within 15 days from the date of acceptance of application/revised application
- GEDA shall collect all fees and monthly rent (in case of Government land).
- Each application shall be charged a one-time non-refundable application fee of Rs.10,000 (EUR 113) per location and shall be submitted along with required documents
- GEDA shall mention all dues to be paid by the applicant to any Government departments/local bodies at the time of granting the permission.
- The Applicant shall have no right over the property which has been approved to use for installation and operation of EV Charging Station.
- The charging station operator shall be allowed for other revenue generation purposes with prior approval. The revenue generated shall be shared with GEDA on a 50:50 basis. In the GEDA charges, 20% will be shared with land owning agency and the balance of 80% will go to Goa Decarbonisation Fund.

The details of the charging infrastructure to be used at the charging stations for fast and slow charging is given in Table 4.9.

Table 4.9: Details of charging infrastructure to be used at charging stations

Sl no	Type of Charger	Duration of charging
1	AC-001 Chargers, AC smart charging instrument	6 hrs. (depends on the state of vehicle battery)
2	DC fast charging instrument, Bharat DC-001	60-90 minutes (depends on the state of vehicle battery)
3	Fast combined charging system 122 kW fast chargers (CCS+CHaDeMo+AC type-2)	Less than 60 minutes (depends on the state of vehicle battery)

4.6.17.3 Scheme for promotion of Electric Vehicles in the State of Goa

The state government of Goa had issued a scheme for promoting e-mobility named 'Grant of subsidy for purchase of Electric Vehicles to consumers in the State of Goa' in November 2021[67]. The main scope of this scheme is to provide an incentive in the form of subsidy to the prospective consumers for the purchase or conversion of Electric vehicles (2-W/3-W/4-W) and buses in the State. It also intends to provide scrapping incentives for 2-W/3-W/4-W towards the purchase of EV Vehicles. Another objective of this scheme is to support local manufacturing of EVs in Goa along with the promotion of employment opportunities to skilled persons in the field of Electric Vehicle servicing.

The details of financial assistance as mentioned in the scheme which will be provided to the users in form of subsidy is given in Table 4.10.

66 Government of Goa, "Goa Electric Mobility Promotion Policy 2021," 2021.

67 Government of Goa, "Goa Electric Mobility Promotion Policy 2021," 2021.

Table 4.10: Details of financial assistance

Sl no	Scheme	Implementation of scheme		Quantum of subsidy
1.	FAME II	Government of India		As applicable
2.	EV vehicle scheme	Government of Goa		
i)	Financial Year	2 wheeler	3 wheeler	4 wheeler
	2021-2022	INR 10,000/kWh (EUR 113.53/kWh)	INR 10,000/kWh (EUR 113.53/kWh)	INR 10,000/kWh (EUR 113.53/kWh)
	2022-2023	INR 8,000/kWh (EUR 90.8/kWh)	INR 8,000/kWh (EUR 90.8/kWh)	INR 8,000/kWh (EUR 90.8/kWh)
	2023-2024	INR 6,000/kWh (EUR 68.12/kWh)	INR 6,000/kWh (EUR 68.12/kWh)	INR 6,000/kWh (EUR 68.12/kWh)
	2024-2025	INR 4,000/kWh (EUR 45.41/kWh)	INR 4,000/kWh (EUR 45.41/kWh)	INR 4,000/kWh (EUR 45.41/kWh)
	2025-2026	INR 2,000/kWh (EUR 22.7/kWh)	INR 2,000/kWh (EUR 22.7/kWh)	INR 2,000/kWh (EUR 22.7/kWh)
ii)	Capping of state subsidy	Not exceeding INR 30,000 (EUR 340.6)	Not exceeding INR 60,000 (EUR 681.2)	Not exceeding INR 3,00,000 (EUR 3406)
iii)	Number of vehicle for which subsidy will be provided	3000	50	300
3.	Other Contribution for the scrapping of vehicles by OEM/CESL	INR 5,000 (EUR 56.7)	NIL	NIL
4.	Goa Government incentive for scrapping of vehicle	INR 5,000 (EUR 56.7)	INR 10,000 (EUR 113.53/kWh)	INR 10,000 (EUR 113.53/kWh)
5.	Manufactured in Goa	INR 5,000 (EUR 56.7)	INR 10,000 (EUR 113.53/kWh)	INR 15,000 (EUR 170.3)

The Convergence Energy Services Ltd. (CESL) will club the incentives provided under the FAME II scheme along with the subsidy proposed by the State Government of Goa and contribution of Original Equipment Manufacturer (OEM) to reduce the upfront cost of the EV to the consumer. CESL will also provide low-cost loans to the users for the purchase of EVs as well as training/capacity building to local youths in the field of servicing EVs and their financial incentives will be available if the EV is purchased from CESL.

Permanent residents of Goa having an Aadhar Card and Driving License issued in the state are entitled to the benefits under this promotion scheme. Also, the total amount of financial subsidy will be decided by the Department of New & Renewable Energy and disbursement shall be done on First Come First Serve (FCFS) basis. The subsidy shall be disbursed in a single instalment to the concerned applicant i.e., 100% on purchase/conversion of the vehicle and submission of documents of purchase/conversion i.e. copy of RC book and Insurance by the applicant.

GEDA shall operate the "Goa De-carbonization Fund" to undertake various activities for the promotion of EVs and to give financial assistance to beneficiaries as per the launched scheme. For the implementation of the promotion scheme, Government grants and other financial assistance and support will be provided to Goa De-carbonization Fund.

4.6.17.3 Key Attributes Targeted in Goa EV Policy:

Building on indigenous strengths of tourism and IT industries, Government of Goa aims to make Goa a model State in EV sector.

Figure 4.36: Key highlights in Goa Electric Mobility Promotion Policy

The state also announced some e-mobility initiatives under clean mobility program in which, the 2-wheelers in state that constitutes 70% of the state's total vehicle population will be converted into e-2Ws or e-bikes by Convergence Energy Services limited (CESL). The clean mobility program will be applicable to first 10,000 electric-2Ws sold in the state, which will reduce 5,000 tonnes of CO2 and remove 10% of the polluting vehicles off Goa's roads.

The State is offering a number of subsidies and incentives to promote switching of conventional mobility to EV mobility such as:

- Cash incentive or buyback program in which participating automobile companies incentivize users to exchange old ICE vehicle to buy new e-vehicle
- Waiving off of registration charges resulting in immediate 5% reduction in EV cost
- Subsidy to help buyers' easy access of affordable lease
- Scrappage incentives for old vehicles

So far, three high-capacity combo EV chargers of 122-150 kW, type 2A standards have been installed in the state, which are able to charge long range EVs like Hyundai Kona, Tata Nexon etc. As part of the Green Goa initiative, the first public electric vehicle charging station is inaugurated in the state on January 2021 by CESL. It is a 142-kW fast charger and is the first among 12 EV public charging stations to be set up by CESL in the state. Adjoining these EV chargers, Bharat standard DC 001 EV chargers are planned for recharging moderate range EVs and this shall be completed soon according to the state release.

Limitations related to EV charging infrastructure in Goa EV Policy:

a) No mention of retrofitting and public awareness plans.

b) No mention of utilization of V1X or V2X capabilities.

4.6.17.3 EV market of Goa

The EV market of Goa is still at it's infancy, with only 330 e-4W, 1432 e-2W and only 28 e-3W as of February 2022. However, comparatively 9,87,000 petrol vehicles and 1,21,000 diesel vehicles are in the state.

4.6.18 PUNJAB

With various initiatives/schemes launched by Government of India, both EV adoption and manufacturing is expected to grow rapidly in the next decade. Punjab is well placed as an Auto & Auto Ancillary manufacturing destination with leading players already present in the State, access to large consumption markets and state of art infrastructure. Further, Government of Punjab recognizes the need for promoting cleaner mobility considering high level of vehicular emissions in Major Cities - Ludhiana, Jalandhar, Patiala, Amritsar and Bhatinda contribute to more than 50% of Vehicular Emissions in the State.

Therefore, Government of Punjab recognizing the potential of EVs as a long-term sustainable solution for India, and accordingly has decided to develop a dedicated policy for promoting EV & EV Component Manufacturing and supporting EV adoption in the State with a prime focus on promoting cleaner mobility and creating jobs[68].

4.6.18.1 Key Objectives of Punjab Electric Vehicle Policy 2019

Measures to Enable EV charging on supply-side	
Elements	**Focus on State EV Policy**
Definition of a fundamental market design framework to limit distortions and entry barriers	• Punjab State Power Corporation Limited (PSPCL) to act as the state-level nodal agency for implementation of Charging Infrastructure. Each district to have a District Level Implementation Committee (DLIC) which will be responsible for creation/approval of charging infrastructure through a dedicated approval and inspection desk. • Power tariff for fleet charging / swapping stations set at INR 6.00/kVAh (EUR 6.8 cents/kVAh). • Special ToD may also be introduced for EV charging loads.
Incentives for promoting the EV charging infrastructure	• First 1000 charging points shall be eligible for 25% capital subsidy on equipment / machinery (limited up to a total of INR 50,000 (EUR 579) per charging point). In case the charging equipment is manufactured in Punjab, the maximum capital subsidy shall be 50% (limited up to a total of INR 10,000 (EUR 116) per charging point). • 100% electricity duty exemption for the policy period (5 years) for EV Charging points. • Concessional lease rentals to be charged for the establishment of public charging stations at appropriate locations identified by the state.
Easing out administrative barriers for establishing charging stations	• Byelaws to ensure EV Charging infrastructure availability in both residential and non-residential buildings. • Single window service for all approvals required for installation of EV charging infrastructure.
Focus on RE integration and EV charging	To encourage the use of RE power for EV charging, the EV policy has waived off the wheeling chares for purchase of power from RE sources subject to the approval of the state electricity regulatory commission.
Additional Measures for promotion of EV sector	
Elements	**Focus on State EV Policy**
EV Market Support services to promote EV adoption	• For 2-W: 100% waiver on Motor Vehicle Tax and permits during the policy period. • For 3-W (e-autos, e-rickshaws, and Goods Carriers): 100% waiver on Motor Vehicle Tax and permits during the policy period. Only E-autos will get fresh permits in target cities. Free registration of existing e-rickshaws.

68 "Draft Punjab Electric Vehicle Policy (PEVP) 2019" (Government of Punjab, 2019), http://punjabtransport.org/Punjab EV Policy_Final Draft 15112019_Upload.pdf.

	• For 4-W (Private, Commercial, and corporate fleets): 100% (50% for Hybrids) waiver on Permit fee & Motor Vehicle Tax during the policy period. BEVs (Battery Electric Vehicles) to be given priority in all fresh procurement of vehicles/services by the government. • Buses: Private Bus operators to be offered 100% waiver on Permit Fee; Motor Vehicle Tax for a period of 5 years. • For vehicles manufactured in Punjab, above waivers will be applicable for a period of 10 years. • The EV and component manufacturing units will receive the following benefits: 100% reimbursement of net SGST for a period of 15 years subject to a maximum 200% of fixed capital investment, employment generation subsidy for each employee annually for a period of 5 years, 100% exemption from Change of Land Use (CLU)/ External Development (EDU) Charges for anchor units, 100% exemption from electricity duty for 15 years, Subject to applicable guidelines on security for night shifts, anchor units will be eligible to run three shifts
Institutional framework for roll out of policies	• To Promote EV Manufacturing in the State, EV Related technology companies would be added to the list of service enterprises under MSME or large category eligible for financial incentives under Punjab Industrial and Business Development Policy 2017. • Establishment of e-Mobility Centre of Excellence to promote R&D incubation and skill development in the EV space.
Enhancement of EV value chain peripheral ecosystem	• The mobility start-ups to be supported by incentives to incubators and start-ups laid down in Punjab Industrial and Business Development Policy, 2017 • Green number plates-In the case of Battery-Operated Vehicles, the registration mark shall be exhibited in yellow on green background for transport vehicles and for all other cases, in white on green background. • Tolls on select state highways to be waived off for vehicles with green number plates, and reserved slots at public parking places. • Special Green Zones to be declared at strategic locations in target cities where only electric vehicles shall be permitted. • Incentivize EV buyers through transition credits dovetailed with "to-be notified" scrappage policy. • Special concessions for EV Units for Giga Battery Manufacturing Unit and E-tractor manufacturing units.
Promotion of Battery Recycling/ scrapping facilities	• OEMs and private ecosystem players will be encouraged to operate schemes for Battery buyback and set up recycling facilities in the state. • Disposal/Dumbing of EV Batteries in trash and landfills to be prohibited. • The government would encourage the creation of an e-marketplace for resale of used batteries.

4.6.18.2 Key Attributes Targeted in Punjab EV Policy

Figure 4.37: Key highlights in Punjab EV policy

The Punjab state policy framework provides numerous fiscal and non-fiscal support to EV value chain players which includes concessional land acquisition, capital subsidy, rebate of taxes etc. The state also promotes adoption of shared mobility in the state which is aimed at 100% transition of public transportation fleet to electric in target cities in a phased manner. It also plans to convert 25% of bus fleet under department of transport to electric buses. It is expected that the 2W and 3W vehicle sales will reach at least 25% penetration during the policy period. The policy guidelines also treat various R&D and skill development aspects along with support of battery recycling and vehicle scrapping.

Limitations related to EV charging infrastructure in Punjab EV Policy:

a) No mention of home/workplace charging, funding resources and retrofitting.

b) Lack of clarity in expense recovery for DISCOMS in setting up charging stations.

c) Development of digital platforms for database management, setting up of facilities to address consumer complaints and specifications of payment methods are not considered.

d) No mention of utilization of V1X or V2X capabilities in EV charging infrastructure.

4.6.18.3 EV Market of Punjab

Punjab is one of the poorer markets, both for BEV and PHEV in India as of February 2022. A cumulative sum of 19,000 EVs have been registered in the state as shown in Figure 4.38.

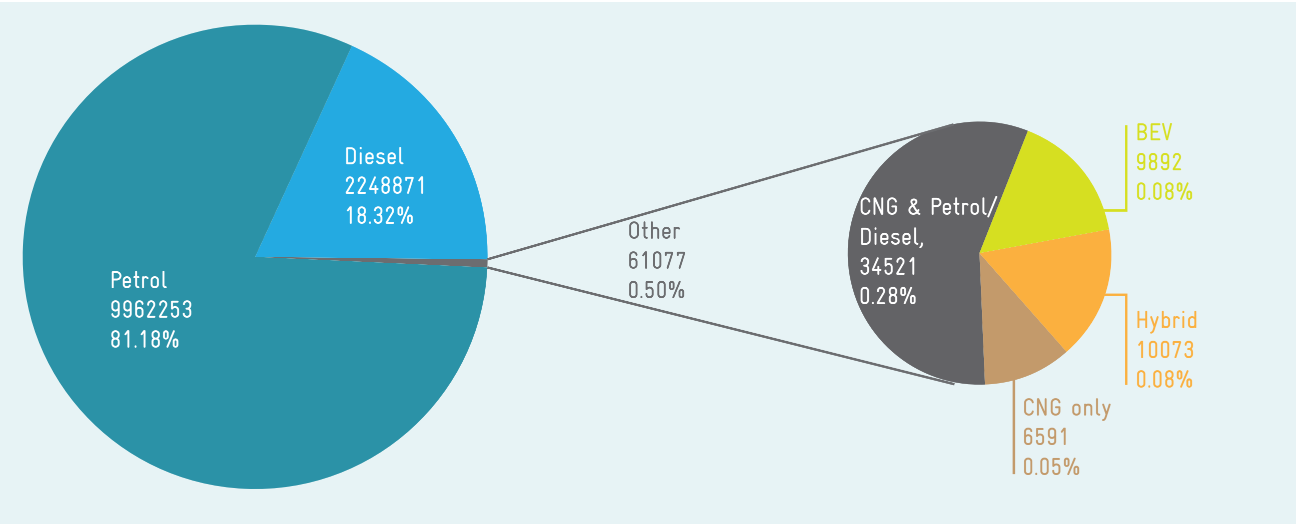


Figure 4.38: Share of total registered vehicles in Punjab by fuel type (till Feb 2022)[42]

4.6.19 BIHAR

The popularity of electric vehicle, especially electric rickshaws have significantly increased in Bihar in recent times because of various factors such as lower capital/acquisition cost, lower operating and maintenance cost, environmental friendliness etc.

Bihar Industrial Investment Promotion Policy established in 2016 handles governing of various incentives for Industries in Bihar. This policy recognizes ten high priority sectors, however, EV sector was not considered as one, even though Bihar is one of the fastest growing markets in India, for commercial vehicles such as e-rickshaws. In order to leverage strength of this market, for development of an EV manufacturing eco-system in the state, now the EV Sector has been declared as a high priority sector in the said policy by introducing suitable amendments[69,70].

Bihar Electric Vehicle Incentive Policy 2019 targets to establish the state as most preferred investment destination of e-mobility in the country by leveraging its market strength and maximize employment opportunities through it. The vision of the policy also includes creation of manufacturing eco- system for EVs and fulfil Sustainable Development Goals in the state automobile and transport sector.

4.6.19.1 Key Objectives of Bihar Electric Vehicle Incentive Policy 2019

Measures to Enable EV charging on supply-side	
Elements	**Focus on State EV Policy**
Definition of a fundamental market design framework to limit distortions and entry barriers	• Petrol pumps will be allowed to setup charging/swapping station freely subject to charging station areas qualifying fire & safety standard norms of relevant authorities under relevant acts/rules. • As per requirement facility of Robotic Battery Swapping Arm shall be created at public bus stations by the Transport Dept. • Across the state, the rate of Electrical power required for EV charging shall be industrial rate of electricity.
Incentives for promoting the EV charging infrastructure	• Commercial public EV charging stations will be eligible for 25% capital subsidy on equipment/machinery (limited to INR 5,00,000 (EUR 6,000) per station) for first 500 commercial public EV charging stations.
Prioritization in terms of EV characteristics and social geography	• Fast charging infrastructure (normal and fast) shall be created at all major Government offices by the Transport Department. • Charging infrastructure would be created by the Transport Dept. at all 'Rain Baseras' for e-Rickshaws and a concessional fee for charging may also be introduced. • Charging locations would be identified at all municipal parking locations with at least 100 sites identified within 6 months of notification of policy.

69 "Draft Bihar Electric Vehicle Policy 2019," 2019, http://www.investbihar.co.in/Download/Draft_for_e_vechile.pdf.
70 "Amendment to Bihar Industrial Investment Promotion Policy - 2016 for Inclusion of EV Sector under High Priority," n.d., https://static.psa.gov.in/psa-prod/files/EV-policy_Bihar_0.pdf.

Easing out administrative barriers for establishing charging stations	• The Government of Bihar will identify and allot suitable land across the state on lease basis based on traffic movement and population distribution, for setting up of charging/swapping stations. • Bihar Government shall support EV charging service providers with electricity connections, extension of supply and any other connectivity issues. • Single window system would be provided for applications for setting up of PCS/BSF.
Additional Measures for promotion of EV sector	
Elements	**Focus on State EV Policy**
EV Market Support services to promote EV adoption	• The state shall offer incentive for the first 100,000 vehicles manufactured within the state. • All categories of buyers, i.e., private transporter and individual buyer shall get end user subsidy over policy period. • Additional incentive of INR. 7,000 (EUR 81) /- per kWh shall be given on electric rickshaw and e-2 wheelers using Lithium-ion battery instead of conventional lead acid battery • Interest subvention of 10% to buyer of light electric freight vehicle or e-bus • Special grant of INR. 10,000 (EUR 116) /- per kwh to manual pedal rickshaw puller for conversion/upgradation to 100% electric mobility. For pedal rickshaw fleet owner interest subvention of 10% on loan taken for conversion/upgradation to 100% electric mobility. • Top up subsidy of INR. 8000 (EUR 93) /- on ex-showroom price if the end user is below poverty line or belong to MBC or S.C./S.T. • 100% Exemption from road tax and registration fees for Electric, 50% exemption for Strong Hybrid Vehicles and 25% exemption for CNG vehicles • Exemption from toll charges and public parking lots • Interest subvention of 10% to buyers on EVs manufactured in Bihar
Institutional framework for roll out of policies	• The government shall encourage tie up with mobility service providers for introducing leasing models for e-rickshaws in the state. • Green plate registration for EV for both private and commercial vehicles • All government departments to buy EVs as a strategy to promote EV. • A suitable Information, Education and Communication (IEC) Program shall be undertaken by the Transport Dept. for creating consumer awareness and promotion of e-mobility
Enhancement of EV value chain peripheral ecosystem	• Tailor made incentives for EVs for schools/hospitals by transport department in consultation with SIPB. • In order to promote e-mobility research and development in the state, the government will issue a request for proposal (RFP) for companies in interested in establishing their R&D units. • State will offer R&D funding, as decided by SIPB, to companies that have set up a plant in Bihar with minimum investment of INR. 200 crore (EUR 23 Million) and generating employment of 200 persons.
Miscellaneous	• In order to qualify for financial incentives, all such vehicles must be accompanied by 3- year comprehensive warranty including that of battery from manufacturer.

4.6.19.1 Key Attributes Targeted in Bihar EV Policy:

Figure 4.39: Key highlights in Bihar EV policy

Bihar is spotted as one of the fastest-growing markets for e-rickshaws in India. Thus, the state decided to leverage its market strength and promote e-rickshaws manufacturing. The Bihar Industrial Investment Promotion Policy published in 2016, dictates all incentives for industries such as reimbursement of stamp duty, registration duty, and SGST, as well as other tax benefits. The state amended the policy to incorporate prioritized EV market aspects. As per the guidelines, a special incentive of INR 10,000 (EUR 116) per kWh on Lithium-ion battery e-rickshaws, and INR 7,000 (EUR 79.47) per kWh on Lithium-ion powered e-2W will be provided to promote the EV adoption. The government plans to deploy charging stations at major commercial locations, residential and workplace areas and on state/ national highways.

Limitations related to EV charging infrastructure in Bihar EV Policy:

a) No support for home/workplace charging infrastructure.

b) No mention of battery recycling, building bye-laws, retrofitting, vehicle scrappage incentives, and promotion of shared mobility.

c) Development of digital platforms for database management, setting up of facilities to address consumer complaints and specifications of payment methods are not considered.

d) No mention of utilization of V1G or V2X capabilities and integration of RE based sources in EV charging infrastructure.

4.6.19.1 EV Market of Bihar

In Bihar, the number of BEVs account for 0.67% of the total state vehicle count till February 2022 (Figure 4.40). However, of these vehicle stock more than 60,000 BEVs comprises of 3 wheelers, with only 126 4W LMV and 5159 2W till February 2022[42].

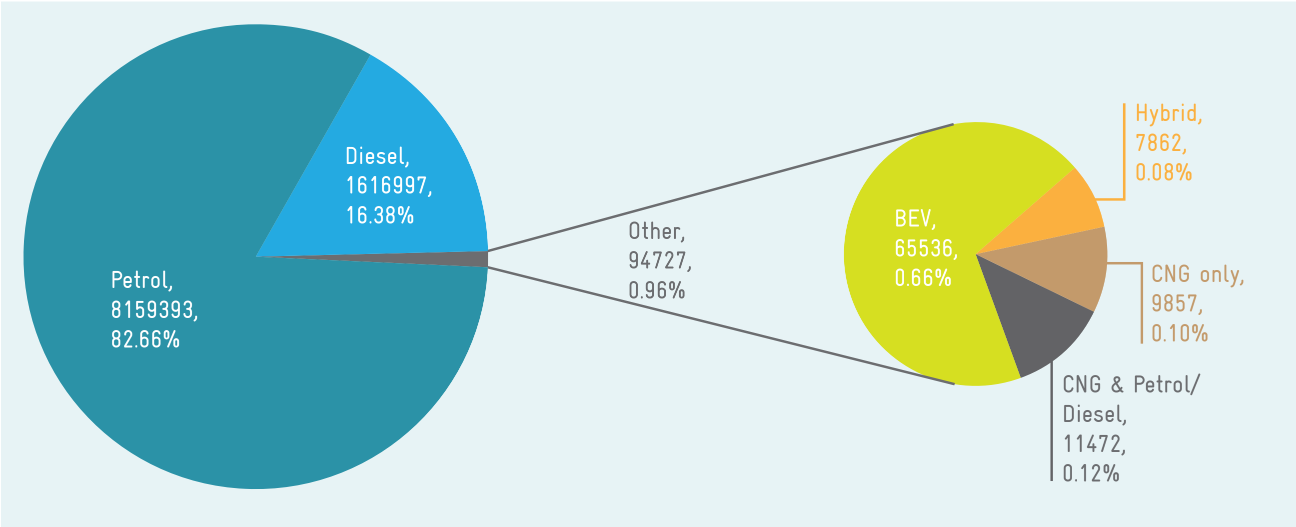


Figure 4.40: Share of total registered vehicles in Bihar by fuel type (till Feb 2022)[42]

4.6.20 HARYANA

The automobile population in Haryana has been increasing rapidly over the last decade thereby increasing environmental pollution and associated health hazards. In line with Government of India, endorsing and supporting the EV boom, the state government of Haryana planned to come up with an electric vehicle policy that will guide every aspect of e-mobility and accelerating adoption of EVs in state that eventually will lead to healthier environment. The state released a draft of electric vehicle policy in the year 2017[71] .

4.6.21.1 Key Objectives of Haryana Electric Vehicle Policy 2017

Measures to Enable EV charging on supply-side	
Elements	Focus on State EV Policy
Definition of a fundamental market design framework to limit distortions and entry barriers	• Charging infrastructure in public buildings, public places shall be developed, and assured provisions to set up charging outlets, regular electric supply, etc. • Phase wise/ City wise, promotional discounted tariff will be offered for charging Battery Electric Vehicles (BEVs).
Incentives for promoting the EV charging infrastructure	• Direct Current (DC) Chargers (100 Volt and above): Capital Subsidy of 25% of the value of the charging station equipment/ machinery for first 100 charging stations/battery banks will be provided up to a maximum subsidy of INR 10,00,000 (EUR 11,578) . • Direct Current (DC) Chargers (Below 100 Volt): Capital Subsidy of 25% of the value of the charging station equipment /machinery for first 300 charging stations/battery banks will be provided up to a maximum subsidy of INR 30,000 (EUR 347). • Capital subsidy of 25% of Fixed Capital Investment (for eligible assets excluding cost of battery inventory) up to a maximum subsidy of INR 10,00,000 (EUR 12,000) for swapping stations/ battery banks for the first 50 stations will be provided. • 100% net State Goods and Service Tax (SGST) accrued to the state, as reimbursement for purchase of fast chargers (Direct Current (DC) chargers of capacity 100 Volt and above). • 100% net State Goods and Service Tax (SGST), accrued to the state, as reimbursement for purchase of advanced batteries for Battery Electric Vehicle (BEV) swapping stations/ battery banks
Prioritization in terms of EV characteristics and social geography	• New apartments, high rise buildings, technology parks in the state will be provided charging infrastructure for Electric Vehicles (EVs) by making modifications to building codes.
Easing out administrative barriers for establishing charging stations	• Public Sector units will be encouraged in setting up charging infrastructure in the State. State will facilitate availability of land to such Public Sector Undertakings (PSUs) at concessional rates in designated areas. • The Government of Haryana will allocate 100 to 200 acres of land for developing Electric Vehicle (EV) Parks with plug and play internal infrastructure, common facilities, and necessary external infrastructure.
Focus on RE integration and EV charging	• The policy encourages clean fuel and Renewable energy-based Charging/Battery Swapping Station – for hydrogen powered fuel cells, or solar powered cells.

71 "Haryana Electric Vehicle Policy," 2017, https://haryanatransport.gov.in/sites/default/files/Electric Vehicle Policy_2.pdf.

Measures to Enable EV charging on demand-side	
Elements	Focus on State EV Policy
Harmonization of Intra/ interstate mobility of EVs	Electric Vehicle (EV) mobility on prominent highways with heavy density of vehicles, will be provided with fast charging stations, battery swapping infrastructure, at every 50 kilometers
Additional Measures for promotion of EV sector	
Elements	Focus on State EV Policy
EV Market Support services to promote EV adoption	**Capital subsidy of Fixed Capital Investment (FCI) in the following amounts:** • 25% of FCI up to a maximum of INR 15,00,000 (EUR 17,000) for Micro industries • 20% of FCI up to a maximum of INR 40,00,000 (EUR 46,000) for Small and INR 50,00,000 (EUR 58,000) for Medium Industries • 10% of FCI up to a maximum of INR 10 crore (EUR 1 Million) for first two units, under Large industries, in each segment of EV (2 wheelers, 3 wheelers, 4 wheelers, buses), battery and charging equipment, hydrogen storage & fueling equipment manufacturing. • 10% of FCI up to a maximum of INR 20 crore (EUR 2 Million) for first two units, under Mega category, in each segment of EV (2 wheelers, 3 wheelers, 4 wheelers, buses), battery and charging equipment, hydrogen storage & fueling equipment manufacturing. • Additionally, special incentives will be given according to their need for Mega, Mega Integrated automobile projects and Ultra-Mega battery as well as Li-ion battery manufacturing plants on a case-to-case basis. • 25% subsidy, for MSMEs and Large projects, for sustainable green measures on total FCI of the project (excluding cost of land, land development, preliminary and pre-operative expenses, and consultancy fees) with a ceiling of INR 50 crore (EUR 6 Million). **Stamp Duty:** • 100% of stamp duty and transfer duty paid by the industry on purchase or lease of land meant for industrial use will be reimbursed. • 100% of stamp duty for lease of land/shed/buildings, mortgages and hypothecations will be reimbursed. • Stamp duty will be reimbursed only one time on the land. Stamp duty will not be waived on subsequent transactions on the same land. **Power:** • The government will provide dedicated feeders to all units involved in manufacturing components for EV as required. • The government will provide fixed power cost reimbursement at INR 1/kWh (1.1 cents/kWh) for a period of 5 years from the date of commencement of commercial production. The power cost reimbursement for certain specific sector/sub-sector may be higher. • Al new EV manufacturing units and battery units will be exempted for paying electricity duty for first 10 years. • A dedicated line along with special discount for night-time/non-peak time usage will be offered for testing of BEV batteries based on requirements • The rate per unit will be less for EV charging. **Water:** • Water Supply will be made at 50% of the price of existing industrial supply tariff for the initial 3 years from the date of commencement of commercial production. • In order to provide quality water, the Haryana Government will reimburse 25% of the cost of water treatment plant wherever necessary, with a limit of INR 2 crore (EUR 232,000) on this subsidy. • Tax Incentives: 100% net SGST accrued to the state will be reimbursed for a period of 5 years for micro & small, 7 years for medium, 10 years for large industries. This reimbursement will be limited to 100% of capex or for the period stated, whichever is earlier. • Skill development incentives: Stipend of INR 10,000 (EUR 113) per employee per year to a maximum of first 50 employees for a single company for Micro, Small, Medium, and Large firms.

	• **Marketing incentives:** 50% of cost of participation with a maximum amount of 5,00,000 (EUR 6,000) to be reimbursed to a maximum of 10 MSME units per year for participating in international trade fairs. • Reimbursement of the Net State Goods and Service Tax (SGST) for services rendered, accrued to the state, for firms involved in services such as leasing of fleet of Electric Vehicles, owning, or operating Electric Vehicle (EV) fleets and providing charging/ battery swapping/ Hydrogen stations for recharging/ refueling Electric Vehicles, until 2024.
Institutional framework for roll out of policies	• **Land:** In case of Mega integrated projects, government will offer land to dependent ancillary units at the same rates as offered to respective Original Equipment Manufacturer (OEM) (wherever Government allocates land to OEM) up to a maximum of 50% of the land allocated to OEM. • **Water:** The Haryana Government will provide water supply and also facilitate/support setup of water treatment plants in/around major auto hubs in order to meet this requirement wherever necessary. • **Rail and Road Connectivity:** The Haryana Government shall strive to construct elevated expressways to decongest roads to the industrial areas and will also look to ensuring better road access to ports.
Miscellaneous	**Model Electric Mobility Cities:** • 2020-21 shall be announced as the "Year of the Electric Vehicle" in Haryana • The cities of Gurugram and Faridabad will be declared as model EM cities with phase-wise goals to adopt EVs, charging & hydrogen refueling infrastructure and new EV enabling building codes. • Gurugram will be the pilot city for all new initiatives. • Model EM cities will have a deadline to convert 100% of all commercial & logistics fleets to electric fleet by 2024. These fleets can belong to any government organization, State Transport undertakings, educational institutes, hospitals or corporates and other institutions. • Smart city proposals to the central government will include support for charging infrastructure and hydrogen fueling stations. Identified areas will be designated as "Green zones" with entry only to non-fossil fuel-based vehicles. • These cities will develop specific goals of charging and Hydrogen refueling infrastructure density within a defined timeline linked to target for deployment of EVs. These cities will create mobility blueprints and make provision in infrastructure needs to support the charging stations and EV only zones. • One or more of higher registration, renewal, parking fees, congestion charges, taxes/cess on sale, and limitation of entry into city limits etc. will be levied on sale/usage of highly polluting vehicles in order to support the switch to environmentally friendly vehicles. • Multiple government offices and public areas will be chosen for installing public charging equipment that can be used by all.

4.6.21.2 Key Attributes Targeted in Haryana EV Policy

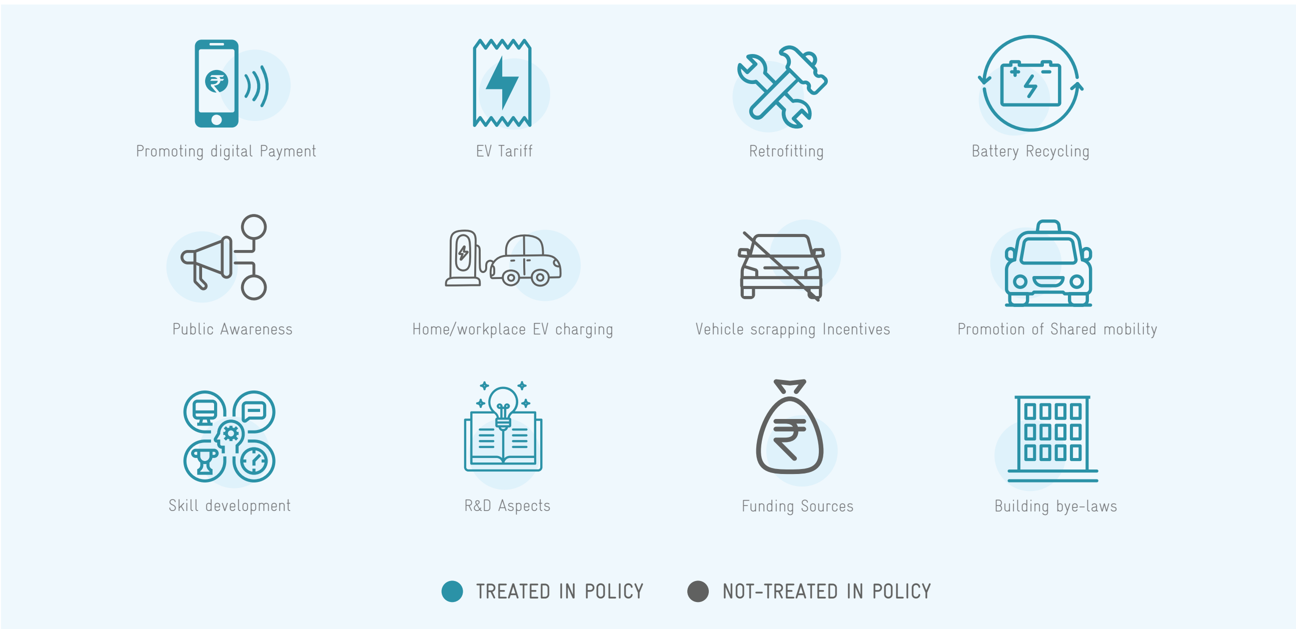


Figure 4.41: Key highlights in Haryana EV policy

The Haryana state government aims to convert 100 % of its vehicle fleet owned by state transport undertakings into e-buses by 2029, with the first phase of bus fleet conversion in Gurugram and Faridabad by 2024. All forms of government owned vehicles including government ambulances will be converted to EVs by 2024, as per the draft EV policy released by the state. Also, public sector units (PSUs) will be encouraged to set up charging infrastructure and the state will facilitate availability of land at concessional rates in designated areas in the state.

4.6.21.3 EV market of Haryana

Figure 4.42 shows the share of registered vehicles in Haryana as of February 2022 differentiated by the fuel type. In Haryana, both BEVs and PHEVs are almost equally popular with both of them accounting for 0.45% of the total state registered vehicles.

Limitations related to EV charging infrastructure in Haryana EV Policy:

a) No support for home/workplace charging infrastructure.

b) No mention of vehicle scrapping incentives, public awareness programs and funding sources.

c) No mention of utilization of V1G (smart charging) or V2X capabilities.

d) Development of digital platforms for database management, setting up of facilities to address consumer complaints and specifications of payment methods are not included.

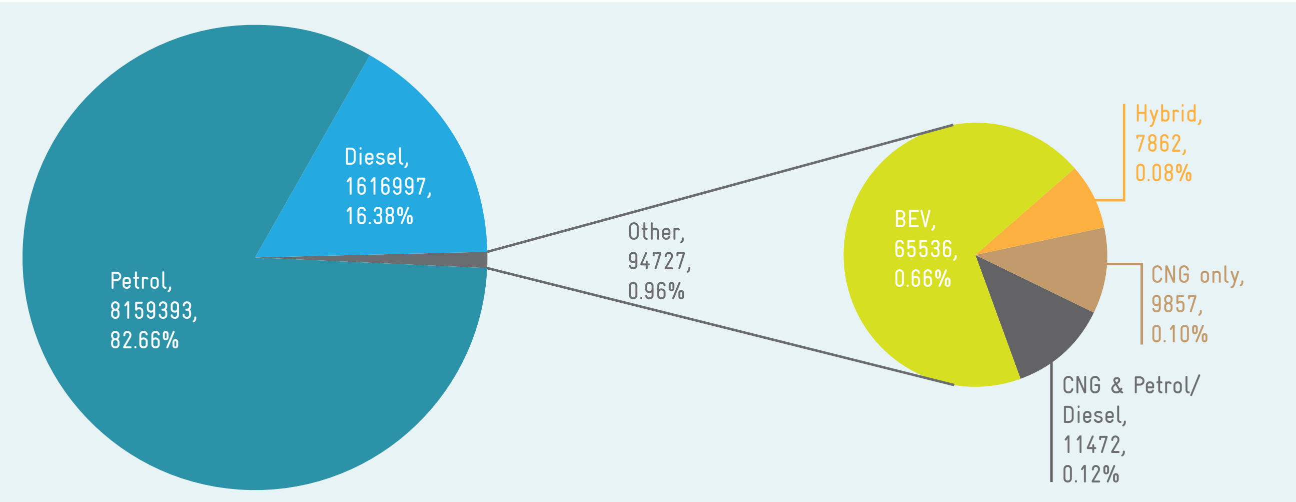


Figure 4.42: Share of total registered vehicles in Haryana by fuel type (as of Feb 2022)[42]

4.6.22 CHANDIGARH

Chandigarh, one of the UTs in India, has formulated its draft EV policy and released in February 2022, which will remain in force for a period of 5 years once the official notification is issued. This policy prioritizes public and shared transport, goods carriers, and 2-wheelers to promote EV adoption in the UT. The vision of the policy is to enable the adoption of zero-emission mobility for achieving carbon neutrality in Chandigarh by 2030. It also aims to provide an enabling framework through various incentives and initiatives to promote e-mobility with societal, economic, and environmental considerations at the forefront[72]. According to the draft policy, the administration of UT plans to set the following targets for the successful and fast E-Mobility adoption in the city:

a. 80 % of the total vehicle registrations should be EVs, with an expected share of 100% transition for e-2W, e-3W (passenger autos), e-3W (goods), e-4W (goods), e-cars (commercial with local permit), e-buses, and 50% transition for e-cars (personal) by the end of the policy period.

b. Establish Chandigarh as a 'Model EV City' by achieving one of the highest penetration of Zero-Emission automobiles amongst all Indian cities, by the end of the policy period.

c. Leverage the cycling track infrastructure of the city to promote usage of E-Bicycles as a replacement of 2/4W, especially for short trips.

d. Establish a wide network of EV Charging points by enabling availability of power supply and related processes.

4.6.22.1 Key Objectives of Chandigarh Draft Electric Vehicle Policy 2022

Measures to Enable EV charging on supply-side	
Elements	Focus on State EV Policy
Definition of a fundamental market design framework to limit distortions and entry barriers	• Joint Electricity Regulatory Commission has fixed EV tariff of INR 3.6/kWh (4.08 cents/kWh) for the public charging stations. • Electricity tariff applicable to Public Charging Station (PCS) shall also be applicable to Battery Charging Stations (BCS) and Battery Swapping Stations (BSS). • Domestic charging shall be treated akin to domestic consumption.
Incentives for promoting the EV charging infrastructure	• Private charging: infrastructure incentive on purchase and installation of charging equipment with a maximum incentive of INR 6,000 (EUR 70) only for the first 30,000 private chargers installed during the policy period. • Public charging: 100% reimbursement of GST paid on the Fast Charging/Swapping EVSE procured by private enterprises/individuals, with a maximum incentive of INR 50,000 (EUR 579) only for the first 50 fast charging /Swapping EVSE installed during the policy period. (will not be applicable on Chargers under Central Subsidy) • Public charging: Upfront cost on infrastructure for bringing power supply to Electric Vehicle Charging Station with a maximum incentive of INR 5,00,000 (EUR 5,789) only for first 50 Public fast Charging/ Swapping Stations installed in the state during the policy period. (will not be applicable on Chargers under Central Subsidy) • Public charging: 100% Electricity duty exemption for Public Charging and Swapping stations during the policy period

72 Department of Science and Technology and Renewable Energy, Chandigarh, "Draft Electric Vehicle Policy," 2022

Prioritization in terms of EV characteristics and social geography	• EV Charging Infrastructure is mandatory for all private and Government-owned Petrol Pumps operational in Chandigarh in 6 Months from the release of the final EV policy. If space is not available with the petrol pumps, the owner will make necessary arrangements for installing the EVCS in some nearby parking area belonging to the UT • All new home and workplace parking slots are mandated to be 'EV ready' (i.e., with conduits and power supply infrastructure in place for Electric Vehicle chargers) for at least 20% of all vehicles holding capacity/ parking. • All New /Renovated residential and non-residential building owners shall be encouraged to install Private Charging Points (PCPs) within their premises.
Easing out administrative barriers for establishing charging stations	• Chandigarh shall amend existing building bye-laws in accordance with Model Building Bye-Laws, 2016 for EV Charging Infrastructure issued by the Ministry of Housing and Urban Affairs, Government of India • To facilitate the setting up of EV Charging infrastructure in housing societies, offices, and other places for private/semi-private usage, CREST shall make an IT-based platform. This platform shall provide a one-stop solution within a defined timeline by enabling features such as power connection, standard models of EVSEs, cost of equipment & installation, and empaneled vendors. • CREST as a nodal agency will develop a single window platform which is integrated with all the stakeholders to provide the one stop solution to the User for various incentives under this policy. • Amendment to building and construction laws to integrate charging infrastructure at the planning stage itself for all new constructions
Focus on RE integration and EV charging	Harnessing the New & Renewable Energy sources for charging EVs to positively impact the indirect emissions.
Measures to Enable EV charging on demand-side	
Elements	Focus on State EV Policy
The mandate for the development of digital platforms and database management systems	CREST will develop a mobile application whereby all the real-time information on Electric Vehicle Charging Stations such as real-time updates on time slot availability, type of charging infrastructure, the available load of Charging Station, distance from the present location of Electric Vehicle user and applicable tariff.
Additional Measures for promotion of EV sector	
Elements	Focus on State EV Policy
EV Market Support services to promote EV adoption	• Exemption from road tax and registration charges for all eligible vehicles registered during the period of this policy. **The proposed incentives for various vehicle categories are as follows:** • **E-bicycle:** 25 % of the cost of bicycle with a maximum incentive of INR 3,000 (EUR) applicable for the first 25,000 Bicycles purchased during the policy period • **e-2W:** incentive of INR 5,000/kWh (EUR 58) with a maximum incentive of INR 30,000 (EUR 347) for fixed battery vehicles and incentive of INR 3,000/kWh (EUR 35) with a maximum incentive of INR 15,000 (EUR 174) for swappable battery vehicles, applicable for only the first 10,000 vehicles registered during the policy period. • **e-cart:** incentive of INR 5,000/kWh (EUR 58) with a maximum incentive of INR 30,000 (EUR 347) for fixed battery vehicles and incentive of INR 3,000/kWh (EUR 35) with a maximum incentive of INR 10,000 (EUR 116) for swappable battery vehicles, applicable for only the first 1,000 vehicles registered during the policy period. • **e -autos:** incentive of INR 5,000/kWh (EUR 58) with a maximum incentive of INR 30,000 (EUR 347) for fixed battery vehicles and incentive of INR 3,000/kWh (EUR 35) with a maximum incentive of INR 15,000 (EUR 174) for swappable battery vehicles, applicable for only the first 1,000 vehicles registered during the policy period. • **e-goods carrier L51:** incentive of INR 5,000/kWh (EUR 58) with a maximum incentive of INR 50,000 (EUR 579) for fixed battery vehicles for swappable battery vehicles, applicable for only the first 1,000 vehicles registered during the policy period. • **e-goods carrier N1:** incentive of INR 5,000/kWh (EUR 58) with a maximum incentive of INR 80,000 (EUR 928) for fixed battery vehicles for swappable battery vehicles, applicable for only the first 1,000 vehicles registered during the policy period.

EV Market Support services to promote EV adoption	• **4-W e-cars (personal):** incentive of INR 5,000/kWh (EUR 58) with a maximum incentive of INR 1,50,000 (EUR 1737) applicable for the first 2000, personal e-Cars (including Hybrids as defined in FAME II) registered during the policy period, and only for vehicles with ex-showroom price below INR 20 lakhs (EUR 24,000). • **4-W e-cars (commercial):** incentive of INR 10,000/kWh (EUR 116) with a maximum incentive of INR 2,00,000 (EUR 2316) applicable for the first 1000, e-Cars (including Hybrids as defined in FAME II) registered during the policy period. • The proposed scrappage incentives for various vehicle categories are as follows: – e-2W: INR 5,000 (EUR 58) – e-autos: INR 7,500 (EUR 87) – e-goods carrier L5N: INR 15,000 (EUR 174) – e-goods carrier N1: INR 15,000 (EUR 174) – 4-W e-cars: INR 7,000 (EUR 80) for both personal and commercial vehicles • The policy proposed a retrofit kit of 15% of the total cost for various vehicle categories with maximum incentive amount as listed below: – e-carts: INR 10,000 (EUR 116) – e-autos: INR 15,000 (EUR 174) – e-goods carrier L5N: INR 15,000 (EUR 174) – e-goods carrier N1: INR 25,000 (EUR 290)
Institutional framework for rollout of policies	• The policy also mentions the establishment of the Centre of Excellence (CoE) on Future Mobility and EV Skill Development Centre in the city to foster innovation in clean transportation and create required manpower for the industry. • Administration of Chandigarh shall promote industry-led CoEs for advanced electric and automotive research in partnership with leading academic institutions/ industry partners in UT.
Enhancement of EV value chain peripheral ecosystem	The building premises shall also enable additional power load, equivalent to the power required for all charging points to be operated simultaneously.
Promotion of Battery Recycling/ scrapping facilities	• The policy shall encourage the reuse of EV batteries that have reached the end of their life and the setting up of recycling businesses in collaboration with batteries. • The Chandigarh administration will promote second-life usage and recycling of EV batteries. • Disposal of EV Batteries in trash/landfills will be strictly prohibited. OEMs, through their networks, partnerships, and retail centers should channel the collection of batteries for reuse.

4.6.22.2 Key Attributes Targeted in Chandigarh Electric Vehicle Policy

Figure 4.43: Key highlights in Chandigarh EV policy

Under the various guidelines formulated and published by the policymakers, the UT is promoting the deployment of EV charging stations in every sector of the city to promote EV adoption. A battery swapping facility is set up in Chandigarh, jointly by IOCL and Sun mobility GIZ and Deloitte[73].

Limitations related to EV charging infrastructure in Chandigarh EV Policy:

a) Setting up of facilities to address consumer complaints and specifications of payment methods are not considered.

b) No mention of the utilization of V1G or V2X capabilities.

c) No mention of technical standardization of chargers for inter-operability and Harmonization of Intra/ interstate mobility of EVs.

4.6.22.3 EV Market of Chandigarh

The vehicle market of Chandigarh till February 2022 has been provided in Figure 4.44. It can be seen that conventional fuelled vehicles are still dominant, comprising roughly 99% of the entire Chandigarh vehicle segment. BEVs account for only 0.26% with 1,985 vehicles while PHEVs account for 0.5% vehicles with 2,654 vehicles.

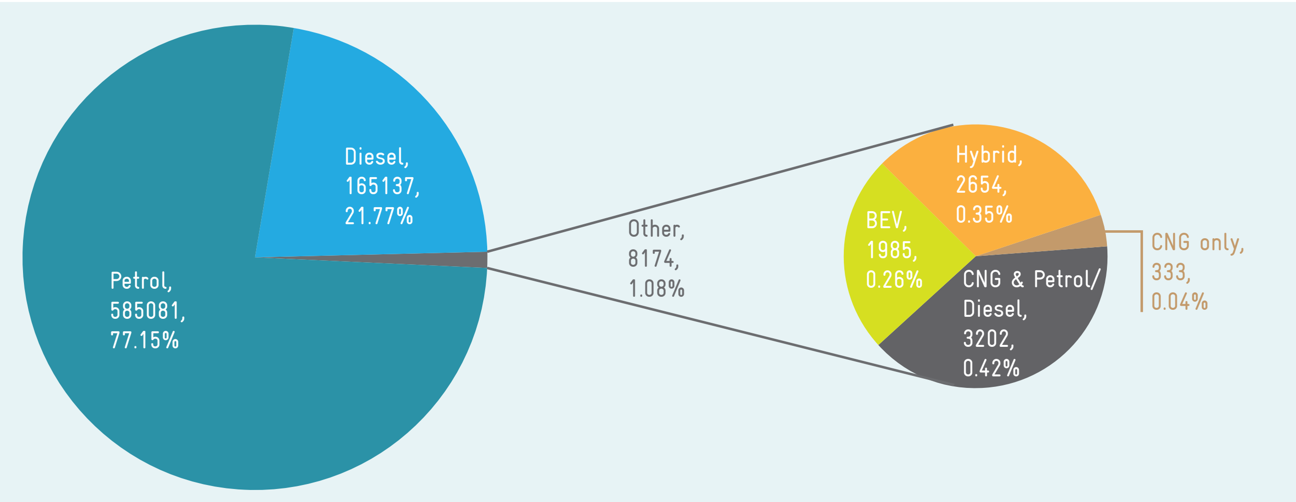


Figure 4.44: Share of total registered vehicles in Chandigarh by fuel type (as of Feb 2022)[42]

73 Autocar Pro News Desk, "Sun Mobility partners Indian Oil for battery swapping station in Chandigarh", Autocar Professional, 26th June 2020, https://www.autocarpro.in/news-national/sun-mobility-partners-indian-oil-for-battery-swapping-station-in-chandigarh-56667

4.6.23 JHARKHAND

The state of Jharkhand has initiated its EV promotion drive by signing an agreement with Energy Efficiency Services limited (EESL), which will deploy 50 electric vehicles at various Jharkhand Bijli Vitran Nigam Limited (JBVNL) offices in Ranchi. This is in accordance with the adoption of e-mobility program across the state, to initiate its transition towards a reduced carbon footprint and a more sustainable and greener future of state's transport sector. In addition to the deployment of EV, the state has also set up 12 charging stations at four offices of JBVNL including their corporate office at Ranchi in the first step, 20 EVs were supplied in September 2018, followed by a batch of 30 EVs by October 2018. It is expected that with these 50 EVs, JBVNL will save over 1.2 lakh litres of fuel every year and it will also result in significant CO2 reduction of over 1,400 tons annually.

4.7 Comparative Analysis of all State EV Policies

Here, a comparative analysis is provided of all state EV policies and the steps that have been taken to grow the EV charging infrastructure. The impact of EV charging infrastructure has been analysed based on 8 different lenses described below:

Target of Charging Network (number of chargers or charger density):

The first criteria that have been looked at is whether the state EV policy has a defined target of the number of chargers or the density of chargers that is to be met by the time the policy period ends.

Conducive market for participation of private players:

Private player participation is also a vital factor in determining the health of a charging infrastructure, with more private players generally denoting a better competitive market. So, creation of a conducive market for market participation of private players have been considered as a criterion for analysing the state EV policy.

Support for Grid Upgradation:

The next criteria that have been looked into is whether the EV policy has any provision for support towards grid upgradation costs.

Support for battery swapping:

Another metric that has been considered here is whether the EV policy has made reservations to accommodate battery swapping in its EV charging infrastructure.

Focus of RE integration for EV charging:

Utilization of RE for charging of EVs is crucial to lower the greenhouse gases (GHG) emission. So, the policies have also been analysed on which states have laid down provisions to increase the use of RE for EV charging.

Facilitation of affordable and accessible land:

Lack of land for installation of PCS has been one of the key difficulties faced by CPOs for development of the PCS. So, the facilitation of land in the stare EV policies have been considered.

Financial Incentive:

The provision of incentives has also been considered as one of the criteria for analysing the EV policies. Here the incentives have been differentiated between, incentives for home/ workspace chargers, incentives towards public chargers and incentives for energy operators.

Infrastructural accommodations:

The final criteria for analysing the state EV policies are whether the EV policy has recommended modification to existing building byelaws, made reservations for EV charging in parking lots, allocated a minimum requirement of charging points in a public parking space etc.

The comparative table has been given in Table 4.11.

Table 4.11: Cross-comparison of state EV policies*

	Target of Charging network (# of chargers or density)	Support for grid upgradation	Conducive market for participation of private players	Financial incentives			Facilitation of affordable and accessible land	Support for battery swapping	Focus on RE integration for EV charging	Infrastructural recommendations (modification of building bye laws/ parking spaces reserved for EV charging etc)
				Home/ workspace chargers	Public chargers	Energy operators				
Delhi	✓	×	✓	✓	#	✓	✓	✓	✓	✓
Karnataka	✓	×	✓	×	✓	✓	✓	✓	✓	✓
Haryana	✓	×	✓	×	✓	✓	✓	✓	✓	✓
Maharashtra	✓	✓	✓	✓	✓	✓	✓	✓	×	✓
Andhra Pradesh	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Kerala	✓	✓	✓	×	✓	✓	×	✓	✓	✓
Bihar	✓	×	✓	×	✓	✓	✓	✓	✓	✓
Uttar Pradesh	✓	×	✓	×	✓	✓	✓	✓	×	✓
Gujarat	×	×	✓	×	✓	✓	×	✓	×	✓
Tamil Nadu	×	×	✓	×	✓	✓	✓	×	✓	✓
Chandigarh	✓	×	✓	✓	✓	×	×	×	×	✓
Madhya Pradesh	✓	×	✓	×	✓	✓	✓	✓	✓	✓
Punjab	✓	×	✓	×	✓	×	✓	✓	✓	✓
Uttarakhand	×	×	✓	×	×	×	✓	×	×	×
Telangana	✓	×	✓	×	×	×	✓	✓	✓	×
Meghalaya	×	×	✓	×	×	×	✓	×	×	×
West Bengal	✓	×	✓	×	✓	×	✓	✓	✓	✓
Assam	×	×	✓	×	✓	×	×	✓	×	×
Odisha	×	×	✓	✓	#	✓	✓	✓	×	✓
Goa	✓	×	✓	×	#	✓	✓	✓	✓	✓
Rajasthan	✓	×	✓	×	×	×	×	✓	✓	×

#: Subsidy on capital cost of charger installation expenses

4.8 EV Regulations in India

India, one of the most populous countries in the world is now at an infection point of the growth and development in the automobile and transportation sector. The government of India's 2030 vision of e-mobility translated to nearly 102 million units of EV sales. This offers huge opportunities for the states to take part in accelerating the transition to EVs, which necessitates attention and action by various stakeholders and government entities such as automobile manufacturers, suppliers, EV component manufacturers, dealers, and utility players alike.

4.8.1 REGULATIONS BY CEA

Regulatory support would play a key role in the adoption of e-mobility across the nation along with the central and state policies issued in the interest of a successful EV ecosystem. In this subsection, the regulatory framework and various technical standards issued with respect to adoption of EVs in India are analysed. Central Electricity Authority (CEA) recently issued two amendments to the existing regulations "Technical Standards for Connectivity of the Distributed Generation Resources, 2013" by introducing standards and regulations associated with advent of electric vehicles and its charging stations, in 2019.

Out of these two amendments, the first one which was issued in February 2019 focuses on technical standards for connectivity of Distributed Generation (DG) resources issuing guidelines for connectivity of EV charging station with the electricity system below 33 kV voltage level whereas the second amendment issued in June 2019 deals with measures relating to safety and electric supply provisions for EV charging infrastructure connected with the grid. The key provisions of the First Amendment inserted under 'standards for charging station, prosumer or an individual connected or seeking connectivity to the electrical system' are as follows:

1. EV charging station operator needs to provide a reliable protection system to detect various faults and abnormal conditions and provide an appropriate means to isolate the faulty equipment or system automatically.
2. It would be the responsibility of the charging operator that fault in the EV charging infrastructure equipment or system does not affect the grid adversely.
3. DISCOM should carry out adequacy and stability study of the network before permitting connection with its electricity system.
4. DISCOM to continuously measure and meter the harmonics with power quality meters complying with the provisions of IEC 61000-4-30 Class A
5. Charging operator needs to install power quality meters and share the recorded data with the DISCOM.
6. DISCOM should periodically measure the voltage sag, swell, flicker, disruptions as per relevant IEC standard.

Along with these technical connectivity aspects, additional mentions are made in the sections of regulation dealing with registration in registry maintained by the authority, compliance and relaxation of regulations which ensures the responsibility of concerned licensee to make sure all the key provisions with regard to the connectivity stipulated in these amendments are complied with by the applicant, failure of which would results in disconnection of the user or generating unit from the grid. It also introduces concept of a Unique Registration Number from the authority to the registered applicants who are granted connectivity with grid.

The second amendment refers to the modifications brought in Central Electricity Authority (Measures relating to Safety and Electric Supply) Regulations, 2010 which includes incorporation of a new chapter on measures relating to safety and electric supply requirement for EV Charging Stations. The key provisions of this amendment are classified into subsections as given below:

1. **General safety requirements of EV charging stations:**
   - All electric vehicle charging stations are required to provide protection against the overload of input supply and output supply fittings.
   - All electric vehicle charging points should have socket-outlet of supply at least 800 millimetre above the finished ground level.
   - In addition to the supply lead, a cord extension set/second supply lead shall not be used for the connection of the EV to its charging point.
   - An adaptor shall not be used to connect an EV connector to inlet of EV. Also, Portable socket-outlets are not to be used for EV charging.
   - Suitable lightning protection system needs to be provided as per Indian Standards Code IS/ IEC 62305.
   - EV parking location shall be such that the connection on the vehicle during its charging shall be within 5 meters from EV charging point.
   - EV charging station shall be equipped with a protective device against any uncontrolled reverse power flow from EV.
   - One second after having disconnected the EV from its main supply, the voltage between accessible conductive parts or any accessible conductive part and earth shall be less than or equal to 42.4 V peak (30 V rms), or 60 V D.C., and the stored

energy available shall be less than 20 J (as per IEC 60950). In cases of violations of these mentioned limits, a warning label shall be attached in an appropriate position on the charging stations.

- A vehicle connector used for DC charging shall be locked on a vehicle inlet if the voltage is higher than 60 V D.C. and the vehicle connector shall not be unlocked (if the locking mechanism is engaged) when hazardous voltage is detected through charging process including after the end of charging and in case of charging system malfunction, a means for safe disconnection shall be provided.
- If output voltage exceeds maximum voltage limit sent by the vehicle, DC EV charging point shall disconnect electricity supply to prevent overvoltage at the battery.
- EV charging points shall not energize the charging cable when the vehicle connector is unlocked and the voltage at which the EV connector unlocks shall be less than 60V.

2. **Earth Protection system for EV charging stations:**
   - All residual current devices (RCD) used for the supply protection of EV shall have (i) residual operating current of not greater than 30 mA; (ii) interrupt all live conductors, including the neutral; and (iii) have a performance at least equal to Type A and be in conformity with IS 732-2018.
   - All residual current devices used for the protection of supplies to electric vehicle needs to be permanently marked to identify their function and the location of the charging station or socket outlet they protect.
   - Each electric vehicle charging points needs to be supplied individually by a dedicated final sub-circuit protected by an overcurrent protective device complying with IEC 60947-2, IEC 60947-6-2 or the IEC 60269 series and the overcurrent protective device should be part of a switchboard.
   - All EV charging stations shall be supplied from a sub-circuit protected by a voltage independent RCD and also providing personal protection that is compatible with an EV charging supply.
   - A protective earth conductor shall be provided to establish an equipotential connection between conductive parts of EV and supply earth terminal and shall be of sufficient rating to satisfy the requirements of IEC 60364-5-54.

3. **Fire Hazard Prevention of EVSE:**
   - Enclosure of charging stations should be made of fire-retardant material with self-extinguishing property and free from Halogen.
   - Fire detection, alarm and control system shall be provided as per relevant Indian Standards.
   - Power supply cables used in charging station or charging points should conform to IEC 62893-1 and its relevant parts.

4. **Charging Station Testing**
   - All apparatus of charging stations should have the insulation resistance value as stipulated in the relevant IEC 61851-1.
   - The EVSE owner shall ensure that the tests as specified in the manufacturer's instructions for RCD and the charging station have been carried out.

5. **Inspection and assessment:**
   - Every EVSE shall be tested and inspected by the owner/Electrical Inspector/Chartered Electrical Safety Engineer before its energisation.
   - The owner of the charging station needs to establish and implement a safety assessment program for regular periodic assessment of the electrical safety of charging station. Electrical inspectors and/or Chartered Electrical Safety Engineers are entrusted with the responsibility of testing and inspection of charging infrastructure.
   - The EVSE owner shall establish and implement a safety assessment programme for regular periodic assessment of the electrical safety of charging station.

6. **Record Maintenance:**
   - The EVSE owner shall keep records in regard to design, construction and labelling to be compatible with a supply of standard voltage at a nominal frequency of 50 Hertz of the charging station.
   - The owner of the charging station shall keep records of the relevant test certificate as indicated in these regulations and as per IEC 61851.

- The EVSE owner needs to keep records of the results of every inspection, testing and periodic assessment and details of any issues observed during the assessment and any actions required to be taken in relation to those issues.

7. **International Standards**

- The safety provisions of all Alternating Current charging stations should be in accordance with IEC 61851-1, IEC 61851-21, and IEC 61851-22.
- The safety provisions of all Direct Current charging stations should be in accordance with IEC 61851-1, IEC 61851-21, IEC 61851-23, and IEC 61851- 24.

4.8.2 MoP's REVISED GUIDELINES FOR EV CHARGING INFRASTRUCTURE

The Ministry of Power published the revised the EV charging infrastructure guidelines on 14th January 2022. This is the third iteration of the EV charging guidelines having once already been revised on 1st October 2019 which highlights the proactive stance taken by the MoP to address the concerns of EV owners with respect to the installation of charging stations for faster adoption of e-mobility in the country.

MoP's revised Guidelines for Charging Infrastructure can be summarized as follows:

1. **General Aspects**

- Any charging station or group of charging stations may obtain electricity from any generation company through open access.

2. **Private Charging**

- One of the most prominent introductions made in this revision with regard to private charging at residences/workplaces/offices is that the owners may charge their EVs in their existing electricity connections.
- Minimum infrastructure requirements as per these Guidelines do not apply to Private Charging Points meant for self-use by individual EV users (non-commercial basis).
- Captive charging infrastructure for 100% internal use for a company's own/leased EV fleet will not be required to install all type of chargers and to have Network Service Providers (NSP) tie ups.

3. **Public Charging**

- Notified as a De-licensed activity any individual/ entity is allowed to set up Public Charging stations (PCS) provided, such stations meet the technical and safety aspects, performance standards and protocols as well as further norms/ standards/ specifications laid down by MoP and CEA from time to time.
- For such PCS, connectivity is provided on priority basis by the Distribution Company i.e., post submission of application complete in all respect, 7 days in metro cities, 15 days in other municipal areas and 30 days in rural areas.
- Electric Vehicle Supply Equipment (EVSE) shall be type tested by an appropriate agency/ lab accredited by National Accreditation Board for Testing and Calibration Laboratories (NABL) from time to time.
- Location of PCS specified as at least one charging station in a grid of 3 km x 3 km.
- One charging station should be set up at every 25 km on both sides of highways/ major roads.
- Density/Distance requirement shall be used by the concerned State/UT's Governments for purpose of land use planning for PCSs as well as for priority installation of distribution network including transformers/feeders etc. This shall be done in all cases including where no Central/State subsidy is provided.
- Appropriate Governments (Central/State/UT's) may also prioritize existing retail outlets of Oil Marketing Companies for PCS installations (in compliance with safety norms) to meet the requirements as laid down in the respective guidelines.
- Fast Charging Stations (FCS) shall be installed to cater long range EVs and heavy duty EVs like buses/trucks, etc., at every 100 km on each side of the highway/major roads located preferably within/alongside the PCS with the following requirements
- At least two chargers of minimum 100 kW (200-750 V or higher) each of different specifications (CCS/CHAdeMO or BIS standards for eBus Charging Station (Level 4: 250 kW to 500 kW, IS 17017-23-2, IS 17017-3-1)).

- Appropriate Liquid Cooled Cables for high-speed charging as mentioned above, for onboard charging of Fluid Cooled Batteries (currently available in some long range EVs), if required.
- FCSs meant only for 100% in-house/captive utilization, such as in case of buses of a company, the company is free to decide the charging specifications as per its requirement for its in-house company EVs.
- Additional PCS/FCS can be installed even if there exists a PCS/FCS in the required grid or distance.
- Charging stations may also be installed by Housing Societies, Malls, Office Complexes, Restaurants, Hotels, etc. with a provision to allow charging of visitor's vehicles which have permission to come in its premises.
- A database of all public charging station would be maintained by the Bureau of Energy Efficiency (BEE).
- The tariff for supply of electricity to the PCS would be a single part tariff and should not cross the Average Cost of Supply of the respective DISCOMs till 31st March 2025. The same tariff is also applicable for battery charging stations.
- DISCOMs may leverage the funding from the Revamped Distribution Sector Scheme for the general upstream network upgradation requirements.

4. **Public Charging Infrastructure Requirements**

- Exclusive Transformer with all the related Sub-station equipment including safety appliance if required.
- Appropriate cabling and electrical works and all civil works.
- Charging station for electric 2-W/3-W shall be free to install any charger other than the specified ones subject to compliance of technical and safety standards laid down by CEA.
- Tie up with at least one online NSP to enable provision for advance remote/online booking of charging slots by EV owners. Such information shall include location, types and number of chargers available at the charging stations.
- Land available with the government/public entities would be provided to the PCS on a revenue sharing basis. For government /public entity installing a PCS the land would be provided at a fixed rate of INR 1/kWh (EUR 0.011/kWh) (used for charging), while for private entities the land would be provided after a competitive bidding with floor price of INR 1/kWh (EUR 0.011/kWh).

5. **Standards specified for Public Charging Stations**

Charger Type	Charger Connectors*	Rated Voltage (V)	No. of connector Guns	Charging vehicle type (W-wheeler)
Fast	Combined Charging System (CCS) (min 50kW)	200-750 or higher	1 CG	4-W
	CHArge de Move CHAdeMO (min 50 kW)	200-500 or higher	1 CG	4-W
	Type 2 AC (min 22 kW)	380-415	1 CG	4-W, 3-W, 2-W
Slow/ moderate	Bharat DC-001 (15 kW)	48	1 CG	4-W, 3-W, 2-W
	Bharat DC-001 (15 kW)	72 or higher	1 CG	4-W
	Bharat AC-001 (10 kW)	230	3 CG of 3.3 kW each	4-W, 3-W, 2-W

Additional EV charging standards that can be used in PCS,

- Light EV AC Charge Point (up to 7 kW): IS-17017-22-1
- Light EV DC Charge Point (up to 7 kW): IS-17017-25
- Parkbay AC Charge Point (11 kW/ 22 kW): IS-17017-1
- Parkbay DC Charging Point (DC 50 kW to 250 kW): IS-17017-23
- eBus Charging Station (DC 250 kW – 500 kW)
- Dual Gun Charging Station: IS-17017-23-2
- Automated Pantograph Charging Station: IS-17017-3-1

6. **Priority for Rollout of EV Public Charging Infrastructures:**
   - Phase I (1-3 Years) - It is envisaged that all Mega Cities with population of more than 4 million as per 2011 census, all existing expressways connected to these Mega Cities and important Highways connected with each of these Mega Cities may be taken up for coverage.
   - Phase II (3-5 Years) – Big cities like State Capitals, UT headquarters may also be covered for distributive and demonstrative effect. Important highways connecting to these Mega Cities may be taken up for coverage.

4.8.3 EV REGULATIONS IN INDIAN STATES

As mentioned in Section 4.8, independent regulatory structure is not available for EV adoption in the country or in individual states in India. The states are either following the guidelines mandated by Central Electricity Authority (CEA) issued regulations/amendments or the revised regulations published by Ministry of Power. However, five states in India, including Madhya Pradesh, Andhra Pradesh, Haryana, Tamil Nadu, and Rajasthan, has mentioned (not in detail) about the revised regulations/guidelines to be followed while promoting increased EV penetration in their transport sector in their respective EV policies.

4.9 EV Tariff Landscape

In spite of Indian government's distinct and transparent policy frameworks and attractive and considerable financial support, the country's e-mobility sector is finding itself on a bumpy road. EV charging infrastructure undoubtedly is the backbone of electric mobility and has been the most contentious issue. This charging infrastructure closely binds transport sector with electricity sector, in such a way that the reformation of the former sector eventually results in the shifting of electricity distribution paradigm. The inter-linkages between e-mobility and electricity grid make the role of power distribution utilities critical and demanding .

EV charging has dual implications for distribution utilities. On one hand, the charging requirement for e-vehicles results in additional electricity sales that would increase the revenue of the utility. However, this increased electricity demand may accentuate the peak load in the utility's service area which has a significant impact on its cost of power procurement and the management of distribution companies, thus becoming one of the key factors in their resource and investment planning. Tariff for EV charging becomes a critical fiscal and regulatory tool in this regard and the proper information of when, where, and how much charging would add additional load to the grid is crucial. Hence the structuring of electricity tariff should allow the utility to recover the expenses incurred while making EV charging cost-effective to a user and making charging services a commercially viable business.

Tariff is defined in electricity sector as the monetary cost incurred by customers to avail electricity for its various use. In India, tariff setting is a complex subject and setting of electricity tariff is a state affair, which is decided and structured by an appropriate agency/regulator at the state level, generally the State Electricity Regulatory Commission (SERC). The setting of tariff is dictated by Electricity Act 2013, and the Tariff policy issued by GoI from time to time. EV sector is now a new entrant to the nation's electricity consumer category, which is distinct from other groups of electricity consumers. Hence distribution companies and regulatory commissions are trying to figure out the demand characteristics of this category which requires a dedicated tariff structure to be fixed by ERC of the respective state or UT. There are three salient features of EV charging which make EV a unique consumer-class:

a. **Dynamic electricity demand** – EVs are mobile sources of electricity demand. Even though EV charging points are stationary, the power demands at the charging places could widely vary based on different factors such as EV battery capacity, charging techniques, EV use etc. and thus are hard to predict.

b. **Uneven load** – Charging loads at EV charging points are anticipated to be highly varying in nature with spikes in the demand curve. This could create severe impacts on the distribution network, especially in the regions where hosting capacities of the distribution networks are quite less. Such issues are more likely to occur in the case of fast charging of EVs with large batteries.

c. **Prosumer nature of EVs** – The prosumer nature of EVs due to bidirectional energy flow is another issue that need to be considered seriously. The presence of batteries in EVs enables Vehicle-Grid Integration possible which entails bi-directional energy flow making them Distributed Energy Resources (DER) which can feed electricity back into grid. This evokes the requirement of appropriate metering and tariff-setting to enable the use of EVs as a Virtual Power Plant (VPP).

The regulators have to consider these aspects while designing the tariff structure for EV charging. Not to mention, tariff structure for charging of EVs is an instrument that could influence the outlook of power distribution companies, charging service providers, potential EV users and technology suppliers and would impact the future of EV ecology in a state at large.

The EV tariff eco system consists of four major key players. They is regulatory commission which sets up the regulations and tariff structure based on various factors as mentioned above, the DISCOMs, playing the role of an interlinking node between ERCs and Charging Service Providers (CSPs) and State Nodal Agencies (SNAs). The last component of the chain is EV users as indicated in the Figure 4.45 who pay their respective cost of charging at EV charging stations. SNA or state government can fix the ceiling of service charges in case of PCSs installed with government incentives.

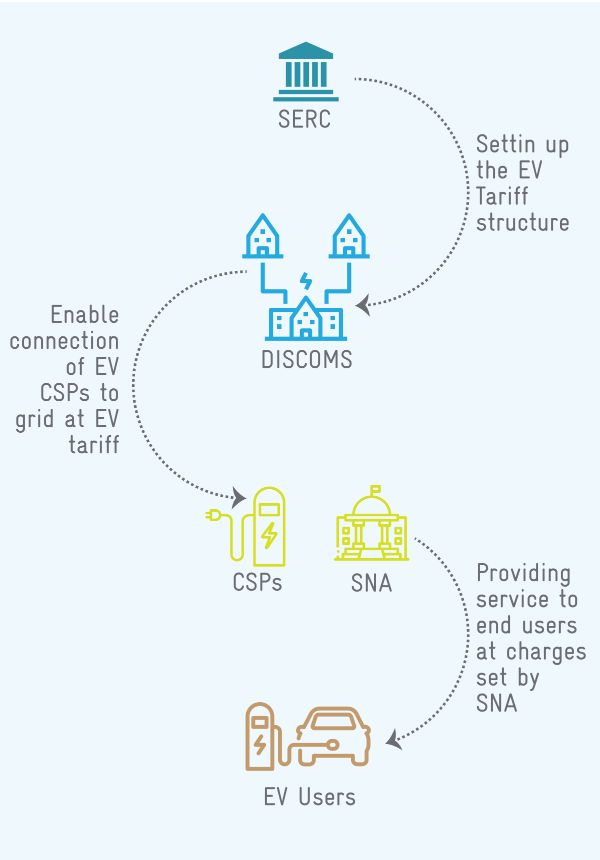


Figure 4.45: EV tariff setting Eco-system in India

The tariff structure is framed for different consumer categories and the energy and demand charges are two parts which constitutes the total tariff payable by the EV users. In practice, it is found to vary across states. The Ministry of Power (MoP) issued a clarification regarding delicensing of the EV charging procedure and facilities across India on 13 April 2018. A number of states had published specific tariff structure for EV charging in their states even in the absence of a specific direction or guideline with respect to tariff determination for EV charging at that time. On 14 December 2018, MoP issued the first official document for EV charging: “Charging Infrastructure for Electric Vehicles – Guidelines and Standards -reg.” to accelerate affordable EV adoption in the country.

According to the guidelines, the tariff has to be determined by the appropriate commission and it should not exceed the Average Cost of Supply (ACoS) by more than 15%. It also provided guidance regarding captive or domestic charging stations that, it would attract tariffs applicable for those consumer-categories. Following this, a handful of states including Andhra Pradesh, Telangana and Uttar Pradesh issued EV tariffs solely based on the MoP guideline. However, MoP revised and re-issued the guideline: “Charging Infrastructure for Electric Vehicles – Revised Guidelines and Standards -reg”, on 1 October 2019. In accordance with the revised guideline, the respective state commission has to fix the tariff based on the guidelines of Electricity Act 2003. It also has done away with the EV tariff capping at 15% of ACoS. However, the National Tariff Policy remains the overarching guidance for the state regulatory commissions to frame tariffs, which states that consumer tariffs should be brought within +/- 20% of the ACoS. With respect to India’s cross-subsidy tariff regime, the subsidized consumers should not be charged less than 80% of ACoS and tariff charging of cross-subsidizing consumers should not be more than 120% of ACoS.

In traditional tariff structure, the subsidy benefits are awarded to domestic and agricultural consumers, whereas commercial and industrial consumers cross-subsidize by paying more than ACoS. Although the guidelines provide state government freedom to offer subsidy to a class of consumers as per their interest, the government needs to make the subsidy amounts available by their own in such cases. By adding EV charging as a new set of power consumers, the government and regulators are now facing the question of whether to keep preferential tariffs for EV charging to promote adoption of EV or to consider EV charging on an equal footing to commercial consumers or take a neutral stance. It would be interesting to see the take of various states on tackling this issue.

The electricity tariff usually consists of two parts, a fixed/demand charge and variable/energy charge based on energy consumption. Only a few states have introduced demand charges and the details are given in Table 4.6. EV tariffs vary from INR 4 (EUR 0.046)/kWh to INR 6 (EUR 0.069)/

kWh in most of the states. In most of the states and Union Territories, EV specific tariffs are found to be higher than residential rates and lower than commercial tariffs. In most states, EV charging tariffs have a flat energy rate which do not vary based on amount of consumption irrespective of the type of connection (Low Tension (LT)/ High Tension (HT)). However, in Andhra Pradesh, Delhi, Gujarat, Maharashtra, Uttar Pradesh etc. the issued EV policies specify separate EV tariffs for LT and HT connections. As of 31st January 2022, a total of 20 states and 6 UTs have announced EV specific tariffs. The states /UTs with the respective EV charging tariff is indicated in Figure 4.44 and Table 4.12.

Table 4.12: EV tariff structure for different states

State	Energy Charge		EV demand charge	TOD charge/Rebate
	LT	HT		
Gujarat	INR 4.1/kWh (EUR 0.046/kWh)	INR 4/kWh (EUR 0.045/kWh)	INR 25 to INR 50 per kVA per month (EUR 0.283-0.567/kVA)	Not specified
Haryana	INR 5.55/kWh (EUR 0.063/kWh) or INR 5/kVAh (EUR 0.057/kVAh)		INR 100/kW or kVA per month (EUR 1.135/ kW)	ToD during off-peak demand period between 9 PM to 5:30 AM (March to November): INR 3.75/kVAh (4.2 cents/kVAh)-INR 4.25/kVAh (4.8 cents/kVAh)
Karnataka	INR 5/kWh (EUR 0.056/kWh)	INR 5/kWh (EUR 0.056/kWh)	INR 70/kW (EUR 0.79/ kW) per month and INR 200/ kVA (EUR 2.27/kVA) per month	During peak periods from 6pm to 10 pm (December to June) surcharge of INR 1/kWh (1.13 cents/kWh) During off-peak periods from 10 pm to 6 am (December to June) rebate of INR 1/kWh (1.13 cents/kWh)
Maharashtra	INR 4.12/kWh (EUR 0.046/kWh)	INR 4.94/kWh (EUR 0.056/kWh)	INR 70/kVA/ Month (EUR 0.794/kVA)	Additional charge of INR 0.80 / kWh (0.908 cents/kWh) levied for usage from 9 AM to 10 AM and INR 1.1/ kWh (EUR 0.012/kWh) from 6 PM to 10 PM. • Rebate of INR 1.50 / kWh (EUR 0.017/kWh) for usage between 10 PM and 6 AM
Madhya Pradesh	INR 6/kWh (EUR 0.068/kWh)	INR 5.9/kWh (EUR 0.067/kWh)	INR 100/kVA (EUR 1.135/kVA) to INR 120/kVA (EUR 1.362/ kVA) of Billing Demand	Not specified
Kerala	INR 5/kWh (EUR 0.056/kWh)	INR 5/kWh (EUR 0.056/kWh)	INR 75/kW (EUR 0.85/ kW) per month and INR 250/ kVA (EUR 2.83/kVA) per month	50% surcharge during peak hours from 6 PM to 10 PM- and 25% rebate during off-peak hours from 10 PM to 6 AM
Rajasthan	INR 6/kWh (EUR 0.068/kWh)		INR 40/HP (EUR 0.454/HP) per month and INR 135/ kVA (EUR 1.53/kVA) per month	15% rebate during off-peak hours from 12 AM to 6 AM and 5% surcharge during peak hours from 6 AM to 10 AM

State	Energy Charge		EV demand charge	TOD charge/Rebate
	LT	HT		
Himachal Pradesh	Up to 20 kVA: INR 5/kWh (EUR 0.056/kWh) Above 20 kVA INR 4.7/kWh (EUR 0.053/kWh)		INR 130/connection (EUR 1.47/connection) per month and INR 140/ kVA (EUR 1.59/ kVA) per month	Not specified
Jharkhand	INR 5.75/kWh (EUR 0.065/kWh) to INR 6/kWh (EUR 0.068/kWh)		INR 50-100/ connection (EUR 0.567-1.135/ connection) per month	Not specified
Odisha	INR 5.9/kWh (EUR 0.067/kWh) to INR 7.6/kWh (EUR 0.086/kWh)	INR 4.75/kVAh (EUR 0.54/kVAh) to INR 5.85/kVAh (EUR 0.066/kWh)	INR 200 (EUR 2.27) to INR 250 (EUR 2.83) / KW or kVA per month	Not specified
Assam	INR 5.1/kWh (EUR 0.058/kWh)	INR 6.6/kWh (EUR 0.075/kWh)	INR 130/kW/ (EUR 1.47/kW) per month and INR 160/ kVA (EUR 1.81/kVA) per month	Not specified
Meghalaya	INR 9.7/kWh (EUR 0.11/kWh)	INR 9.9/kWh (EUR 0.112/kWh)	INR 120-230 (EUR 1.362-2.611)/ connection per month	Not specified
Andhra Pradesh	INR 6.7/kWh (EUR 0.076/kWh)		Not specified	Not specified
Bihar	INR 7.15/kWh (EUR 0.08/kWh)	INR 6.45/kVAh (EUR 0.07/kVAh)	Not specified	Not specified
Punjab	INR 6/kVAh (EUR 0.068/kVAh)		Not specified	ToD applicable Rebate of INR 1.25/kVAh (EUR 0.014/kVAh) between 10 PM and 6 AM (1st April – 31st May, 1st October – 31st March) Surcharge of INR 2/kVAh (EUR 0.022/kVAh) between 6 PM to 10 PM (1st June – 30th September)
Telangana	INR 6/kWh (EUR 0.068/kWh)	INR 6/kWh (EUR 0.068/kWh)	Not specified	ToD applicable for HT Peak hours: 6 AM to 10 AM and 6 PM to 10 PM: INR 7/ kWh (EUR 0.079/kWh) Off-peak hours: 10 PM to 6 AM: INR 5/ kWh (EUR 0.056/kWh)

State	Energy Charge		EV demand charge	TOD charge/Rebate
	LT	HT		
Uttar Pradesh	INR 5.9/kWh (EUR 0.067/kWh) to INR 7.7/kWh (EUR 0.087/kWh)		Not specified	15% surcharge or rebate during peak and off-peak hours Peak hours for summer and winter months from 5 PM to 11 PM Off-peak hours for summer and winter months from 5 AM to 11 AM and 11 PM to 5 AM, respectively
Chhattisgarh	INR 5/kWh (EUR 0.056/kWh)	INR 5/kWh (EUR 0.056/kWh)	Not specified	• Peak (6 PM to 11 PM): Surcharge of 20% • Off-peak (11 PM to 5 AM): Rebate of 35%
Uttarakhand	INR 5.5/kWh (EUR 0.062/kWh)		Not specified	Not specified
Delhi	INR 4.5/kWh (EUR 0.051/kWh)	INR 4/ kVAh (EUR 0.045/ kVAh)	Not specified	Applicable to consumers with load above 10kW/ kVA • Surcharge or rebate of 20% in case of peak and off-peak hours • May-September: Peak hours: 2-5 PM & 10 PM-1 AM • Off-peak hours: 4-10 AM
Goa	INR 3.5/kWh (EUR 0.039/kWh)		Not specified	Not specified
Chandigarh	INR 3.6/kWh (EUR 0.0408/kWh)		Not specified	Peak Hours (6pm-10pm): 20% surcharge Off-peak hours (10pm-6am): 10% rebate
Andaman & Nicobar Islands	INR 6.9/kWh (EUR 0.078/kWh)		Not specified	Not specified
Daman & Diu	INR 4.5/kWh (EUR 0.051/kWh)		Not specified	Peak Hours (6pm-10pm): 20% surcharge Off-peak hours (10pm-6am): 10% rebate
Lakshadweep	INR 4.79/kWh (EUR 0.054/kWh)		Not specified	Not specified
Puducherry	INR 4.5/kWh (EUR 0.051/kWh)		Not specified	Peak Hours (6pm-10pm): 20% surcharge Off-peak hours (10pm-6am): 10% rebate

* Tamil Nadu has not yet mentioned about EV tariff for public charging stations. For private EV charging, the cost of charging is as per the relevant customer domestic tariff category.

** The states of Sikkim, Arunachal Pradesh, Mizoram, Manipur, Tripura, Nagaland, Jammu & Kashmir and West Bengal have not yet mentioned about EV tariffs.

The states /UTs with the respective EV charging tariff are indicated in the Figure 4.46.

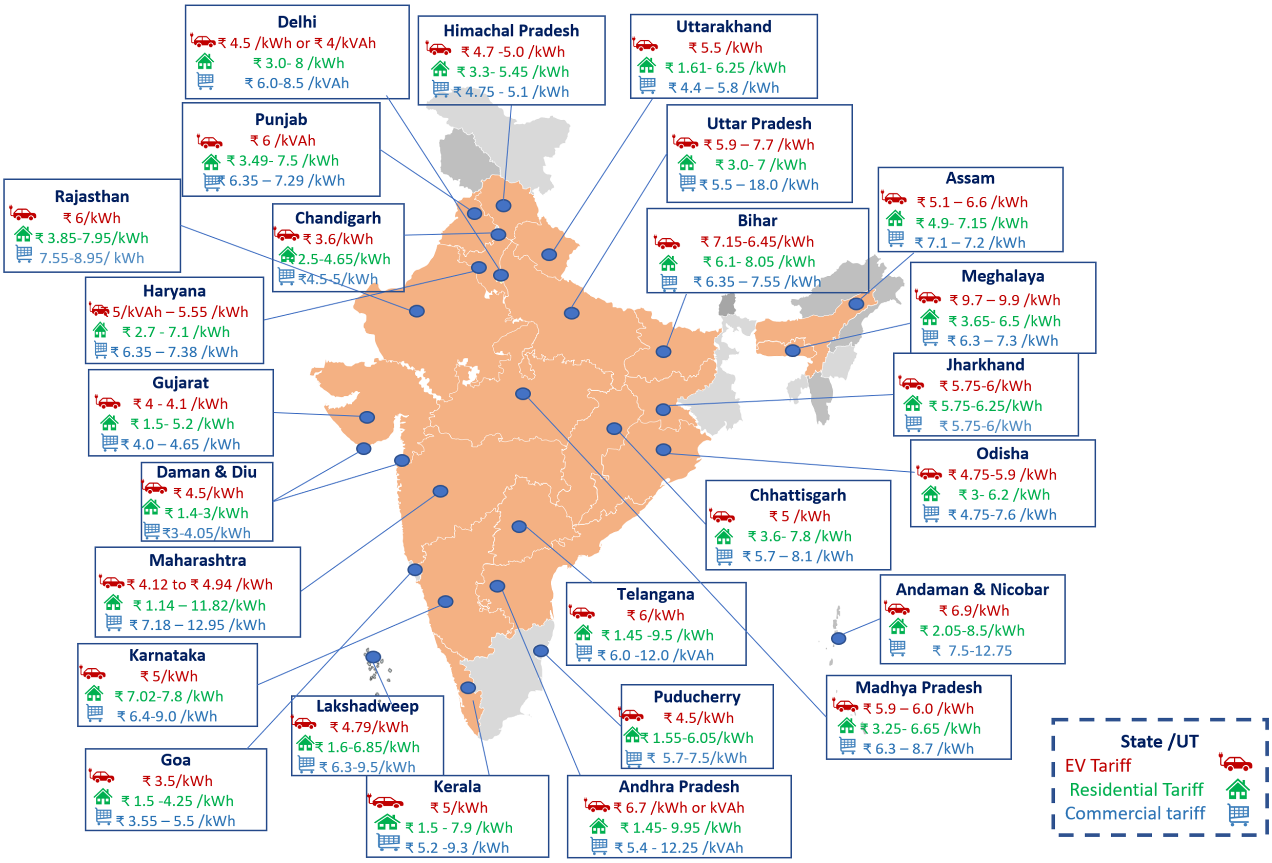


Figure 4.46: State-wise EV specific tariffs and comparison with residential and commercial rates

4.10 Impact of National Electricity Policy 2021 reforms on the EV charging infrastructure adoption

The Indian distribution companies are overall loss-making and debt-ridden with poor operational and financial conditions. To transition this sector into a modern system, INR 3,00,000 crore (EUR 34,734 Million) DISCOM reform scheme has been recently sanctioned by the Indian parliament with the objective of improving the quality and reliability of power supply, reduction of aggregate technical and commercial losses (AT&C losses), improvement in metering infrastructure etc .

The reforms have stressed on improvement of metering infrastructure with emphasis on smart meters. Along with smart meter installation, the reforms also emphasized on implementation of SCADA systems on distribution systems on priority basis. The SCADA systems would allow for better observability throughout the distribution system. Alongside the SCADA systems is the addition of metering of 100% of distribution feeders. The meters installed in the feeders are also to be linked using communication modems to the National Power Portal (NPP) by 2022. Currently only 37% of distribution transformers in the country are metered. The emphasis on implementation of smart meters and increasing the observability of the distribution system would highly benefit the integration of EVs as it would go a long way in enabling signal based smart charging of EV.

Along with the above, the reform has also stressed on the introduction of Ancillary services by CERC for active and reactive power balancing, black start services etc. To tackle the variability of intermittent distributed generation, demand response has been advocated to be enabled by the respective State regulators. With regard to power markets, it has been recommended that the future procurements of power by the state DISCOMS should be on a competitive basis and reduce the emphasis on long term PPAs. The government is also committed to introduce more market mechanisms in order to deepen the spot markets and increase the share of energy transacted through spot markets to about 25% by 2023-24. There is also stress on the introduction of longer duration forward contracts and derivatives on the power exchanges. Creation of these markets is vital for utilization of EVs to participate, and thus provide grid support services.

Creation of a separate consumer category by all DISCOMS for EV charging load, due to the unique characteristics of the load, has also been advocated. The creation of a separate load category would enable the regulators to create unique tariff schemes for the EV loads, such as Time of Use (ToU) tariffs to avoid EV charging during peak load hours. Also, with the increase in the number of fast charging stations that are likely to come up, the provision of injection of power back to the grid from the EV has to be explored to help the grid during critical periods. In this respect, the respective SERCs are required to come up with regulations for enabling bidirectional charging of EVs. Further, the distribution licensees have also been recommended to actively identify parts of the distribution network that

needs augmentation for EV charging. Here, the SERC may need to create special provisions for approval of augmentation proposed by the distribution licensees to facilitate EV charging. Also, to maximize the potential of EVs in providing environmental benefits by utilizing more RE based sources for EV charging, the aggregation of multiple PCSs by aggregators has been recommended in order to purchase renewable energy using open access.

05

Indian EV Statistics and Charging Infrastructure

5.1 Indian EV Statistics

The Indian EV market is in early stages of development. Rapid adoption of EVs is yet to catch up the pace, however, with the improved policies and regulations it is expected that there would be a sharp increase in the number of EVs in the upcoming years. Nationally, there are approximately 10,00,495 electric vehicles by the end of February 2022 , of which the majority are either 2W or 3W. The total market share of BEVs is however only 0.36% of the total registered vehicles. Looking at the PHEV market, there are about 4,64,400 PHEVs which accounts for 0.16% of total vehicle stock. Looking at the state wise distribution, Uttar Pradesh has the highest number of registered BEVs with 2,80,331 followed by Delhi which has 1,34,537 BEVs as shown in Figure 5.1. However if we look at the market share, Delhi has the highest percentage of BEVs with 1.09% followed by Uttarakhand at 0.76% and Uttar Pradesh at 0.71%.

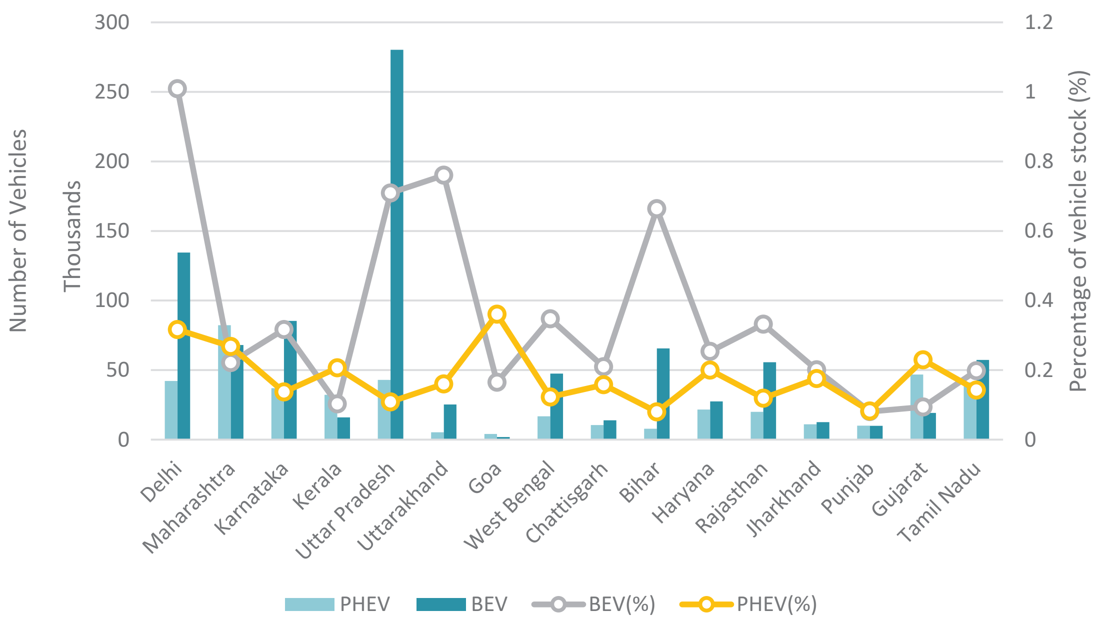


Figure 5.1: Market status of BEV and PHEV in different states in India till Feb, 2022[42]

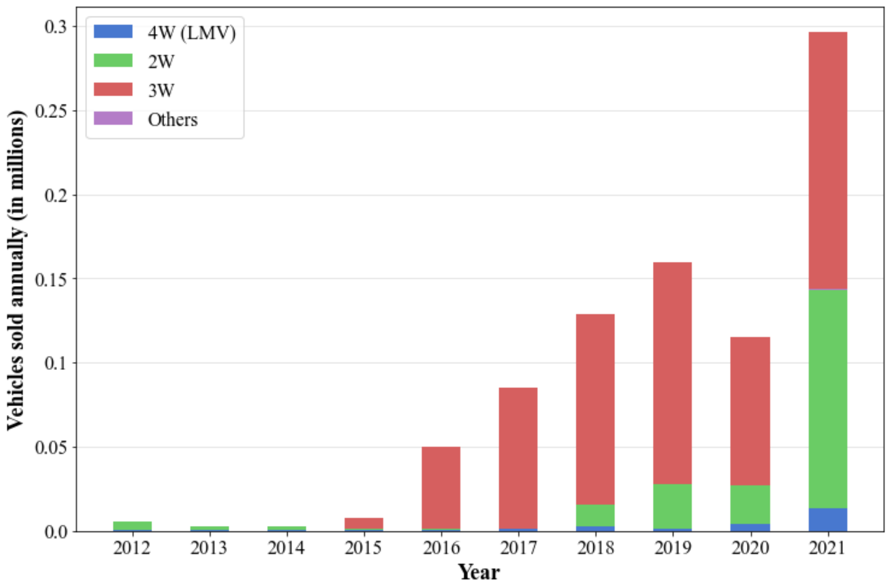


Figure 5.2: Growth of BEV 4W(LMV), 2W, 3W and trucks and buses market in India till Dec 31st, 2021 [42]

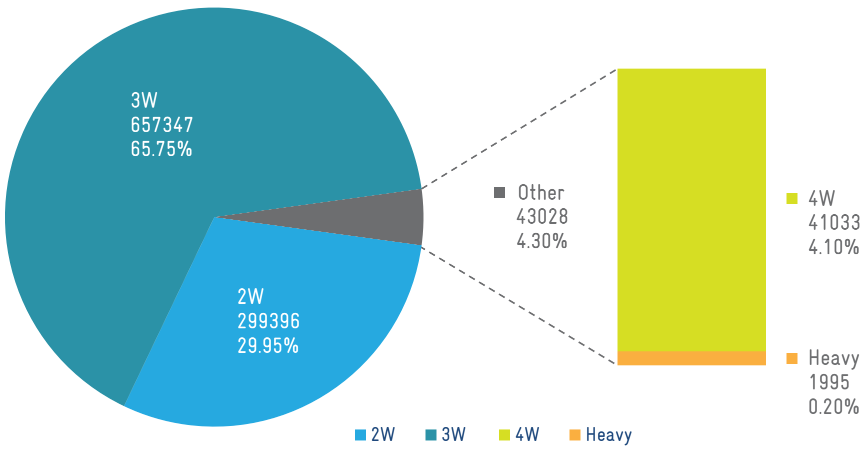


Figure 5.3: Sector wise categorization of total BEVs in India till Feb 2022[42]

Figure 5.2 shows the trend of EV adoption in India across the different vehicle segments. The sector wise categorization of BEVs in the country has been shown in Figure 5.3, which shows that the 3W segment is the largest when it comes to electric vehicles in India, with almost 66% of all BEVs being a 3W. This is followed by the 2W segment with around 2,99,400 2W BEVs as of February 2022. The number of 4W in India is limited to only 41,033 4W BEVs till February 2022 .

5.1.1 2W EV DEMAND IN INDIA

Compared to e-4W, the adoption of e-2W started a bit earlier, from 2018 as can be seen in Figure 5.4. Since 2019, the annual sales of e-2W have always exceeded 20,000. However, even though the number of e-2W is high compared to e-4W, compared to the number of 2W powered by conventional fuels, the share of e-2W is only about 0.15% as shown in Figure 5.5. Also, among all the states, Uttar Pradesh has the highest uptake of e-2W followed by Haryana, Maharashtra and Gujarat as shown in Figure 5.6 .

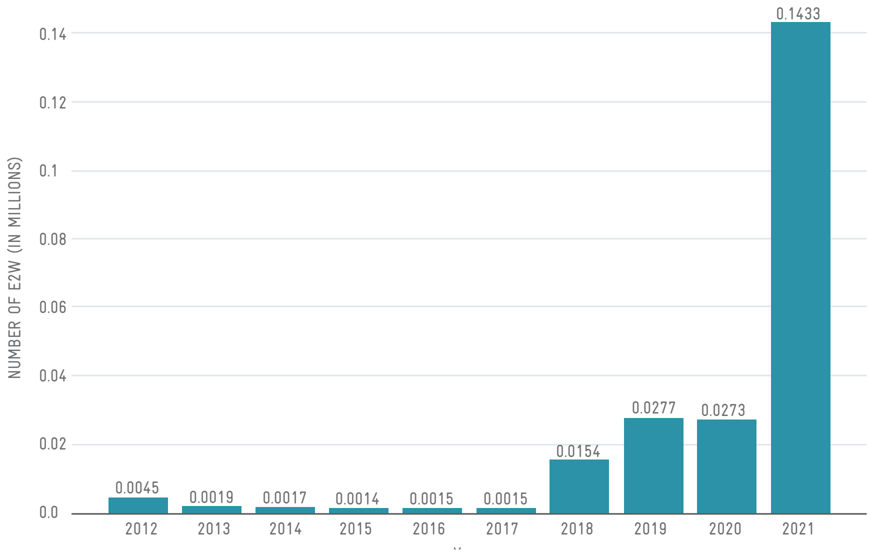


Figure 5.4: Growth of BEV 2W market in India till Dec 31, 2021[42]

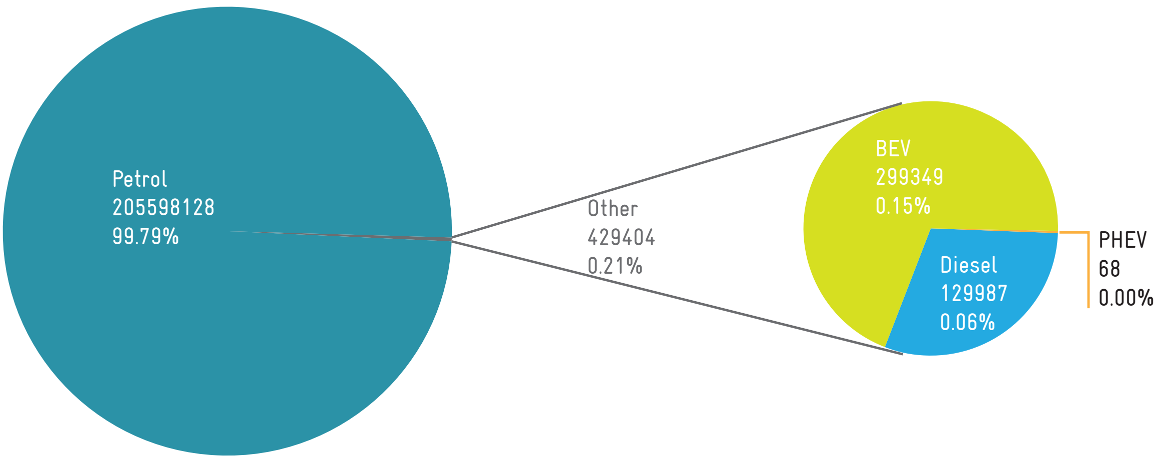


Figure 5.5: Share of 2W in India by fuel type till Feb 2022[42]

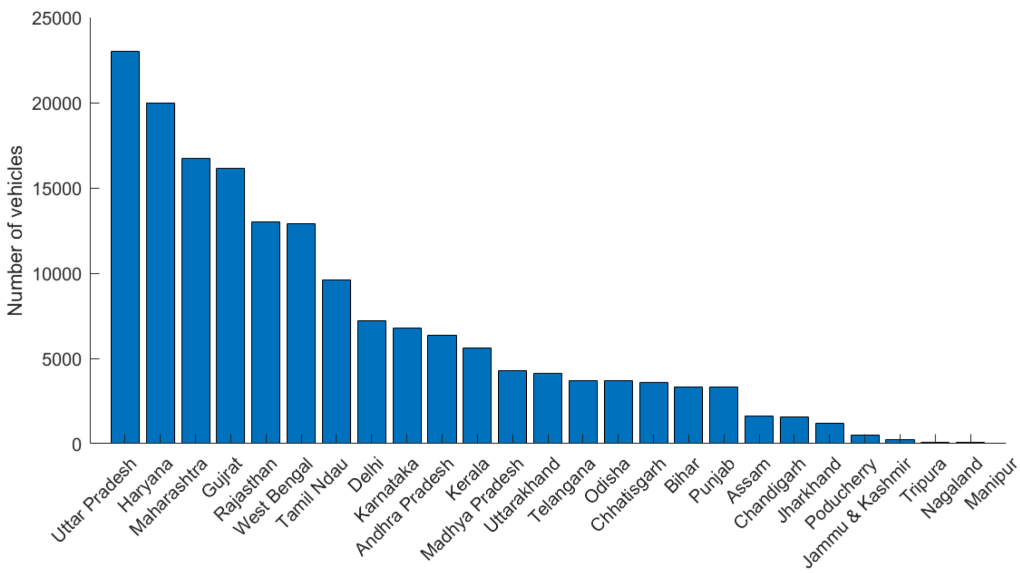


Figure 5.6: State wise sale of e-2W using FAME subsidy (April 2015 to June 2019)[74]

74 TERI, "Faster Adoption of Electric Vehicles in India: Perspective of Consumers and Industry" (New Delhi: The Energy and Resources Institute, 2019).

5.1.2 3W EV DEMAND IN INDIA

The 3W market has seen the highest adoption of electric vehicles across all vehicle segments. The adoption of e-3W started in India since around 2015 as seen in Figure 5.7. BEVs account for 12% of total registered 3W in India till February 2022, which is quite significant as can be seen in Figure 5.8.

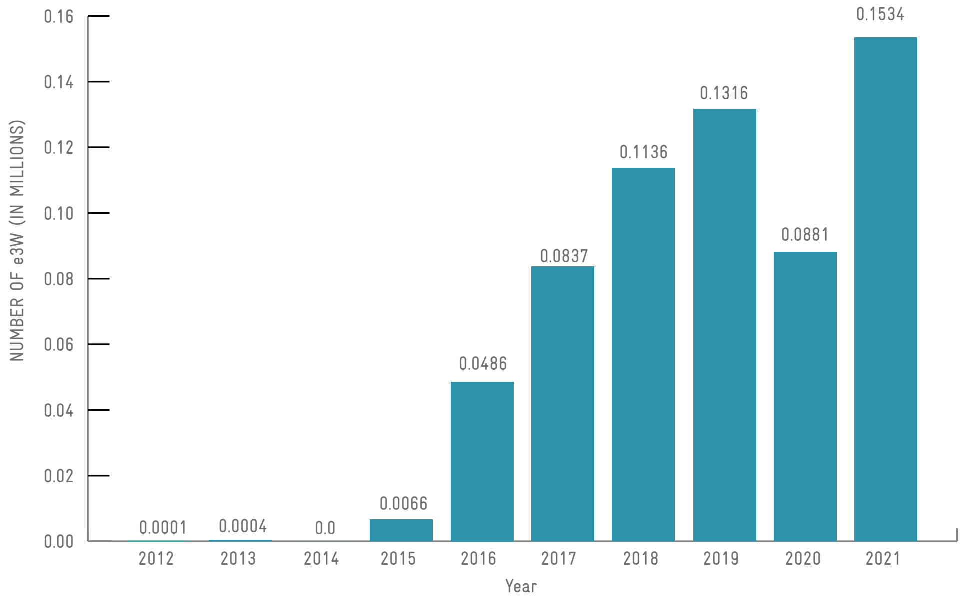


Figure 5.7: Growth of BEV 3W market in India till 31 Dec 2021[42]

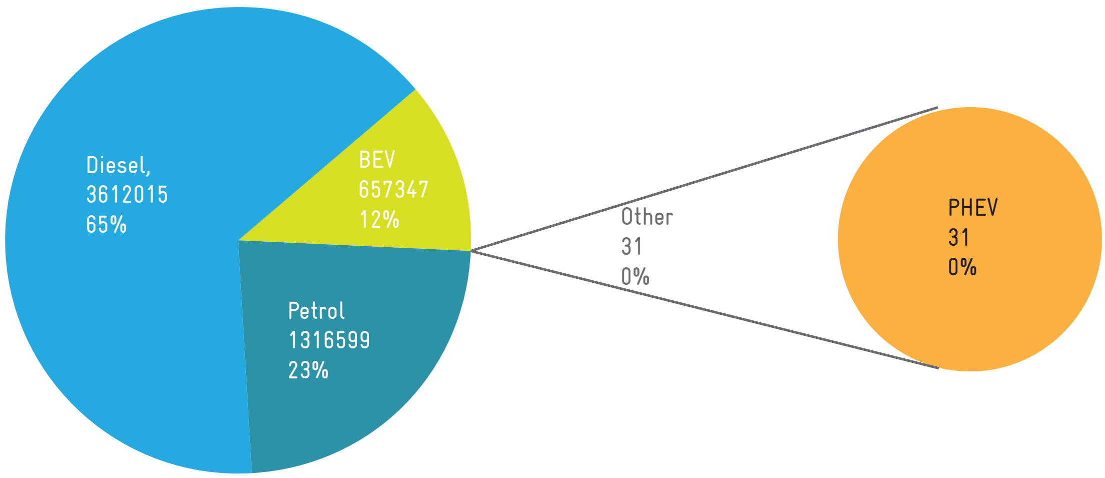


Figure 5.8: Share of 3W in India by fuel type till Feb 2022[42]

5.1.3 4W EV DEMAND IN INDIA

From Figure 5.9, it can be seen that in regard to 4W EV adoption in India, there has been a significant rise since 2020. In fact, the number of 4W EVs purchased in 2021 is higher than the annual sale of EV up to 2019. The annual sales of 4W EVs have seen a sharp increase of around 328% from 2020 to 2021. Figure 5.10 shows the share of 4W in India based on fuel type. PHEV has a significantly higher share in India compared to BEVs, with 4,63,900 PHEVs and 41,000 BEVs till February 2022 (VAHANSEWA, 2021).

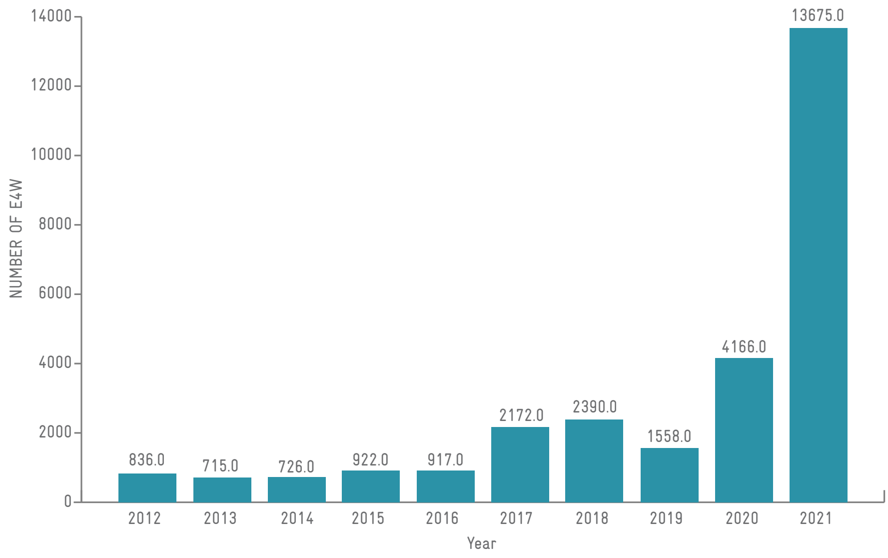


Figure 5.9: Growth of BEV 4W(LMV) market in India till Dec 31st, 2021[42]

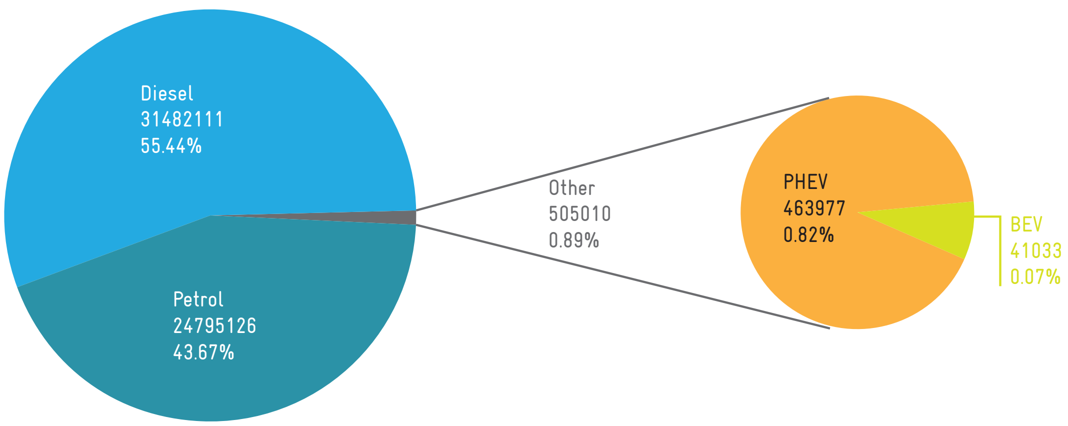


Figure 5.10: Share of 4W(LMV) in India by fuel type till Feb 2022[42]

5.1.4 E-BUS DEMAND IN INDIA

The government of India through the FAME schemes has put a significant stress on electrification of the public bus fleets used for both intercity and intracity transportation. As can be seen in Figure 5.11, in 2019 alone more than 350 e-Buses have been purchased/deployed. In 2020, the addition of e-Buses reduced, while in 2021, 922 e-Buses have been purchased. In total, around 1500 e-Buses have been deployed in the nation, as of February 2022[75]. In addition 5,595 e-Buses have been allotted to 64 different cities in India for intra-city public transportation[76].

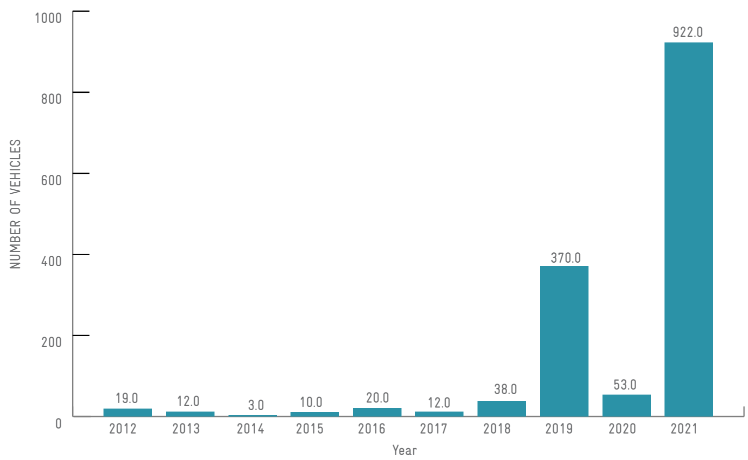


Figure 5.11: Growth of heavy BEV (e-Bus) market in India till Dec 31st, 2021[42]

The state-wise vehicle statistics in India till February 2022 has been provided in Table 5.1.

75 VAHANSEWA, "DASHBOARD."
76 GIZ, "Training Needs Assessment for Electric Buses in India: Volume I - Identification of Training Needs," May 2021, https://greenmobility-library.org/public/uploads/resource_attachments/1621924040_Training_Needs_Assessment_for_Electric_Buses_in_India_Volume%201.pdf.

Table 5.1: Number of registered vehicles in different states of India till Feb 2022 categorized based on the fuel used[77]

State	2W				3W				4W				Heavy				Total			
	Petrol	Diesel	BEV	PHEV	Petrol	Diesel	BEV	PHEV	Petrol	Diesel	BEV	PHEV	Petrol	Diesel	BEV	PHEV	Petrol	Diesel	BEV	PHEV
Arunachal Pradesh	129802	66	14	1	1818	1390	0	0	54465	35253	6	255	19	11248	0	1	186104	47957	20	257
Assam	3155087	401	790	0	41926	85579	48188	5	686766	436016	575	7731	247	90271	16	1	3884026	612267	49569	7737
Bihar	7801155	2869	5159	0	8431	410676	60035	0	349438	1002420	308	7857	340	197835	33	5	8159364	1613800	65535	7862
Chandigarh	390786	43	304	0	12	4127	1458	0	194283	157807	183	2654	0	3160	40	0	585081	165137	1985	2654
Chhattisgarh	5317827	1060	6698	0	10100	49484	5505	0	369456	644640	1256	10411	130	167872	8	7	5697513	863056	13467	10418
Delhi	8491616	245	15954	0	71329	529	113677	0	2567416	908461	4871	42196	1295	70385	31	0	11131656	979620	134533	42196
Goa	724586	105	1432	0	2877	638	28	0	259757	100989	342	4026	55	19519	37	0	987275	121251	1839	4026
Gujarat	14459854	10012	14989	5	50152	338598	1926	2	1377680	2417739	1927	46780	82	364830	228	5	15887768	3131179	19070	46792
Haryana	6842812	2208	8106	3	135	125313	18859	0	1224219	1774638	451	21617	201	313166	18	1	8067367	2215325	27434	21621
Himachal Pradesh	1040338	576	392	0	3726	5639	168	0	539557	307312	106	3030	710	82683	84	0	1584331	396210	750	3030
Jammu & Kashmir	936195	676	1434	0	10619	31330	94	0	498910	2207120	27	2691	58	50747	42	3	1445782	2289873	1597	2694
Jharkhand	4790183	1790	30974	9552	197406	197406	9105	0	450789	616418	284	10967	145	143087	58	0	5438523	958701	40421	20519
Karnataka	19821459	27884	59589	1	245623	329886	16665	3	2539329	3277166	9006	36882	5868	532827	70	3	22612279	4167763	85330	36889
Kerala	10241788	13532	11088	43	342827	643152	2176	7	2433542	1714096	2758	32114	2873	149060	14	54	13021030	2519840	16036	32218

Maharashtra	22382857	5599	54220	2	144645	128478	6345	5	2613035	3575214	6840	82131	56	492703	609	50	25140593	4201994	68014	82188
Manipur	310976	34	86	0	5609	13287	448	0	100433	34299	4	544	16	8271	1	0	417034	55891	539	544
Meghalaya	178150	51	16	0	10468	7767	6	0	159551	73706	14	548	121	21664	0	0	348290	103188	36	548
Mizoram	310976	34	86	0	5609	13287	448	0	100433	34299	4	544	16	8271	1	0	417034	55891	539	544
Nagaland	66991	25	44	0	9583	1472	0	0	74350	59403	7	329	18	160877	3	0	150942	221777	54	329
Odisha	7787997	2039	10818	0	13564	243108	1838	1	437279	850043	321	11155	909	262646	20	1	8239749	1357836	12997	11157
Punjab	8952985	7173	6553	0	5969	75695	3062	0	991472	1594604	197	10063	275	167212	15	3	9950701	1844684	9827	10066
Rajasthan	12395954	2474	24473	0	3536	178580	30254	0	1026356	2591414	940	19979	158	428722	14	1	13426004	3201190	55681	19980
Sikkim	21932	9	1	0	0	0	0	0	40299	27730	21	133	2	3330	1	0	62233	31069	23	133
Tamil Nadu	22765524	33984	46257	3	187958	239168	4630	5	1764420	3149454	6104	41141	3512	584140	222	2	24721414	4006746	57213	41151
Tripura	457700	579	68	0	23755	6768	7589	1	51920	44725	16	356	265	12192	0	0	533640	64264	7673	357
Uttarakhand	2366824	283	2675	0	4833	29379	22362	1	441325	369272	183	5313	90	66010	10	1	2813072	464944	25230	5315
Uttar Pradesh	31784806	11868	18806	2	31203	381745	260568	0	1911658	4021041	589	42885	236	488344	277	1	33727903	4902998	280240	42888
West Bengal	10378620	3411	2732	4	55537	78782	41271	1	1392945	1257159	3346	16733	1213	397482	64	12	11828315	1736834	47413	16750
Telangana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4822880	1358999	16080	4702

77 Source: Vahansewa, Telangana Open Data Portal

5.2 EV Charger Infrastructure in India

The growth of public Indian EV charging infrastructure began since the past 5 years. The total number of public chargers as of 2019 in India is 1,827 with the majority of them being installed in 2019 as shown in Figure 5.12 . From Figure 5.13 and Figure 5.14, the majority of chargers that are publicly accessible are slow chargers with power ratings of less than 22 kW.

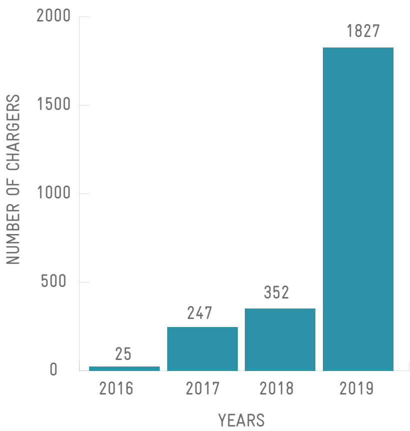


Figure 5.12: Trend of public chargers in India[78]

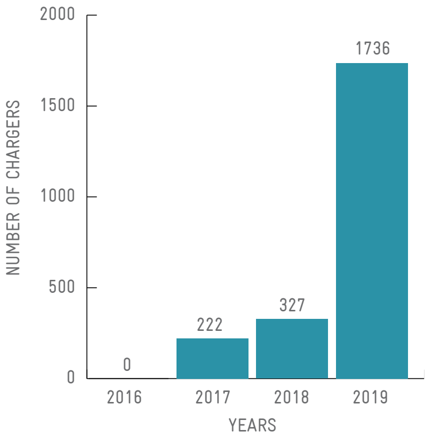


Figure 5.13: Trend of slow chargers[79] in public charging stations in India

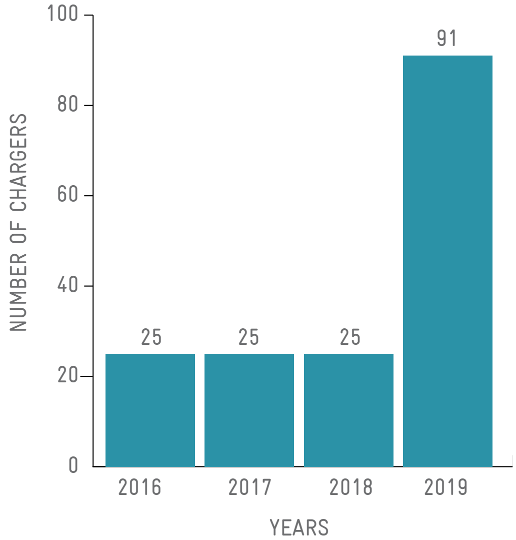


Figure 5.14: Trend of fast chargers in public charging stations in India[80]

The Government of India under the FAME II policy have allotted charging stations pan India to boost up the public charging infrastructure. As of 2021, a total of 2877 charging stations were sanctioned to be installed across the nation as shown in Figure 5.15. Each charging station has requirements of minimum number of chargers based

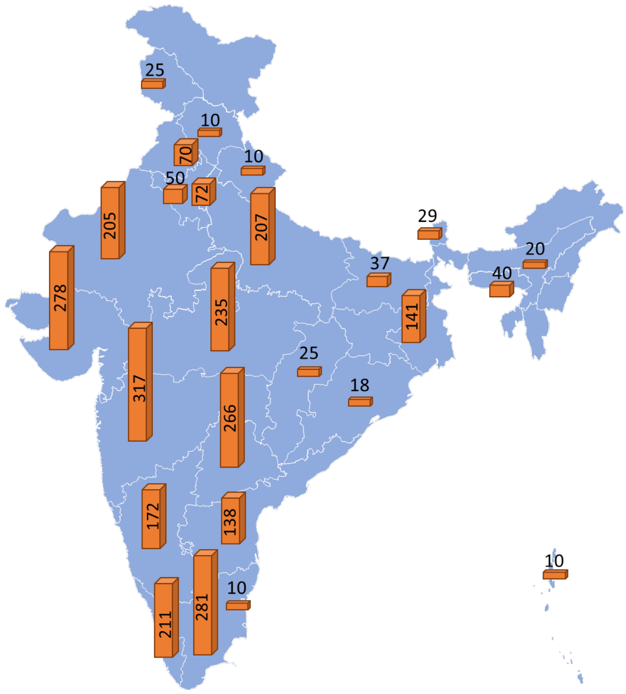


Figure 5.15: Allotted number of charging stations under FAME II scheme to be installed in different states across India

78 IEA, "Global EV Outlook 2020," 2020.
79 Here slow charges refer to chargers with less than 22 kW charging power and fast chargers are chargers with more than 22 kW charging power.
80 IEA, "Global EV Outlook 2020."

on whether the station is a fast-charging station or slow charging station. Under this scheme, Andhra Pradesh, Gujarat, Kerala, Maharashtra, Madhya Pradesh, Rajasthan, Tamil Nadu, and Uttar Pradesh have all been allotted more than 200 charging stations each, while Himachal Pradesh, Puducherry, Uttarakhand, and Andaman have been allotted 10 charging stations each. The Union Minister of Power commented that till March 2021, a total of 970 charging stations were installed under FAME I and FAME II. He commented that 140 chargers were installed by NTPC, 141 were set by EESL, 14 by PGCIL and 386 were earlier installed under FAME I[81]. As of December 2021, the

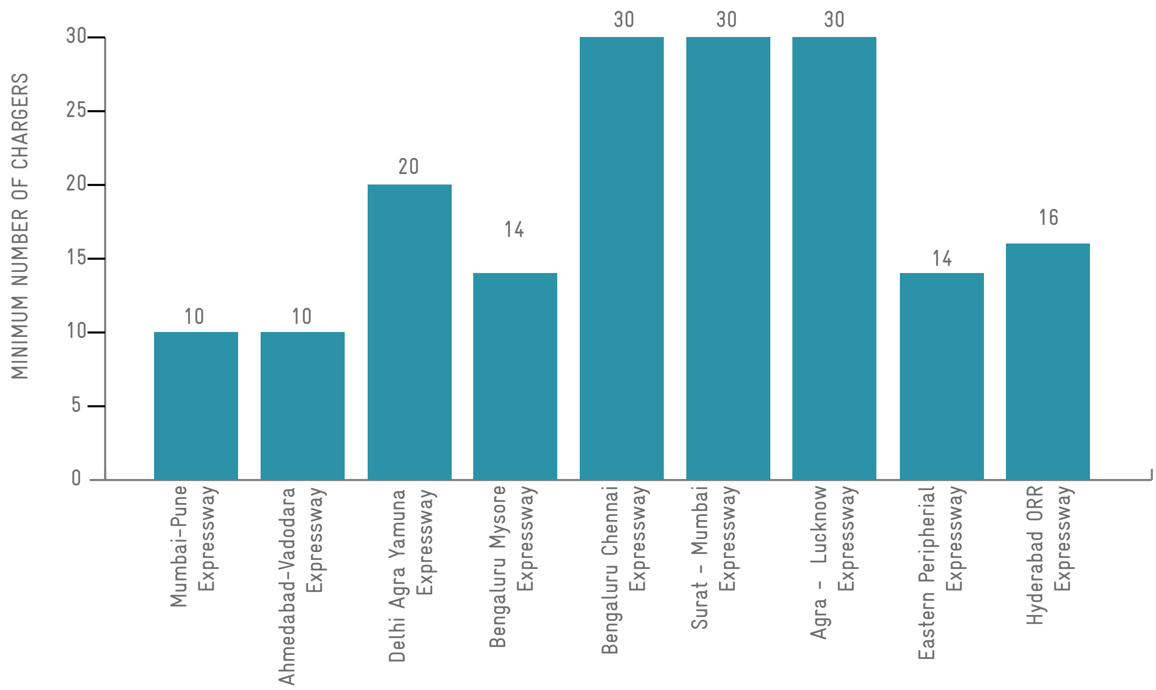


Figure 5.16: Minimum number of charging stations to be installed in expressways under FAME II [82]

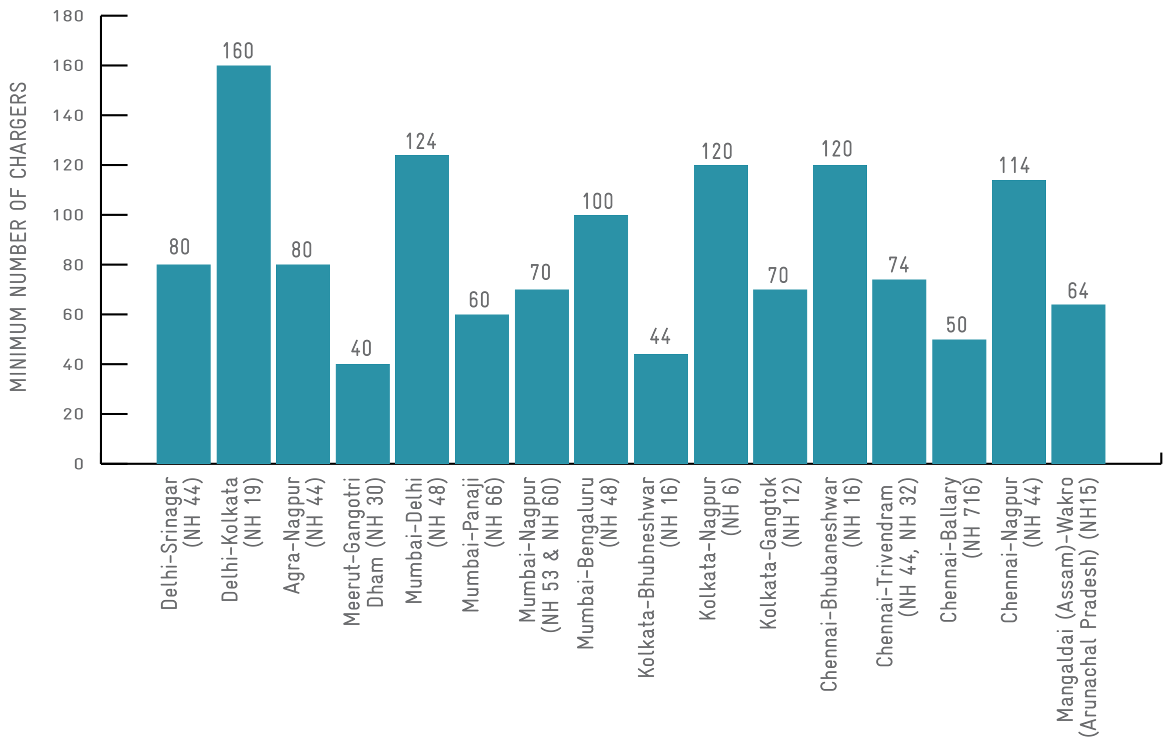


Figure 5.17: Minimum number of charging stations to be installed in highways under FAME II

81 Ayush Verma, "970 Government Funded Public EV Charging Station Installed in India so Far," Saur Energy International, 2021, https://www.saurenergy.com/ev-storage/970-public-ev-charging-station-installed-india.

number of installed public EV charging stations increased to 1028.[82]

Besides the charging stations in cities, under the FAME II scheme, an expression of interest has also been invited to install 1544 charging stations in expressways and highways as shown in Figure 5.16 and Figure 5.17. The mentioned number of charging stations in the two figures is the minimum requirement for charging stations to be installed for the identified Express/highways, however, a CPO can propose higher number of charging stations for a given express/highway . The concerned party (for example, CPO/ winning bidder) is allowed to install more charging stations as per their requirement.

So far, Rajasthan Electronics Instruments, Ltd. (REIL) has installed 47 public charging stations along different highways, 4 PCS have been installed in the Mumbai-Pune expressway, 1 PCS has been installed in NH-58 by the Uttarakhand Power Corporation Ltd., 1 PCS along NH-27 by the Paschim Gujarat Vij Company Ltd. And 3 PCS have been installed along NH-47, SH-49 and NH-4 by the Tamil Nadu Generation and Distribution Corporation Ltd.

Further, work has been underway to retrofit the existing petrol depots in the country with EV charging infrastructure. DHI has already notified in December 2021 that charging stations would be installed in 22,000 of the 70,000 petrol pumps in the country by December 2022[83].

Few private players have also been active in the charging infrastructure space in India. In Nagpur, Ola has put up 22 chargers to cater to its EV fleet. Similarly, to promote its line-up of EVs, TATA has around 400 charging points across 65 cities in India, with an aim to scale up its charging network to 700 chargers by December 2021[84]. Fortum Charge and Drive Indian Private Ltd. which is one of the leading charge point installers in the Nordic countries has installed more than 100 public charging points across 39 cities which includes 15 kW DC001 chargers as well as 50 kW CCS/CHAdeMO chargers by November 2020 . Ather Grid, which is another charging network installed by the 2W OEM Ather, has 128 public charging points across 18 cities in India till April 2021 . These charging points although specifically installed to cater to 2W, can also be used to charge 4W through the provided standard AC socket. In totality, till Q1 2021, a total of 4305 chargers have been installed in India by different owners and charge point operators[85].

5.3 EV models available in the Indian Market

Different EV models in 2W, 3W, and 4W available in India is mentioned in table given in Table 5.2, Table 5.3 and Table 5.4 respectively.

82 DHI, "Expression of Interest Inviting Proposals for Availing Incentives under Fame India Scheme Phase II for Deployment of EV Charging Infrastructure on Highways/Expressways" (Ministry of Heavy Industries and Public Enterprises, December 10, 2020), https://dhi.nic.in/writereaddata/UploadFile/EoI%20EV%20Charging.pdf.

83 ToI, "Work underway to set up EV charging stations at 22,000 of 70,000 petrol pumps in the country: Govt", December, 2021, https://timesofindia.indiatimes.com/auto/news/work-underway-to-set-up-ev-charging-stations-at-22000-of-70000-petrol-pumps-in-country-govt/articleshow/88083717.cms

84 Ajit Dalvi, "Tata Power to Expand EV Charging Mission to National Highways, Tourist Places in India," Autocarpro, March 31, 2021, https://www.autocarpro.in/news-national/tata-power-to-expand-ev-charging-mission-to-national-highways--tourist-places-in-india-78839.

85 IIT Bombay research based on the information gathered from different sources.

Table 5.2: e-2W models available in India[86]

Manufacturer	Model	Battery Capacity (kWh)	Range (km/ charge)	Electric Vehicle Efficiency (km/kwh)	Time to Full Charge (hr)	Charger Rating (V/A)	Charger type	Charging type	Battery Technology
Hero Electric	Photon HX	1.872	108	57.69	5	84 / 6	On-board charger (in some models); Portable charger	AC slow charging	Li-ion
	Nyx HX (Dual Battery)	3.072	165	53.71	4-5	58.4 / 6			Li-ion
	NYX LX	1.536	85	55.34	4-5	58.4 / 6			Li-ion
	OPTIMA LX (VRLA)	0.96	50	52.08	8-10	-			VRLA
	Optima LX	1.536	85	55.34	4-5	58.4 / 6			Li-ion
	OPTIMA HX (Dual Battery)	3.072	122	39.71	4-5	58.4 / 6			Li-ion
	OPTIMA HX (Single Battery)	1.536	82	53.39	4-5	58.4 / 6			Li-ion
	Flash LX (VRLA)	0.96	50	52.08	8-10	-			VRLA
	Flash LX	1.536	85	55.34	4-5	58.4 / 6			Li-ion
	Atria LX	1.536	85	55.34	4-5	58.4 / 6			Li-ion
Ola	S1	2.98	121	40.6	4-5 (normal)/ 75 km in 18 min (fast)	-	Portable charger/ Hypercharger network	AC slow and Hypercharger (fast)	Li-ion
	S1 Pro	3.97	181	45.6	4-5 (normal)/ 75 km in 18 min (fast)	-			Li-ion
Okinawa Scooters	Ridge+	1.74	84	48.28	2-3	67.2 / 10	Micro Charger with Auto Cut	AC slow charging	Li-ion
	iPraise+	3.3	139	42.12	4-5	84 / 10			Li-ion
	PraisePro	2	88	44.00	2-3	84 / 10			Li-ion
	Lite	1.25	60	48.00	4-5	54.6 / 5			Li-ion
	R30	1.34	60	44.78	4-5	54.6 / 6			Li-ion
	Dual	2.64	120-130	45.45	2-3	84 / 10			Li-ion

86 IITB research: information collected from various sources including the manufacturer's websites

Manufacturer	Model	Battery Capacity (kWh)	Range (km/ charge)	Electric Vehicle Efficiency (km/kwh)	Time to Full Charge (hr)	Charger Rating (V/A)	Charger type	Charging type	Battery Technology
Ampere	Zeal EX	1.8	87	48.33	5-6	66.88 / 7.5	Portable charger	AC slow charging	Li-ion
	Magnus	1.68	90	53.57	5-6	66.88 / 7.5			Li-ion
	Reo Plus (VRLA)	1.296	62	47.84	8-10	48 / 2.7			VRLA
	Reo Plus (Li-ion)	1.344	63	46.88	5-6	54.6 / 6			Li-ion
	Reo (VRLA)	0.96	45-50	46.88	8-10	48 / 2.7			VRLA
	Reo (Li-ion)	1.152	55-60	47.74	5-6	54.6 / 6			Li-ion
	Reo Elite (VRLA)	1.296	50-60	38.58	8-10	48 / 2.7			VRLA
	Reo Elite (Li-ion)	1.344	50-60	37.20	5-6	54.6 / 6			Li-ion
	V48	1.296	45-51	34.72	8-10	48 / 2.7			VRLA
	Magnus 60	1.296	45-51	34.72	8-10	48 / 2.7			VRLA
Simple Energy	One	4.8	236	49.16	80% in 2-3 hrs	-	Portable charger		
Ather	ATHER 450X	2.9	116	40.00	5.75	5A/15A and also DC fast	Proprietary charger (Ather Dot), Portage charger; Fast charging in AtherGrid stations	AC slow and DC fast charging	Li-ion
	Ather 450 Plus	2.9	100	34.48	5.75				Li-ion
Revolt	RV300	2.7	180	66.67	4.2	85 / 11	On-board charger, Portable charger	AC slow charging	Li-ion
	RV400	3.24	150	46.30	4.5	85 / 11			Li-ion
Li-ions Elektrik	SPOCk	2.8	107.38	38.35	4	-	Household socket	AC slow charging	Li-ion
TVS	iQUBE ELECTRIC	2.25	86.1	38.27	7	-	TVS SmartXHome charger, Portable charger	AC slow charging	Li-NMC
Benling India	Aura	2.8	120	42.86	5-6	84 / 10	On-board charger; Portable charger	AC slow charging	Li-NMC
	Falcon (VRLA)	1.2	70-75	58.33	7-8	60 / 2.5			VRLA
	Falcon (Li-ion)	1.32	70-75	53.03	4	67.2 / 6			Li-ion
	Kriti (VRLA)	0.96	60	72.92	7-8	48 / 2.5			VRLA
	Kriti (Li-ion)	1.152	60	60.76	4	48 / 6			Li-ion
	Icon (VRLA)	1.2	70-75	58.33	8-9	60 / 2.5			VRLA
	Icon (Li-ion)	1.32	70-75	53.03	4	67.2 / 6			Li-ion
Jitendra Electric Vehicle	JMT1000 HS	2.04	90	44.12	3.5	60 / 10	Household socket	AC slow charging	Li-ion
	JMT1000	-	65	-	-	-			VRLA
	JET 250XL	-	60-70	-	-	-			Li-ion
	JET 250XL+	-	60-70	-	-	-			Li-ion

Manufacturer	Model	Battery Capacity (kWh)	Range (km/ charge)	Electric Vehicle Efficiency (km/kwh)	Time to Full Charge (hr)	Charger Rating (V/A)	Charger type	Charging type	Battery Technology
M2GO Electric Vehicle Pvt. Ltd	Civitas	2.088	120	57.47	–	–	–	–	Li-ion
	X1	1.56	120	76.92	–	–	–	–	Li- ion
Thukral Electric Bikes Pvt Ltd	E Gen	1.024	50-60	48.83	4-5	–	5A charger	AC slow	Li- ion
Tunwal E Vehicle India	T 133	2.4	99	20.83	–	–	–	AC slow charging	Li-NMC
	Storm ZX Plus	2.4	99	20.83	–	–	–		Li-NMC
	TEM G33	2.4	99	20.83	–	–	–		Li-NMC
	RomaS	2.4	99	20.83	–	–	–		Li-NMC
	Tz 3.3	2.9	107	17.24	–	–	–		Li-NMC
Bajaj Auto	Chetak	3.0	85-95	28.33	5	–	On-board charger	AC slow charging	Li-ion

Table 5.3: e-3W models available in India [86]

Brand	Model	Battery Capacity (kWh)	Range (km)	Time to Full Charge Battery (hr)	Charger Output Rating (V, A)	Battery Technology	Connector	Charging Type
Mahindra	Treo Yaari	3.69	129	2.5	48 / 15	Li-ion	12 V connector	AC slow
	Treo HRT	7.37	171	3.83	48 / 15	Li-ion	12 V connector	AC slow
	Treo ZOR	7.37	125	3.83	48 / 15	Li-ion	12 V connector	AC slow
Lohia	NARAIN i	3.8	113	–	–	Li-ion	–	–
	NARAIN iCE	3.8	113	–	–	Li-ion		
	Humsafar iB	7.6	111	–	–	Li-ion	–	
Kinetic Green	Kinetic DX	–	80	8-10 (LA), 2-3 (Li)	48 / –	VRLA Tubular / Li-Ion	Standard 15A socket	AC slow
	Kinetic Safar Smart	4.1 (Li)	126	8-10 (LA), 2-3 (Li)	48 / –	VRLA Tubular / Li-Ion		AC slow
Bahubali	Plus	5.76, 6.24,6.72	70-100	7-10hrs	48 / 15	VRLA	–	–
Piaggio Motor	Ape E-Xtra Fixed battery	8	85-95	3.75	48 / –; 3 kW; (offboard)	Li-ion	Standard 15A socket	AC slow
	Ape E-City Swappable battery	4.5	68	–	–	Li-ion	–	Battery Swap
	Apex E-Xtra LDR + FX PU	8	80-90	3.75	48 / –; 3 kW; (offboard)	Li-ion	–	
	Ape E-City/ Fixed battery	7.5	105-115	3.75	48 / –; 3 kW; (offboard)	Li-ion	Standard 15A socket	AC slow

Brand	Model	Battery Capacity (kWh)	Range (km)	Time to Full Charge Battery (hr)	Charger Output Rating (V, A)	Battery Technology	Connector	Charging Type
Jitendra Electric Vehicle	JET 650 Cargo	–	70-80	–	–	VRLA	–	AC slow
	JET 650 Passenger	–	80-90	–	–	VRLA	–	AC slow
Altigreen Propulsion Labs	NEEV	7.7	117	3.5	–	Li-ion	Standard 15A socket	AC slow
Y C Electric Vehicle	YATRI DLX/ Yatri Super/ Yatri/E-loader/ Yatri Cart	4.3	113.2	5-7	–	Li-NMC	–	–
Champion PolyPlast	Saarathi Star	8.1	–	4-5	60 / 30	Li-ion	–	AC slow
	Saarathi Shavak e-auto	8.1	–	4-5	60 / 30	Li-ion	–	AC slow
SKS Trade India Pvt. Ltd	Arzoo base/ Arzoo DLX/ Arzoo Chaat Van/Vegitable and food Cart/Garbage collection Van/ School Van	5.28	–	–	48 / 15	VRLA	Standard 15A socket	AC slow
	Arzoo ER	4.8	70-80	–	48 / 12	VRLA	–	
Harsh Trading Company	NAVRANG	–	90-100	5-6	48 / 15	VRLA	–	
	Payal	–	90-100	6-8	48 / 15	VRLA	–	
GRD Motors	Fighter	–	100	8-10	48 / 12-15	VRLA	–	
	Devarath e-rickshaw	–	100	8-10	48 / 12-15	VRLA	–	
Ambika Enterprises	GS 8000	5.76	105	–	48 / –	–	–	
Terra Motors	Y4A	6.72	80	6-8	48 / 15	VRLA	–	
	Sumo	6.72	80	6-8	48 / 15	VRLA	–	
	X1	6.72	80	6-8	48 / 15	VRLA		
RUTBA Products Pvt. Ltd.	Rutba E Riksha	3.84	80	7-8	–	–	–	
Kinetic Green Energy	Kinetic Safar Smart	4.1	126	–	48 V	Li-ion	–	
	Kinetic Safar Star – 400	4.2	83.5	–	48 V	Li-ion	–	
Top Team Machines Pvt. Ltd.	Hawa Hawai	–	>80	8-10	–	VRLA	–	
	Hawa Hawai E-Cart Cargo	–	>81	8-10	–	VRLA	–	
	Sangam Auto	–	70	8-10		VRLA	–	

Brand	Model	Battery Capacity (kWh)	Range (km)	Time to Full Charge Battery (hr)	Charger Output Rating (V, A)	Battery Technology	Connector	Charging Type
Shigan Evoltz Ltd.	Green Rick Super	1.92	80	9-10	-	VRLA	-	
	Green Cart	3.84	80	7-8	-	VRLA	-	
	Green Passenger	1.92	70-80	7-8	-	VRLA	-	
Goenka Electric Motor Vehicles Pvt. Ltd.	Queen	-	90-100	-	48 / -	-	Home charger	AC slow
	Prince	3.7	83.7	-	48 / -	Li-ion	Home charger	AC slow
	Samrat Garbage	4.3	131.29	-	48 / -	Li-Ion	Home charger	AC slow
Shri Barsana E-Vehicles Pvt. Ltd	Bahubali	5.76, 6.24,6.72	70-100	7-10	48 / 15	VRLA	Home charger	AC slow
	Bahubali Plus	5.76, 6.24, 6.72	70-100	7-10	48 / 15	VRLA	Home charger	AC slow
	Bahubali Loader	-	70-100	7-10	48 / 15	VRLA	Home charger	AC slow
UTTAM	UTTAM	1.01-1.44	70-80	3-4	48 / -	-	Home charger	AC slow
SATHI Motors Pvt. Ltd.	E SATHI	-	80	4-5	60 / -	Li-ion	-	-
Attolent Autogroup Pvt. Ltd.	Atut Shakti	3.84	>80	7-8	-	VRLA	Home charger	AC slow
	Virat Shakti	3.84	>80	7-8	-	VRLA	Home charger	AC slow
	Masoori Shakti	-	-	-	-	-	-	AC slow
	Atut Shakti Cargo	3.84	>80	7-8	-	VRLA	Home charger	AC slow
Speego Electric Vehicles	SPEEGO	-	-	8-10	48 / 20	VRLA	Home charger	AC slow
	SPEEGO CR	-	-	8-10	48 / 20	VRLA	Home charger	AC slow
	SPEEGO DLX	-	-	8-10	48 / 20	VRLA	Home charger	AC slow
	MORNI DLX	-	-	8-10	48 / 20	VRLA	Home charger	AC slow
	SPEEGO DLX Li	4.4	112.5	-	48 / -	Li-ion	-	-
Arna Electric Auto	ARNA 100	4.8	>90	9-10	-	VRLA	Home charger	AC slow
	ARNA 100 CARGO	4.8	>80	9-10	-	VRLA	Home charger	AC slow
AMAN ELECTRIC VEHICLES	A STAR LDR	3.6	-	-	-	VRLA	Home charger	AC slow
	A STAR 900	3.6	-	-	-	VRLA	Home charger	AC slow

Brand	Model	Battery Capacity (kWh)	Range (km)	Time to Full Charge Battery (hr)	Charger Output Rating (V, A)	Battery Technology	Connector	Charging Type
M2J E-VAHAN PVT. LTD.	M2J	–	–	–	48 / 15	VRLA	Home charger	AC slow
	M2J CARGO	–	–	–	48 / 15	VRLA	Home charger	AC slow
SHRI NAMO ELECTIRC AUTOMOTIVE	EWA ECO FRIENDLY	3.5	70-80	–	48 / 20	VRLA	Home charger	AC slow
	EWA ECO FRIENDLY LOADER	3.5	70-80	–	48 / 20	VRLA	Home charger	AC slow
VISHAL ENTERPRISES	SAARAS	3.84	–	–	–	–	–	–
M/S VICTORY ELECTRIC INTERNATIONAL	VICTORY	5.2	136.46	9-10	–	Li-ion	Home charger	AC slow
	VICTORY VIKRANT	5.2	136.46	9-10	–	Li-ion	Home charger	AC slow
	VICTORY VIJETA	5.2	136.46	9-10	–	Li-ion	Home charger	AC slow
	VICTORY SUMFOIL	5.2	136.46	9-10	–	Li-ion	Home charger	AC slow
	VICTORY Bhim	5.2	136.46	9-10	–	Li-ion	Home charger	AC slow
	VICTORY Bhim CLEANER+	5.2	136.46	9-10	–	Li-ion	Home charger	AC slow
M/S OM PACKAGING	KOOZIE ER	4.8	80-100	6-8	48 / 15	VRLA	Home charger	AC slow
M/S Mali Enterprises	E PARIVAHAN	3.84	–	–	–	VRLA	Home charger	AC slow
M/s MINI METRO EV LLP	Mini Metro	–	80	9-10	–	VRLA	Home charger	AC slow
M/s MAA Shakti Exim Pvt. Ltd.	SAARTHAK	3.84	–	7-8	–	VRLA	Home charger	AC slow
M/s G & G Automotive	THOR	7.2, 5.76, 4.8	–	8-9	–	VRLA	Home charger	AC slow
	DON	7.2, 5.76, 4.8	–	8-9	–	VRLA	Home charger	AC slow
	SHAHENSHAH	7.2, 5.76, 4.8	–	8-9	–	VRLA	Home charger	AC slow
Bright Metal Works	RICHLOOK	4.08	–	–	–	VRLA	Home charger	AC slow
Motrac Motors Pvt. Ltd	Motrac Raftaar	5.76	–	–	48 / 15	VRLA	Home charger	AC slow
	Motrac Loader	5.76	–	–	48 / 15	VRLA	Home charger	AC slow
Skyride Automotive	SKYRIDE ER	–	–	–	48 / 12, 15	VRLA	Home charger	AC slow
	SKYRIDE E-Cart	–	100	8-9	–	VRLA	Home charger	AC slow

Brand	Model	Battery Capacity (kWh)	Range (km)	Time to Full Charge Battery (hr)	Charger Output Rating (V, A)	Battery Technology	Connector	Charging Type
Namah Industries Pvt. Ltd.	Swastik	-	100-110	-	48 / 15	VRLA	Home charger	AC slow
GKON Electric Motor Vehicles Pvt. Ltd.	VEER	4.8	100-120	-	-	VRLA	Home charger	AC slow
	VEER CARGO	4.8	100-120	-	-	VRLA	Home charger	AC slow
Other Models	THUKRAL ELECTRIC BIKES PVT LTD (THUKRAL ER-1), J.S. Auto (E-CART), Asha Implex (DD-CARGO), Nirmal Utility Services Pvt. Ltd. (Tooktook), UMA Auto Industries Pvt. Ltd. (Manzil Express, Manzil Cargo), DD AUTO Pvt. Ltd. (e-Rick 1 Eco, e-Rick 1 Eco Load King, e-Rick 1 LD Plus), Trishika Industries (Kaizen M10), M. K. Enterprises (SAGUN SDLX, SAGUN, SAGUN ECART), Shri Ram Autotech Pvt. Ltd (JANGID LDR, Jangid Deluxe, DLX Prime), A.K. Gupta & Co (TUSKAR, TUSKAR-L), M/S New Arcana India (BYBY), CEEON INDIA (EASY WAY ERX), AVL Electric Vehicles (CAPTAIN POWER, CAPTAIN CARGO, CAPTAIN, CAPTAIN INDIA), PARVEEN AUTO (USTAD), SHIV OM INDIA (JAUNGA, SANWRA, TARA), M/s MINI METRO EV LLP (MINI METRO LD400), M/s MAA Shakti Exim Pvt. Ltd. (SAARTHAK E-Champion), M/s KLB KOMAKI PRIVATE LIMITED (KOMAKI), Laxmi E-Rickhsa (AAMDANI), Rajiv Raj Vehicles Pvt. Ltd. (RVR-BULBUL, BULL MAN), Shri Ram Autotech Pvt. Ltd. (DLX Prime, Jangid Deluxe, JANGID LDR), IMAGE S3P AUTOTECH INDIA (ATUT SANGAM DLX), Jaisik Business Links Pvt. Ltd. (Sahej Savari 0.9AX), Exide Industries Limited (NEO)							

Table 5.4: e-4W models available in India [86]

EV Manufacturer	EV Model	Type of Charger	Connector	Battery Technology	Battery Capacity (kWh)	Range (km)	Time to Full Charge Battery (hr)	Electric Vehicle Efficiency (km/kWh)
Hyundai	KONA	AC (7.2 kW onboard charger) and DC (50 kW)	CCS 2	Li-ion	39.2	452	6 (AC Charging), 1 (DC charging)	11.53
Tata	Nexon EV	AC (3.2 kW onboard charger) and DC (50 kW)	CCS 2	Li-ion	30.2	312	8.5 (10-90%) [Normal]; 1 (0-80%) [Fast]	10.33
	Tigor EV 2021	AC and DC	CCS2	Li-ion	26	306	8.5 (0-80%) [Normal]; 1 (0-80%) [Fast]	11.76
Mahindra & Mahindra	e20 Plus P6	AC	BEVC-AC001,	Li-ion	10.08	115	6	11.4
	e-Verito D6	AC charger	BEVC AC001,	Li-ion	18.55	140	11.5 (0-100%) [Normal]; 1.5 (0-80%) [Fast]	7.55
	e-Supro Cargo Van	AC charger	BEVC AC001,	Li-ion	14.4	115	8.5 (0-100%) [Normal]	7.99

EV Manufacturer	EV Model	Type of Charger	Connector	Battery Technology	Battery Capacity (kWh)	Range (km)	Time to Full Charge Battery (hr)	Electric Vehicle Efficiency (km/kWh)
Morris Garages (MG)	ZS EV	AC (7 kW on-board charger) and DC (50 kW)	CCS 2	Li-ion	44.5	420	6-8 (0-100%) [Normal]; 0.83 (0-80%) [Fast]	9.42
Mercedes-Benz	EQC	AC (7.4 kW on-board charger) and DC (110 kW)	CCS 2	Li-ion	80	472	12 (AC Charging @ 7 kW), 1 (DC charging)	5.9
Jaguar	i-Pace	AC (11 kW on-board charger) and DC (100 kW)	CCS2	Li-ion	90	470	-	5.2
BMW	iX	AC (11 kW on-board charger) and DC (150 kW)	CCS2	Li-ion	76.6	372-425	100 km in 1 hr 39 mins (AC charging @ 11 kW) 100 km in 8 mins (DC charging @ 150 kW) 100 km in 21 mins (DC charging @ 50 kW)	4.4-5.15
Audi	e-Tron GT	AC (11 kW with optional 22 kW) and DC (270 kW)	CCS2	Li-ion	83.7	388-500	9 hr 30 mins (5-80%) [AC @ 11 kW] 22.5 mins (5-80%) [DC @ 270kW]	5.97
	RS e-Tron GT	AC (11 kW with optional 22 kW) and DC (270 kW)	CCS2	Li-ion	93.4	401-481	9 hr 30 mins (5-80%) [AC @ 11 kW] 22.5 mins (5-80%) [DC @ 270kW]	5.14
Champion PolyPlast	Saarathi Golf Cart	-	-	Li-ion	8.1	-	4-5	-
Upcoming Models	Renault KWID, Renault K ZE, Tata Tiago EV, Tata Altroz EV, Mahindra XUV400 Electric, Mahindra eKUV100, Mini Cooper Electric, Hyundai Kona Electric 2022, MG ZS EV 2022, Volvo XC40 Electric, BMW i4							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06

Grid Integration of EV and its Impacts on Distribution System

EV charging load is power intensive and concentrated charging of multiple EVs in a particular location can put significant stress on the distribution network. The impacts of grid integration of EVs have been discussed in detail in Chapter-6 (Page 87) of Report 1 of this project[87]. In this Chapter, the current status of grid integration of EVs of a few EV rich states in India have been explored. Along with this, critical analysis of a few select tenders that have been floated for EV charger installation in the nation have been carried out.

6.1 Current Status of EV Integration in EV rich states

As the EV ecosystem in India is still at the nascent stage, so level of preparedness for EV accommodation varies among DISCOMs. While some states such as Delhi, West Bengal, Karnataka, Maharashtra, Kerala and Telangana have made promising strides in the development of the charging infrastructure, the respective state electricity distribution companies have undertaken different initiatives to manage the increased demand due to EVs in their distribution networks. However, in majority of the states EV penetration is currently very limited, and as such DISCOMs in these states are experiencing minimal EV charging demand. Therefore, grid integration of EVs in some of the EV rich states along with the relevant initiatives taken by respective DISCOMs have been analyzed in this section.

6.1.1 DELHI

Delhi is served by the Delhi TRANSCO Limited (DTL) which is the state transmission system operator along with 4 DISCOMS as listed below:

- Tata Power Delhi Distribution Ltd. (TPDDL)
- BSES Rajdhani Power Ltd. (BRPL)
- BSES Yamuna Power Ltd. (BYPL)
- New Delhi Municipal Council (NDMC)

To have an insight of the different segments of the vehicle owners, BRPL and India E-Mobility Finance Facility (IEMF) conducted a survey in 2020 to understand the customer needs. The survey considered all the four segments of vehicle owners:

- Personal use vehicle owners
- BRPL's commercial consumers like, hotels, restaurants, malls, offices etc.
- Fleet operators
- Individual commercial drivers (3W segment)

6.1.1.1 Personal use vehicles

Of the surveyed people in this segment only 10% showed interest in owning an EV with the primary hurdles being,

87 Zakir Rather, Rangan Banerjee, Angshu Nath, Payal Dahiwale, 'Integration of Electric Vehicles Charging Infrastructure with Distribution Grid: Global Review, India's Gap Analysis and Way Forward, Report 1: Fundamentals of Electric Vehicle Charging Technology and its Grid Integration', GIZ, NITI Aayog, 2021. https://changing-transport.org/publication/fundamentals-of-electric-vehicle-charging-technology-and-its-grid-integration/?nowprocket=1

- Long charging times
- Lack of access to private charging places
- High upfront cost of EV

Majority of the population in Delhi reside in Residential Welfare Associations (RWA). The RWAs have on an average about 100 homes with about 25% of them on lease. The average sanctioned load of each household in around 4.2 kW with different types of electricity[88] . Some residences have a common meter from BRPL, which is then sub divided into sub-meters. BRPL bills the RWA, which then depools the bill based on consumption recorded in the sub-meters of each individual household. In other cases, each home is directly metered by BRPL. The RWAs also generally have a common meter for the common facilities such as lifts, street lighting etc which is included as maintenance bill of the residents. Although the complexes have parking slots available, the number of vehicles in the communities exceed the parking spaces by about 40%. Therefore, in order to set up EV charging stations, the RWAs were generally favourable as it would add an extra revenue stream as well as allow a green branding to the society. The RWAs were also keen to allow DISCOMs to control the charging during peak periods as shown in Figure 6.1. Installation of private charger for each residence in an RWA will not be possible, due to metering issues, availability of headroom in the contracted load of the residence etc. So, shared chargers would instead be installed in these locations, where the chargers would be shared among two or more residents.[89]

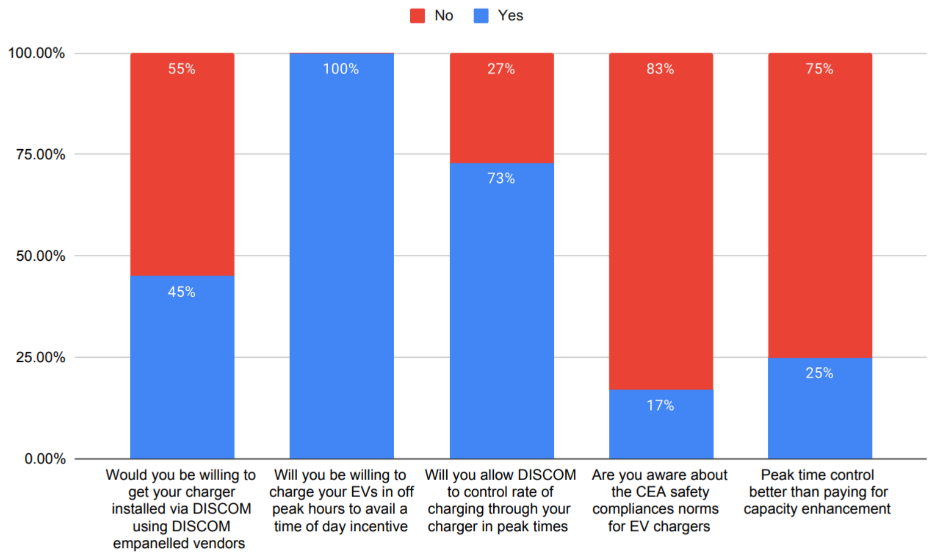


Figure 6.1: Opinions of personal vehicle owners on DISOCM engagement[89]

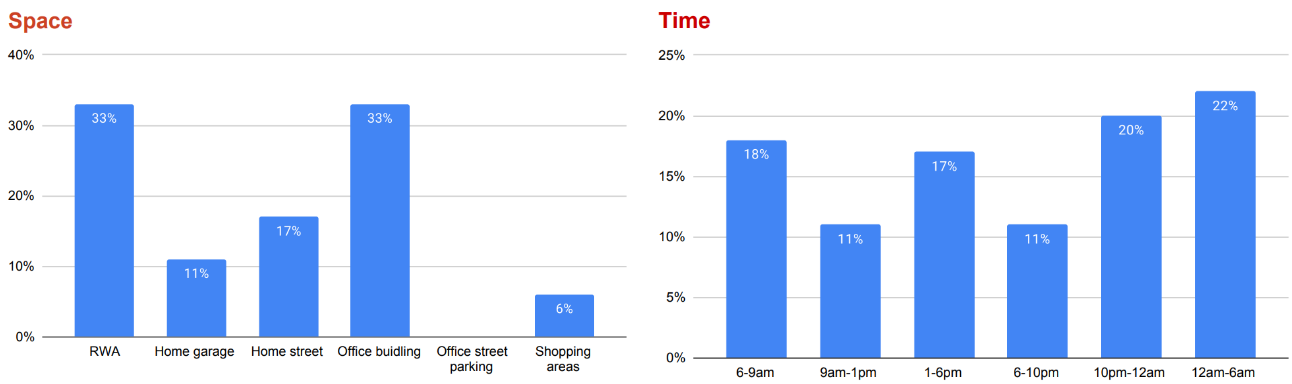


Figure 6.2: Daily parking practices

88 BSES, "Consumer Insights For Electric Vehicle Charging ProgramsDelhi," 2020.
89 BSES.

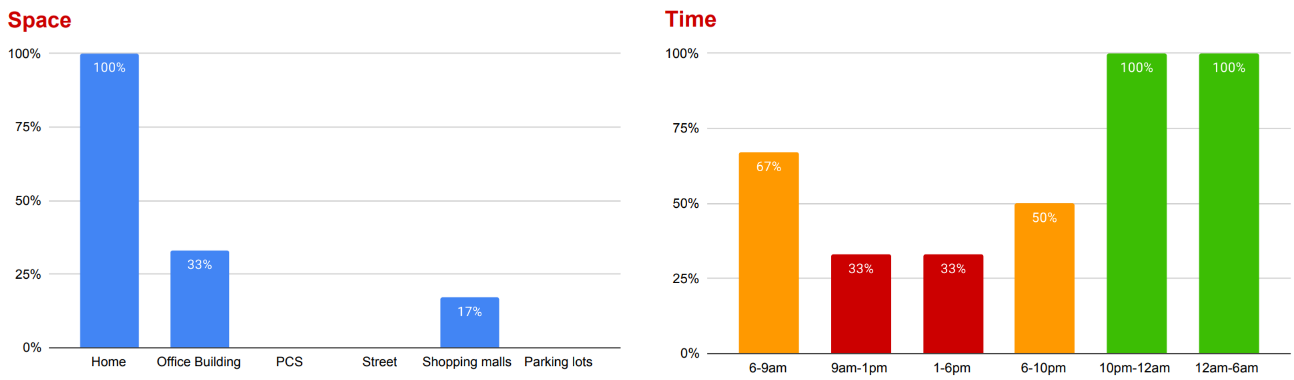


Figure 6.3: Indicative charging distribution[90]

The average parking habits of a personal vehicle is shown in Figure 6.2. As per the survey, it was also found that private charging is the most preferred mode of charging, followed by office charging. It has also been reported that the users would prefer charging during the night as shown in Figure 6.3.

As home charging is one of the most preferred methods of charging, DISCOMS play a vital role in setting up of EV chargers (more pronounced for 4-Wheeler chargers, as chargers for 2-Wheeler vehicles is typically <3 kW). There are two primary roles of the DISCOM,

- DISCOMs can assess the overall load profile and set up charging control strategies so that EV charging does not add to the peak load.
- DISCOMs can also provide additional infrastructure upgrade, but the upgradation charges are to be paid by the customer[91].

Rules and Standards for grid connection of EV as mandated by BSES

- IEC 61851-1: General requirements
- IEC 61851-21: Electric Vehicle Requirements for conductive connection to AC/DC supply
- IEC 61851-22: AC Electric Vehicle Charging Stations
- IEC 61851-23: DC Electric Vehicle Charging Stations
- IEC 61851-24: Digital connection between a DC EV Charging Station and an Electric Vehicle for Control of DC Charging
- IEC 62196-1: Definitions
- IEC 62196-2: AC Connector
- IEC 62196-3: DC Connector
- IEEE 519: Recommended practice and requirements for Harmonic control in Electrical Power Systems
- IEC 62305: Protection against Lightning
- IEC 60950: Safety IS 732: Earthing
- IEC 60529: Degrees of protection provided by enclosures

6.1.1.2 Fleet operators

The next segment of vehicle users are the fleet aggregators. In the initial growth phase of EV market, the fleet operator segment is the most crucial segment as they are expected to form the bulk of early adopters for EVs. The primary driver of willingness of a fleet aggregator to move to EVs is the lower Total Cost of Ownership (TCO), due to lower operational costs.

In most fleet operations, the charging of EV typically happens in a central location so that the management of allocation of chargers can be more efficient. These are generally termed as group charging stations and the fleet aggregators generally set-up their own charging infrastructure. However, the fleet operators reported that the biggest challenge faced while installing the chargers was, first the optimization of the site locality and second, securing a required load sanction from the DISCOMs. The fleet operators faced long lead times in obtaining the required permissions.

Fleet operators are, however, keen towards battery swapping stations as it increases the vehicle availability time.

6.1.1.3 The 3-wheeler segment

The current electric 3-wheeler segment in Delhi has a higher market share than any other fuel type as shown in Figure 4.8. However, one of the hurdles faced by this segment of EV owners is the lack of public charging infrastructure. As per the opinion of the drivers, the best locations for installation of chargers include near the driver's residences for overnight charging as well as chargers in their route plans.

A typical commercial 3-wheeler offering public transportation services drive about 110-130 km per day .

90 BSES
91 BSES, "Utility Led Electric Vehicle Charging Programs," 2020.

6.1.1.3.1 Charging options of 3-Wheelers

6.1.13.1.1 Home Charging

Nearly all 3-wheeler drivers park their vehicles at their residences from 10 pm to 8 am the next day. The charging at their residences is generally done using 230 V home plugs at rented rooms with a sub-meter. Users working in e-fleets generally have their vehicles charged in the charging stations maintained by the fleet operators where the vehicle is charged for around 2 hours[92].

6.1.1.3.1.2 Day charging

Users with 3-wheelers having lead acid batteries reported that they do not charge their vehicles during the day and only charge them over night. This could be due to the long charging times of the lead-acid batteries. Drivers working under fleet operators however reported charging their vehicles at least once in a day, typically during lunch hours.

6.1.13.1.3 Local charging hubs

In Delhi, makeshift charging hubs have cropped up in localities with the homes of the e-rickshaw drivers. These spaces can accommodate up to 60 vehicles at a time and are typically tied up with the EV owners. They tend to offer charging solutions to the EV owners based on subscription models (INR 2500 – 3000 (EUR 28.4-34.05) per month) or pay as you use models (INR 100 – 200 (EUR 1.13 – 2.26) per charging event). However, safety concerns were observed in these hubs as listed below:

The charging stations used either a fuse or an MCB instead of the BSES recommended ELCB.

- The electricians/workers lack the required certified qualification and training.
- The lead-acid batteries have been over-use to the point where corrosion has started to set in.
- There is no system in place in these charging stations to control overloading in the distribution feeder.
- The wirings used were of inferior quality, which is a major safety concern.

6.1.1.4 Procedure for setting up of new EV charger

In order to set a new EV/E-rickshaw charging station (both public and private), the applicant needs to send an application with details such as address of the premises where the charger would be installed, whether the connection would be temporary or permanent, whether the locality is a residential area/ industrial area/ rural area/ shopping complex etc. In addition, the applicant is also required to mention if they want a BSES meter or they have

Figure 6.4: Delhi's e-rickshaw charging hubs

92 BSES, "Consumer Insights For Electric Vehicle Charging ProgramsDelhi."

an existing meter, the desired load (in kW/kVA) and the voltage level from which the power would be drawn (LT/HT/EHV). After the application is filled a security deposit of INR 2,500 (EUR 28) per KW or kVA is to be paid by the customer along with any cost of network upgradation that may be required to accommodate the charger.

Similarly, BYPL have also released an application, which an applicant has to fill in order to install an EV charger. A copy of both applications has been provided in Annexure 2.

6.1.1.4 Smart Grid Lab by Tata Power Delhi Distribution Limited[93]

The Smart Grid Lab by Tata Power DDL provides a test bed to demonstrate smart grid technologies for distribution utilities in the Indian context. The Smart Grid Lab rolled out different technologies such as Advanced Distribution Management System (ADMS) and Distribution Network Automation. One such technology facilitated by Smart grid is Automated Demand Response. This program responds to period of high demand by shifting the consumer load from high peak periods to off-peak periods to reduce grid stress. The participation of consumers is response to factors such as incentive pricing, new tariff schemes and greater awareness and an increased sense of responsibility of the consumers.

For the pilot of the Demand Response programme, 161 commercial and industrial consumers were enrolled with each customer having a minimum sanctioned load of 100 kW and above. In future scenarios, public charging stations can potentially also be integrated into this program to perform demand response services. The Demand Response programme has been enabled by the rollout of smart meters by Tata power DDL.

6.1.2 RAJASTHAN

The Rajasthan Electricity Regulatory Commission (RERC) has undertaken different activities in the matters of EV charging infrastructure. Regarding the availability of energy for required EV charging load, RERC has stated that under the existing PPAs the state DISCOMs have enough energy to meet the additional demand. The surplus power for fiscal year 2019-2020 was assessed to be around 6,372 MU[94].

Regarding installation of charging station, RERC followed the guidelines by Ministry of Power and has de-licensed the establishment of public charging stations. Although DISCOMs are also allowed to install PCS at any location as suitable for the DISCOM, there is no mandatory requirement. The commission has also assured that provision of connectivity to PCS would be provided on a priority basis by the distribution company. The PCS is required to have tie-ups with service provider for enabling of remote/online booking of charging slots and for provision of information regarding charger location, type of charger and number of chargers installed at the station.

The DISCOMs would also maintain a database of all the PCS in its jurisdiction. In its database, the details of the PCS including type of chargers/connectors/rated voltage/number of charging points and the type of charging available would be maintained, and the database should be available on the website of the DISCOM. A separate mobile application would also be developed by the DISCOMs with support from IT companies, where real time updates on the availability of chargers, available load of the charging station, distance from location of user to the charging station and the applicable tariff including taxes and service chargers shall be accessible to all the EV users in the area of supply.

The DISCOMs have been advised to publish information on standard practises and protocols for charging infrastructure in their respective websites accessible to the public. This information would act as guidelines for installation of charging infrastructure and all charging stations are required to adhere to these guidelines along with the guidelines and standards notified by MoP/CEA.

The DISCOMs would also set up an EV cell for monitoring the charging stations installed. The PCS set up through privately owned model of PPP model would need prior clearance from an authorized official designated by the EV cell of the DISCOM, before being operational and

93 "Smart Grid Lab" (Tata Power DDL, n.d.).
94 RERC, "In the Matter If Charging Infrastructure, Tariff and Other Regulatory Issues for Electric Vehicles," December 21, 2020.

accessible to the public[95]. The cell would also be responsible for monitoring the increase in load due to EV charging and would accordingly plan the load management for efficient functioning of the grid.

The regulatory commission has allowed the PCS to purchase power from any source through Open Access in accordance with the terms and conditions for the Open Access Regulations 2016. Also, as per the RERC Renewable Energy Tariff Regulations 2020[96], there shall be 100% exemption in intra state transmission chargers and wheeling charges for solar project established before 31st March 2023 for supplying power to EV charging stations. This exemption would be valid for the initial 10 years from the date of establishment of the EV charging station[97].

In order to control the EV charging load, RERC has structured ToU tariffs specifically for EV category. As per the tariff, during off-peak hours (11 pm – 6 am) there would be a 15% rebate for public charging station. The consumers of other categories charging their EVs in their respective premises would however be charged at their respective existing tariff category, provided that the EV charging load does not exceed the contracted demand. If the EV load exceeds the contracted demand, the consumers should apply to the DISCOMs for a connection upgradation. The commission has also focussed on the implementation of smart charging for optimization of the charging process according to distribution grid constraints and local RE availability. It has mandated that the respective DISCOMs would install smart meters at all the PCS for implementation of smart charging. Further, the respective EV cells of each DISCOM would supply a monitoring and evaluation report to the SNA on smart charging features to be implemented by the PCS, each year. Also, the EV cells would conduct study regarding V2G and G2V and submit their plans to the SNA, so that the DISCOMS may plan for their future power requirement.

6.1.3 WEST BENGAL

The Kolkata metropolitan area has an extensive network of public transport system including buses, metros, trams, ferries, and railways. The study done by Indian Smart Grid Forum qualitatively and quantitatively assessed the potential for electrification of public transport in Kolkata.

The city of Kolkata is serviced by two DISCOMs, the Calcutta Electric Supply Company (CESC) and the West Bengal State Electricity Company Limited (WBSEDCL). In addition to the AC network, Kolkata also has a network of 550 V overhead DC line for its trams, and this DC network can be utilized by the e-buses for DC charging, reducing the cost on infrastructure requirement. Slow chargers can be accommodated in the 415 V LT grid, but power supply for most fast chargers will need to be fed at 11 kV. Thus, placement of these fast-charging stations requires a careful study of the daily load pattern and the available capacities of the DTs in the network.

The hourly available headroom in 4 representative DTs is shown in Figure 6.5, where the red cells indicate little or no available headroom, yellow denotes 40%-50% capacity available and green indicates 80% of DT capacity is available for EV charging[98].

For the purposes of electrification of public transport buses, first an analysis was done for route selection and prioritization considering the following criteria

- Route Congestion, as electrification of highly congested routes will lead to higher fuel savings and lower emission.
- Route Distance, which is optimized based on the size of the battery of the bus.
- Overlap with Electric Tram Infrastructure, thus using the already existing DC infrastructure for EV charging.

Based on the above criteria WBTC included 80 e-buses into operation on 12 different routes by 2019, with plans to increase their e-bus fleet to 5000 by 2030. The buses are charged at 10 charging depots most of which are equipped with 60 kW or 120 kW chargers .

95 PCS for EVs would be set up based on the following models
DISCOM owned PCS
Privately owned PCS
Public Private Partnership (PPP) charging stations
96 RERC Renewable Energy Tariff regulations 2020
97 These exemptions shall only be applicable for projects with an individual plant with rated capacity of maximum 25 MW and for the total project capacity of 500 MW.
98 Implementation Plan, "Report on Implementation Plan for Electrification of Public Transportation in Kolkata," India Smart Grid Forum, 2017, https://indiasmartgrid.org/reports/Report_Implementation_Plan_for_Electrification_of_Public_Transport_in_Kolkata_1_November_2017.pdf.

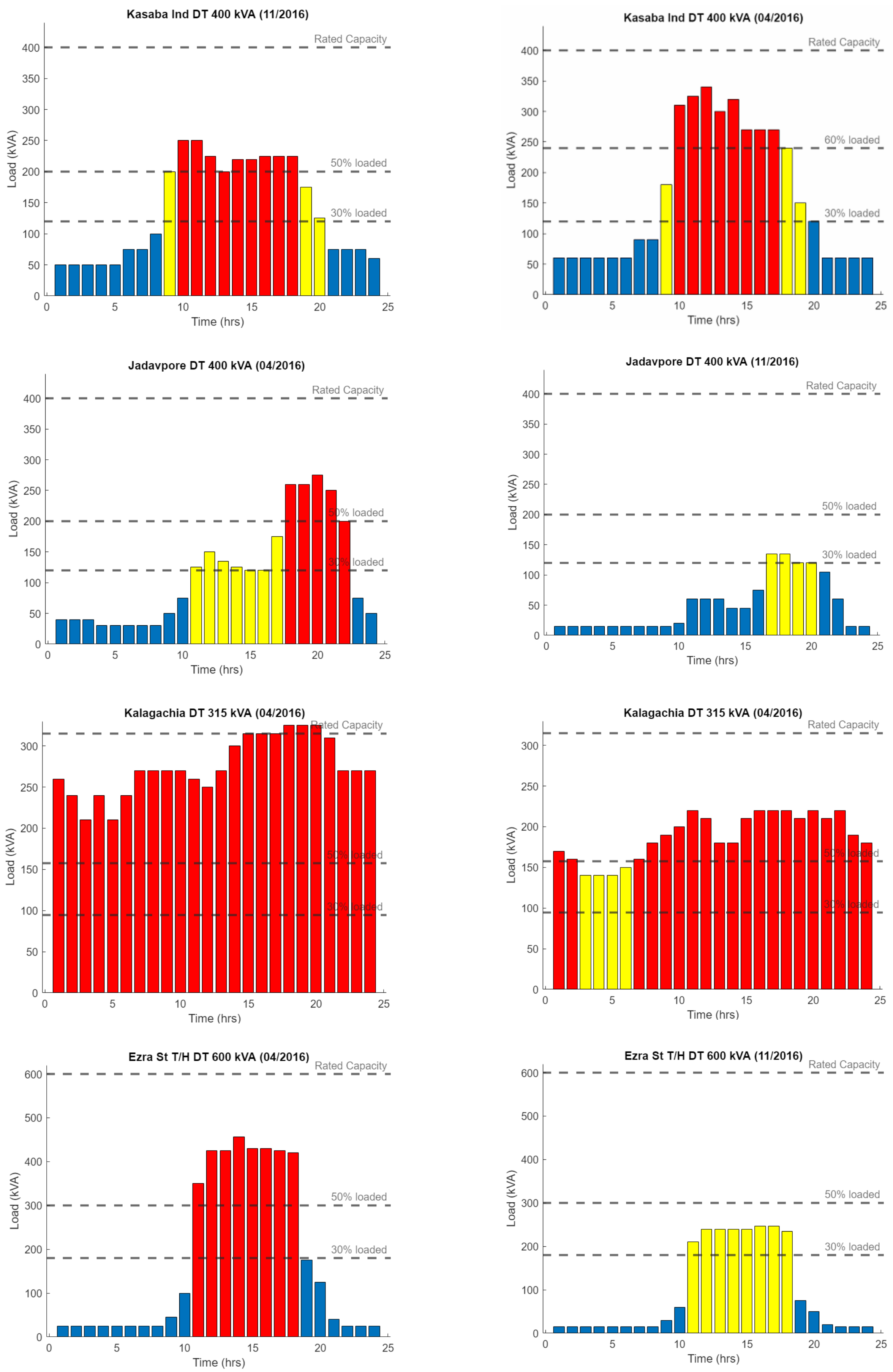


Figure 6.5: Headroom availability in 4 representative DTs in Kolkata[98]

6.1.4 OTHER STATES

6.1.4.1 Karnataka

Bangalore Electricity Supply Company (BESCOM) initially started with Level-1 AC and DC chargers and gradually moved towards fast chargers. Initial installation of chargers first started in BESCOM corporate offices with two 15 kW GB/T chargers followed by state government offices viz, metro corporation, road transportation corporation, and civic bodies. It rented 5 EVs in 2017, and now it has installed twelve 25 kW CCS/CHAdeMO chargers. BESCOM has installed 136 charging units at 70 locations, out of which 35 are located at their own offices. 106 AC001 chargers, 18 DC001, and 12 25-kW CCS/CHAdeMO chargers are installed, and among all, the utilization of the CCS charger is the highest.

In Karnataka state, 172 charging stations have been allocated in the FAME-II policy . MOU is signed with NTPC for 103 chargers and REIL for 37 chargers for achieving this goal. BESCOM is helping them with the identification of land for establishing the charging stations. It contributes to the development of a charging management system for the charging network and can be accessed through the Electreefi app. This app monitors and records the type of chargers available, usage of each charger, and the revenue generated. It also allows booking an EV charger 30 minutes before visiting the charging location through the app. BESCOM has conducted a pilot project to utilize solar rooftop generation and energy storage for EV charging. A 20 kWp solar rooftop system and 43 kWh energy storage unit were utilized for providing power to a DC-001 charger. The priority of energy source can be set as per the requirement to either PV, storage, or the grid. BESCOM also performed load flow studies on selected feeders within their network to examine the impact of future load scenarios on their network.

As BESCOM is a State Nodal Agency for establishing charging infrastructure in the state, it appointed Delta Electronics to introduce a necessary reform in EV Charging Stations installed in several locations across the city[99]. The Delta team has delivered energy-efficient EV charging solutions through AC EV chargers, DC quick chargers, and charging station management systems. The chargers offer 94% efficiency with high performance, communication support and safety issued by UL, IEC, CHAdeMO, CQC and CNS. Delta has provided different AC and DC chargers to BESCOM for various applications, such as parking, workplace, fleet, and residential buildings. The variety of Delta's chargers provided to BESCOM are given in Table 6.1[100]:

Table 6.1: Variety of chargers provided by Delta to BESCOM

Charger Model	Charging mode	Power output	Connector	Communication connectivity	Authentication
Bharat AC001 charger	Mode 2	3.3 kW	IEC 60309 Industrial`	Ethernet, 3G/4G	OTP/ RFID
Bharat DC001 charger	Mode 4	15 kW	GB/T	Ethernet, 3G/4G	OTP/ RFID
DC wallbox	Mode 4	25 kW	CCS Type-2 (200-500 V DC) CHAdeMO (50-500 V DC)	Ethernet, 3G/4G	RFID

Delta chargers installed at various location in the city is shown in Figure 6.6. It provides a mobile application for managing the charging system and finding nearby charging stations and charging station details such as calling, navigating, booking slots, viewing status and availability, remote starting of charging. It also supports different payment modes such as RFID and other online OTP-based payment methods.

The journey of BESCOM in the EV charging sector has created an EV cell, promoted special EV tariff for charging stations, and introduced 5 EVs at the Energy Department, KERC, and BESCOM. It accounts for nearly 50% transition of government ICE vehicles with electric fleets at Corporate Offices of BESCOM[101].

In addition to the earlier proposed tenders, BESCOM invited a proposal for setting up EV Charging or Battery Swapping Stations at BESCOM premises on a land rental basis[102]. The proposal's scope covers installing and managing Electric Vehicle Charging stations on

99 Delta, "BESCOM EV CHARGERS: AT A GLANCE," June 29, 2021, https://deltaelectronicsindia.com/success-stories/bescom-ev-chargers/.
100 Delta.
101 Delta
102 BANGALORE ELECTRICITY SUPPLY COMPAIYY LIMITED, "INVITATION FOR EXPRESSION OF INTEREST: Settlng up EV Charging / Battery Swapping Stations at BESCOM Premises," April 21, 2021, https://webmail.iitb.ac.in/?_task=mail&_action=get&_mbox=INBOX&_uid=5440&_token=tUrijZdcWodNraQf8fnnOoFj7nWz1bcy&_part=2.

Figure 6.6: Delta chargers located at different locations in Bengaluru city

BESCOM-owned land for five years. The chargers in the charging station should comply with Bharat AC-001 and Bharat DC-001 or IS 17017 CCS2 / CHAdeMO / Type2 AC or proprietary standards. It further mentions that stations shall also include battery swapping station that are compatible with the vehicles popular in the EV market. The proposal is open to all the companies, government research organizations from all source countries, and government-owned enterprises.

6.1.4.2 Maharashtra

Maharashtra State Electricity Distribution Cooperation Limited (MSEDCL) has taken the initiative to establish a charging network. It has initiated a pilot project consisting of two charging stations at Nagpur and Pune in June 2018, as shown in Figure 6.7. It was further forwarded to Phase I, Phase II, and Phase III with 10, 40, and 450 charging stations.

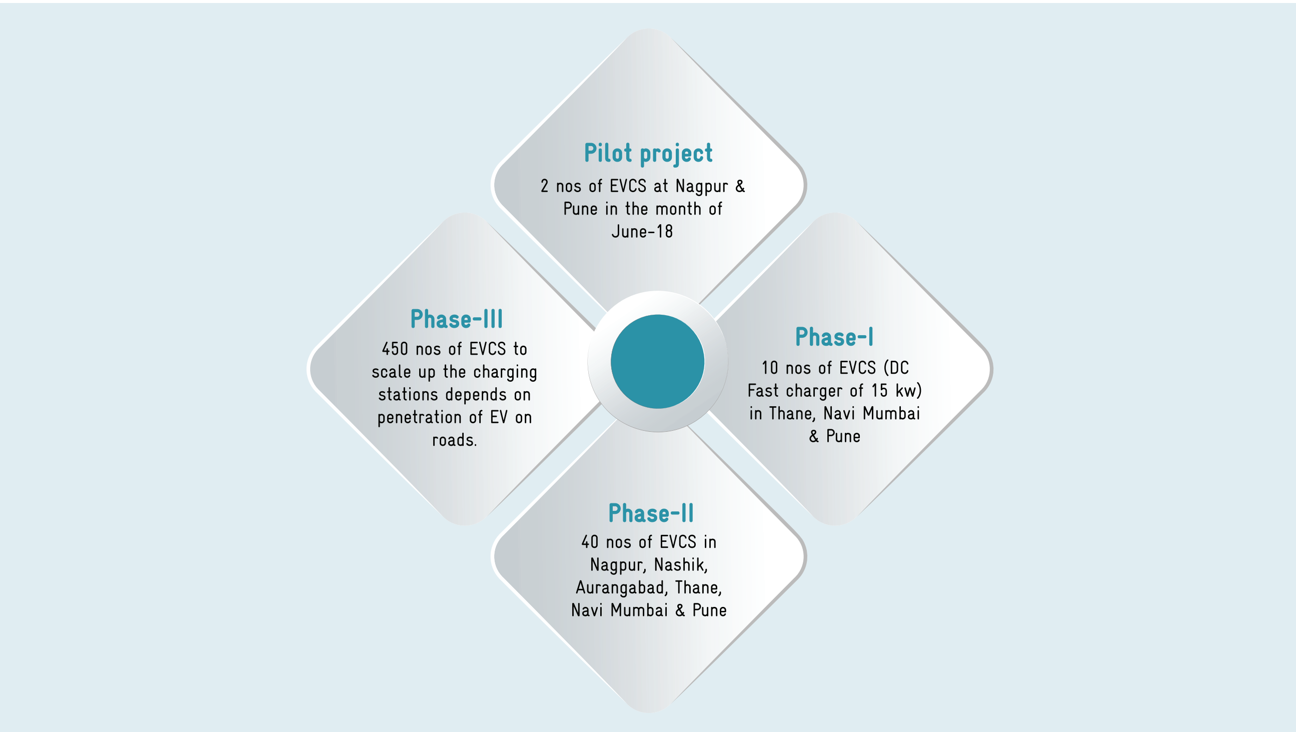


Figure 6.7: Phases of EV charging infrastructure establishment in Maharashtra

MSEDCL has initiated a cloud-based web portal[103] for EV charging infrastructure operating centre with features as provided in Figure 6.8:

Features of the cloud based web portal for charging infrastructure operating centre

- Status of EV Station
- Station Specifications
- Plug Type
- Power (DC, AC)
- Opening Times
- Cost, Available times (book through app/ MSEDCL Consumer number)
- Distance from current location
- Alternate EV station name and distance in case the nearest one is busy or not in service. Also, all proximal stations en route
- Advance booking of charging schedule.

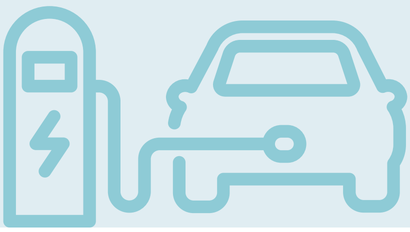


Figure 6.8: Features of cloud-based web portal introduced by MSEDCL

MSEDCL has invited a bid on June 2019 for Tender on Implementation of Electrical Vehicle Charging Infrastructure Operation Centre. The scope of the tender covers 50 charging station with scalability of 500 charging stations for 5 years. Scope of work for the tender given further:

1. Commissioning, installation, and supply of standard EV Charging Infrastructure solution on MSEDCL Cloud. It must include required Databases, map services and applied tools such as charting tools, etc.
2. Design of Web portal on Cloud for EV Charging Infra Operation Centre (OC) solution
3. Design of Mobile App for EV Charging Infra OC solution
4. The above software should be hosted on MSEDCL provided cloud
5. The supplier should provide 24 x 7 Support for EV Charging Infrastructure OC Solution including Web portal & Mobile App for 5 years
6. The supplier should integrate charging stations through Open Charge Point Protocol (OCPP) 1.5 or higher and with all existing and future versions of OCPP
7. The supplier should provide maintenance & support for facilities provided by the solution such as Billing, invoicing, collection, accounting & MIS reports for charging stations. Integrating the solution with payment gateways, SMS gateways and email gateways of MSEDCL (existing & future).
8. The supplier can be asked to Integrate the solution with Energy Audit (EA) module, MSEDCL portal, Online Cash Collection System (OCCS), MSEDCL Dashboards, MSEDCL ERP and other legacy systems
9. Train MESDCL personnel
10. The solution provided by the supplier should have required security audit compliance/certification

MSEDCL has invited another tender for establishing DC fast electric vehicle charging stations[104]. The scope of the bid covers "Planning, Designing, Engineering, Supply, Testing, Erection & Commissioning of 50 DC fast EV charging stations" compatible with Bharat DC001 for an execution period of 3 months and a replacement guarantee of 5 years.

Tata Power is an important private player in the Mumbai EV charging system. It installed the first charging station in Mumbai at Vikroli and added more at Palladium Mall Lower Parel and Phoenix Marketcity, Kurla, with two more coming up at BKC and western express highway at Borivali. The latest installation at Palladium Mall Lower Parel and

103 The cloud portal is accessible here: https://evcadmin.mahadiscom.in/evcs
104 MSEDCL, "Tender Notice: Dc Fast Charging Stations," January 2019, https://www.mahadiscom.in/supplier/wp-content/uploads/2019/02/NIT-for-EVCo.pdf.

Phoenix Marketcity has an efficient monitoring system that performs safe, convenient charging. It monitors car battery charging status and the number of units consumed while charging. Tata Power has introduced a TATA power EV charging mobile app that includes the option to find the nearest charging station, view the charging point's status, and make the online payment[105].

6.1.4.2 Kerala

Kerala is not a part of states establishing charging stations under FAME-I, whereas in FAME-II, 211 charging stations were sanctioned in Kerala[106]. Till 16 December 2021, Kerala had 57 charging stations installed in the state[107]. The 211 charging station installation plan constitutes 58 charging stations at KSEBL owned locations, 97 Government/ autonomous institutes-owned locations, and 56 private players-owned locations[108]. Out of sanctioned 211 charging stations, DHI issued a fund approval under FAME II to 79 charging stations (58 KSEBL-owned, 13 Government agencies-owned and 8 private-owned locations) as of July 2021. The installation work at 30 charging stations is in progress, out of which 25 are KSEBL-owned, and 5 are government agencies-owned locations. The upcoming charging stations at sites sanctioned under FAME-II and ready for tendering after May 2021 are given in Table 6.2[109]:

To establish this sanctioned number of charging stations, various agencies and departments have invited a bid for the construction and design of EV charging stations. Agency for non-conventional energy and rural technology under Government of Kerala has introduced a tender for "Design, Construction, Supply, Erection, Testing, and Commissioning of 30 kWp Grid Connected Integrated

Table 6.2: Location of upcoming charging stations ready for proposing tender

Sr. No	City	Location
1	Kollam	Ayathil KSEBL Substation land
2		Kavanad KSEBL Substation compound
3		Sub regional Store Kundara (Kollam- Theni NH side)
4		Koniyam I6EBL section office
5		220 kV Substation Kundara
6		Chavara KSEBL Section office premises
7		Koniyam Station Compound Kollam
8		Parippallya section office compound
9	Emakulam	Vytilla section office
10	Kannur	Valapattanam section office
11	Malappuram	110 kV substation Malappuram
12		110 kV substation Perinthalamanna
13		Vydyuthibhvanam Compound Venniyur
14		100 kV Substation Compound Ponnani
15		110 kV Substation Compound Tirur
16		33 kV Valluvambaram Substation
17		100 kV Substation compound Chelary
18	Thiruvanathapuram	100 kV TERIS Substation premises
19		Opposite to Thirumala Section Office
20		Avanavanchery section

105 TATA power, "TATA Power EZ Charge: EV Charging Solutions," June 29, 2021, https://www.tatapower.com/products-and-services/ev-charging-solutions.aspx.
106 DHI, "EV CHARGING STATIONS SANCTIONED / INSTALLED UNDER FAME INDIA," June 29, 2021, https://dash.heavyindustry.gov.in/dhics.
107 Ministry of Power, "Lok Sabha Unstarred Question No.3215 Answered on 16.12.2021 Electric Vehicles Charging Stations," December 16, 2021, http://164.100.24.220/loksabhaquestions/annex/177/AU3215.pdf.
108 KERAIA STATE ELECTRICITY BOARD LIMITED (KSEB), "Electric Vehicle Charging Stations (EVCS) under FAIVIE II Central Subsidy Scheme-Tendering of 20 EVC Stations InKSEBt Premises," June 4, 2021, file:///C:/Users/Payal%20Dahiwale/Downloads/b.o._ftd_no.425.2021_ce_rees_.innov.t4.pcs.fame_ii.2020-21_dated_04.06.2021.PDF.
109 KERAIA STATE ELECTRICITY BOARD LIMITED (KSEB).

Solar Roofing System with Battery Backup and Electric Vehicle Charging Station (EVCS)" at ANERT HQ, Thiruvananthapuram on November 2019[110]. It specifies the warranty period of 5 years from the commissioning of the system. The agency focuses on the sustainable and cleanest solution of energy for powering EVs to reduce carbon footprint. In addition to the tender mentioned above, Kerala State Road and Transport Cooperation KSRTC has announced another tender to supply fully ready nine meters non-AC electric buses with charging stations. It invited a supply of 50 non-AC buses and 25 charging stations. The tender mentions that the supplier should provide two years or 2 lakh kilometers warranty and must be willing to provide five years of annual maintenance after the warranty period.

The state is more inclined towards the procurement of electric buses in the public bus fleet. Kerala State Road and Transportation Corporation issued a tender in September 2019 for hiring 12 m Non-AC fully battery-operated electric buses[111]. The buses can be AC, DC or fast charging compatible, with no restriction on the charging type mentioned in the tender. It specifies three zones: 100 buses in Thiruvananthapuram Zone, 100 buses in Kochi Zone, and 50 buses in Kozhikode Zone.

The established and developing charging stations are also focusing on online payment modes. Due to persistent connectivity issues, a Government approved FTTH Plan 749 for EV charging stations is availed; which provides fiber and consistent connectivity[112]. A start-up named ChargeMOD, has come forward to cater for the increasing demand for EV charging by launching 250 community charging stations in Kerala[113].

In addition, KSEB has also recently installed 10 pole-mounted EV charging stations in Kozhikode, with plans to extend this to 1,000 units throughout Kerala. These stations are primarily installed to cater to the e-2W and e-3W users using level 1 AC EV Charger (3.3 kWx1 Gun). The cost of charging at these charging stations is around INR 9 (EUR 0.10) (with added taxes). So, a typical e-3W would be able to completely charge their EVs at a minimal cost of around INR 70 (EUR 0.79) (providing 120-130 km range)[114].

6.1.4.4 Telangana

Under the FAME II scheme, 138 EV charging stations were sanctioned in Telangana[115] out of which 65 charging stations were installed as of December 2021. The existing charging stations are majorly located in Hyderabad near metro stations. At present, there are 50 functioning charging stations in Hyderabad, and additional charging stations are being established at Warangal and Karimnagar, with ten charging stations each[116]. Three companies, namely Rajasthan Electronics & Instruments Ltd (REIL), National Thermal Power Corporation (NTPC), and Energy Efficiency Services Limited (EESL), are installing 37, 32 and 49 chargers, respectively . The ongoing charging station installation process considers the following charging configurations:

- 50 kW CHAdeMO + 50kW CCS + 22kW AC type 2: charger with three guns
- Bharat DC 001: 15kW, single gun
- Bharat AC 001: 10kW, three guns of 3.3 kW each

For increasing the number of EVs in the state, Telangana State Renewable Energy Development Corporation Limited (TSREDCO) is designated as a nodal agency. It has invited travel agencies/firms, fleet operators to supply four-wheeler electric vehicles for official use in government offices in Telangana .

Recently, Magenta Power management has signed an agreement with TSREDCO to deploy electric vehicles

110 ANERT, "E-Tender Notice for Solar Rooftop PV Powered EV Charging Station," November 20, 2019, http://www.anert.in/sites/default/files/inline-files/Solar%20Roofing%20Systm%20and%20EV%20Charging%20Station.pdf.

111 Kerala State Road Transportation Cooperation, "HIRING OF SINGLE AXLE 12 Mtr Non-AC Electric Buses," September 7, 2019, https://dhi.nic.in/writereaddata/UploadFile/Kerala_1.pdf.

112 Kerala State Road Transportation Cooperation, "Setting up of EV Charging Stations across Kerala- Fiber to the Home (FTTH) Connection ," February 26, 2021, https://www.kseb.in/index.php?option=com_jdownloads&view=download&id=17750:setting-up-of-ev-charging-stations-across-kerala-fiber-to-the-home-ftth-connection&catid=2:board-orders&lang=en

113 S. Anil Radhakrishnan, "250 Community EV Charging Stations by Year-End in Kerala," June 15, 2021, https://www.thehindu.com/news/national/kerala/250-community-ev-charging-stations-by-year-end-in-kerala/article34820947.ece.

114 KSEB, "Setting up of Pole Mounted Electric Vehicle Charging Points at KSEBL 's Distribution Poles in 10 Locations of Kozhikode City as a Pilot Project -Payment and Charging Fee," October 6, 2021, https://www.kseb.in/index.php?option=com_jdownloads&view=download&id=20632:setting-up-fo-pole-mounted-electric-vhicle-charging-points-at-ksebl-s-distribution-poles-in-10-locations-of-kozhikode-city-as-a-pilot-project-payment-and-charging-fee&catid=2&Itemid=654&lang=en.

115 DHI, "EV CHARGING STATIONS SANCTIONED / INSTALLED UNDER FAME INDIA."

116 Telangana Today, "118 Electric Vehicle Charging Stations to Dot Hyderabad," May 10, 2021, https://telanganatoday.com/118-electric-vehicle-charging-stations-to-dot-hyderabad.

in the state[117]. Magenta Power will deploy EVs and their charging infrastructure under the electric vehicle-enabled transportation platform (EVET platform). EVET is a tech-enabled platform used for optimal deployment of EV through a centralized network management system.

6.1.5 RECENT DEVELOPMENTS ON EV CHARGING INFRASTRUCTURE

The EV sector has seen tremendous growth in India in the past year. Some of the recent developments have been listed under.

- Hindustan Petroleum Corporation Limited (HPCL) and Magenta have collaborated to release the "ChargeGrid Flare", a streetlamp integrated charger, at HPCL Bandra Kurla Complex outlet in Mumbai and Niti Marg T&E outlet in Delhi. Magenta aims to install around 1000 such stations pan India by the end of 2021. The new set of chargers get automated payment gateway through the ChargeGrid App, thereby eliminating the need of having a station marshal to monitor, maintain and operate the chargers at the location[118].
- Jaguar Land Rover have installed charging infrastructure across more than 35 chargers in 22 retail outlets in the country till March 2021 in preparation of its electric SUV, the Jaguar I-Pace. The Jaguar I-pace can be charged at home using a 11 kW 3 phase AC charger or 100 kW DC charging at public charging stations. A mode 2 charging cable is also provided, which can be used to charge using a domestic 15 A socket[119].
- Fortum Charge and Drive Indian Private Ltd. which is one of the leading charge point installers in the Nordic countries has installed more than 71 public charging points across 39 cities which includes 15 kW DC001 chargers as well as 50 kW CCS/CHAdeMO chargers by November 2020[120].
- Tata Power, which is India's largest integrated power company, is aggressively expanding its charging network. The company has installed over 1000 EV charging station across 180 cities till October 2021. Tata Power has deployed all types of chargers including DC-001, AC Type 2, CHAdeMO and CCS up to 50 kW and also chargers for e-bus with power rating of 240 kW[121].
- Zypp electric, which is a last mile delivery service, has partnered with different grocery, e-tech, and food tech players such as BigBasket, Grofers, Modern Bazaar, Spencers among others. The company also has a fleet of around 1500 customized EVs for logistics purposes and is operational in major cities such as Delhi, Noida, Faridabad, Ghaziabad, and Jaipur[122].
- In order to make India attractive for global EV manufacturers and to boost the EV market, the Indian government has initiated an incentives program. Companies will receive 4-7% government cashbacks on the eligible sale and export value of vehicles and components, but for EVs and their components there is an additional 2% as a "growth incentive" to promote electric mobility. The automotive incentive scheme is part of India's broader INR 1,989 lakh crore (EUR 22,581 billion) programme to attract manufacturers from the likes of China and Vietnam to capture a bigger share of the global supply chain and exports[123].
- The Government of India has also discussed the possibility of construction of a separate e-highway on the 1300 km long Delhi-Mumbai Expressway. The e-highway would have electrified cables running which can power the electric trucks and buses as they travel along the highway similar to electric trains. The technology has already been introduced on a six mile stretch of road in Germany. The proposed construction would bring down the cost of logistics by about 70% along with the environmental benefits[124].
- The first single-app charging solution provider in India was recently launched in 2021. Called EV Plugs, the app maintains an updated database of EV charger listings (across multiple CPOs) and real-time status of its chargers, so that the EV users can utilize chargers based on their preference[125].
- EVRE, which is an EV charging infrastructure company, has partnered with Park+, a parking solution

117 Autocar Pro News Desk, "Magenta Signs Pact with Telangana Nodal Agency for EV Deployment," June 24, 2021, https://www.autocarpro.in/news-national/magenta-signs-pact-with-telangana-nodal-agency-for-ev-deployment-79447.
118 HPCL and Magenta collaboration (link)
119 Jaguar installs chargers (link)
120 Finnfund, "Fortum Partners with Finnfund to Speed up Charging Infrastructure Development and Growth in India," September 11, 2020, https://www.finnfund.fi/en/news/fortum-partners-with-finnfund-to-speed-up-charging-infrastructure-development-and-growth-in-india/.
121 Tata Power (link)
122 Zypp electric (link)
123 The automative incentive scheme (link)
124 1300 km Delhi-Mumbai e-highway (link)
125 EV plugs (link)

brand, to establish 10,000 charging stations across India in the next two years[126].

- Hero Electric has partnered with Axis Bank to facilitate easy financing options for the potential Hero e2W buyers[127].

6.1.5.1 Ola Nagpur EV Project

As one of the leading EV fleet operators in India, Ola has set a mission to deploy 1 million daily-use EVs by 2022. Under this vision, Ola launched India's first multi-modal EV project in May 2017 at Nagpur. It intends to proliferate EVs and experiment on optimizing battery and charging with multiple types of EVs to develop a robust business model of EV deployment in the country[128]. It provided knowledge on operational issues, performance issues, user charging behavior, battery performance at different conditions, and integration of renewables at charging stations. The project included electric cabs, electric rickshaws, slow and fast EV charging infrastructure, and a battery swapping station. For performing the project on diversified EV models, e-cabs and e-rickshaws from Mahindra and Kinetics were used in the project. The features of e-cabs and e-rickshaws studied in the project is given in Figure 6.9 and Figure 6.10.[129]

In its case study on the project in 2018-2019, Ola Mobility Institute reported that the project had helped reduce the emission of 1,230 tons of carbon dioxide in the entire duration, as shown in Figure 6.11.

Figure 6.9: Features of e-cabs used in project (Ola Mobility Institute, 2019)

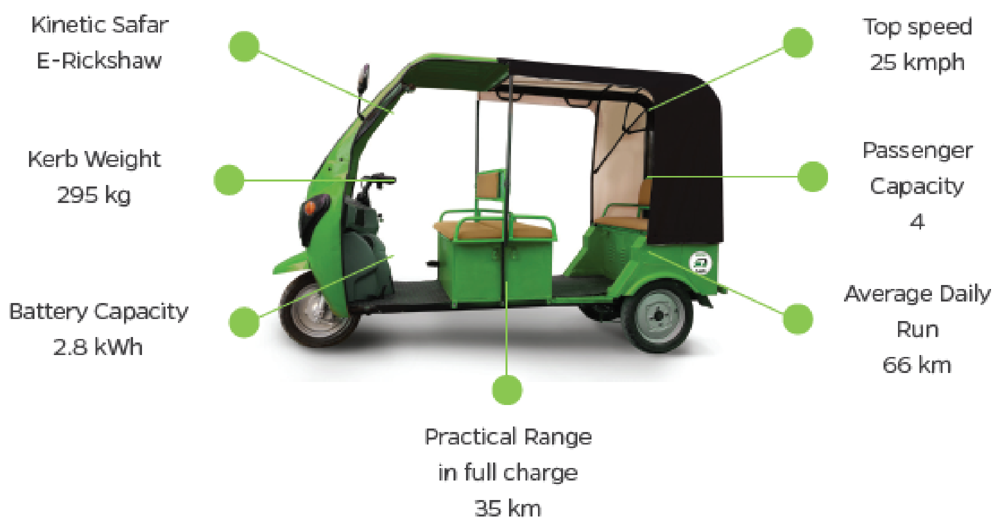


Figure 6.10: Features of e-rickshaw in the project [129]

126 EVRE (link)
127 Hero electric partnership with Axis Bank (link)
128 OLA, "Ola Launches 'Mission: Electric' to Put 10,000 EVs on the Road in 12 Months," April 18, 2018, https://www.olacabs.com/media/in/press/ola-launches-mission-electric-to-put-10000-evs-on-the-road-in-12-months.
129 Ola Mobility Institute, "Beyond Nagpur: The Promise Of Electric Mobility," 2019, https://olawebcdn.com/ola-institute/nagpur-report.pdf.

Customer served	Distance covered	fossil fuel saved	Carbon dioxide emission saved
3,50,000	7.5 million km	5.7 lakh litre	1230 tons

Figure 6.11: Project information collected during this study

For achieving an overall idea of EV and related components, the project intends to experiment on different fronts like effects of temperature on battery and charging, variation in charging behavior, and vehicle performance in extremely versatile climate conditions. Nagpur supports extreme climate conditions for various testing. In addition to climatic conditions, pro-active and favorable policies, and regulation, convenient size for EV ecosystem supports the selection of Nagpur for the multi-modal pilot project.

The project works on the daily leasing of Ola-owned EVs to driver-partners daily. The deployed Ola EV fleet is charged using a slow, fast, and swapping station. In addition to the public charging station, Ola has invested and built a charging point for slow charging at driver's residents, and it sets up the ecosystem of home charging. The capacity and working of EV charging stations in the project are given in Table 6.3.

Table 6.3: Capacity and working of EV charging stations in Nagpur pilot project[130]

Location	Connected load	Number of chargers
Dr. Ambedkar International Airport	150	4 fast and 4 slow
IOCL fuel station	30	2 fast and 2 slow
Nandanvan	150	5 fast and 5 slow

The E-rickshaw used had an advanced lithium-ion battery of 2.85 kWh and came with a special portable slow charger. It takes nearly 2 hours for charging e-rikshaw using a fast track charger and 6 hours using slow charging.

The project data on battery and travelling distance depicts that the average range per charge and varies as 100 km in summer and 110-115 km in winter, depending on the ambient temperature variation in summer and winter.

The break-up of operation cost of charging infrastructure (after October 2018) is given below in Figure 6.12.

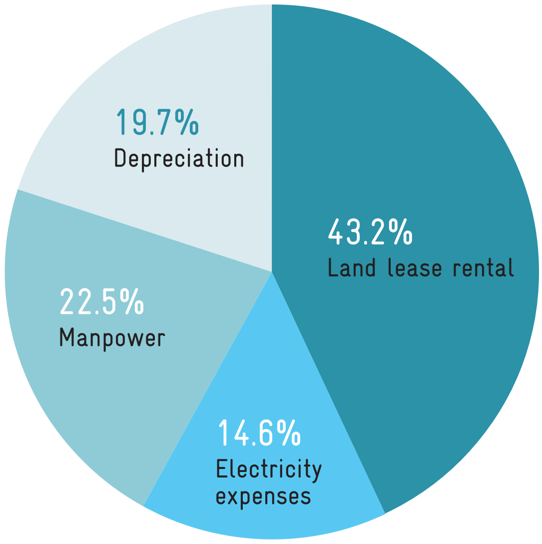


Figure 6.12: Operation cost of charging infrastructure

Project analysis revealed that the total cost of ownership (TCO) at various scenarios for 4W is diminishing compared to the total cost of EV vehicles at the beginning and given in Table 6.4.

Table 6.4: Total cost of ownership of EV and IEC diesel vehicles[131]

Scenario	Total cost of ownership ((INR/EUR)/km)	
	Electric vehicle fleet	ICE diesel fleet
Till September 2018	13.14/0.15	8.86/ 0.01
After EV tariff on October 2018	11.54/ 0.13	8.86/ 0.01
EV charging electricity cost as INR 5/unit with additional waive rin land rent and permit chargers for charging station	9.77/ 0.11	8.86/ 0.01
Expected TCO in 2026	9.9/ 0.11	9.45/ 0.01

TCO comparing EV and ICE-based two-wheeler shows that TCO of e-3W (INR 3.73/km (EUR 0.04/km)) is slightly more than TCO of IEC 3W (INR 3.44/km (EUR

130 Ola Mobility Institute.
131 Ola Mobility Institute.

0.04/km)). Similarly, for e-2W, it is INR 2.25/km (EUR 0.03/km), and IEC 2W is INR 2.03/km (EUR 0.02/km).

The fundamental understanding and learning from the project are shown in Table 6.5.

Table 6.5: Key understanding and learning of the project

Key learnings from the Ola Nagpur Project
Shared mobility is crucial for the success of e-mobility
Enhancement of the charging infrastructure is necessary
Scrapping incentives on ICE vehicles redeemable only at purchase of an EV is essential for increasing the adoption of electric vehicles
Expedition of regulatory processes
Need for longer lock-in period of land leased for charging infrastructure
Inclusion of rooftop solar at charging station would increase the financial viability of the project

The suggested scheme from the analysis and performance of this project is given below in Table 6.6.

6.2 Battery Swapping Station

On 12th August 2020, the Ministry of Road Transport and Highways, in a bid to accelerate the adoption of EVs in the country, had approved the sale and registration of electric vehicles (EVs) without batteries[132]. The reason behind the move is to separate the cost of the battery from the cost of the EV, which accounts for around 30-40% of the EV cost and thereby address the issue of high upfront cost for EVs[133]. However, the move was met with mixed reactions from stakeholders, some of whom cited reliability and accountability issues since low-quality batteries are a fire hazard and the GST on batteries at 18% is higher than that on EVs at 5%. However, several stakeholders in the industry wholeheartedly welcomed the move pointing out that such a step could open up new subscription models. A customer could choose to pay for the battery depending on the distance they are willing to cover in a definite period (weekly, monthly, or annually) or even choose to lease a battery. The pay-per-swap options is made available for fleet owners and commercial EV users such as 2-wheelers and 3-wheelers[134]. It has long been a constant effort by the stakeholders to make the government adopt battery swapping in an elegant way to supplement the growth of charging infrastructure that is heavily

Table 6.6: Suggested scheme

Suggested scheme for early EV adoption	Suggestion to make e-mobility financially viable	Suggestion to set up and strengthen charging infrastructure
Incentivize usage of EV rather than purchase	Reduce the delivery cost of charging electricity	Provide a concessional location for battery swapping stations in every district
Target batteries for incentivization	Implement time-of-day tariff	Reimburse 100% of net SGST on the purchase of advance batteries for swapping stations.
Incentivize scrapping of ICE fleets	Allow open access for electricity purchase and integration of renewable generation	
Support retrofitting of vehicle segments		
Reduce and make consistent GST on eV, battery, charging/swapping station		
EV segments should be excluded from permits		
Subsidize EV fleet electrification		

132 MoRTH allows sale and registration of electric vehicles without batteries (link)
133 N. Madhavan, "Should Govt Promote EV Battery Swapping?," The Hindu BusinessLine, August 27, 2020, https://www.thehindubusinessline.com/opinion/columns/should-govt-promote-ev-battery-swapping/article32458638.ece.
134 Varun Goenka, "Battery Swapping...," The Hindu BusinessLine, June 3, 2021, https://www.thehindubusinessline.com/opinion/battery-swapping-the-key-to-ignite-greater-ev-adoption/article34720214.ece.

investment-dependant. The whole idea behind it is to swap a discharged battery for a fully charged one at a designated location, saving significant time and productivity since a bare minimum time is lost in swapping. However, there are stark issues with the whole battery swapping program, one of which is the need for standardization of the batteries. It is practically a double-edged sword since standardization will delay the innovation and development of battery technology is evolving rapidly in recent years to improve energy density, shape, size, and the battery management system. However, on the other hand, it also allows battery swapping to take off successfully as the consumer will be able to visit more locations to swap the same model of the battery. However, since each manufacturer approaches the construction of batteries differently and India itself is in a nascent stage of battery development, it would not be wise to put a hold on it by standardization necessary for battery swapping.

However, battery swapping provides an immediate solution to some of the most glaring concerns from EV consumers, namely, range anxiety (number of kilometres that can be covered without the need to recharge) and the economic viability of EVs. Battery swapping helps in the mass adoption of EVs and improves their price-performance significantly by allowing the user to cover more mileage in a limited time. The need is to provide more financing incentives on EVs and the batteries, which would encourage battery swapping to a great extent.

The battery swapping service is typically owned by an Energy Operator (EO), which provides a fully charged battery in exchange for a discharged one. The EO purchases the batteries in bulk, charges them, and leases them to the owners at the charging-cum-swapping centres through a suitable business model. For 2-wheelers or 3-wheelers, the swapping can be done manually since the batteries are light, but for 4-wheelers, mechanical or automatic intervention is required.

Another option that has been proposed often is the slow charging plus range extension swapping under which a small 'built-in' battery will be charged and used for covering small distances. However, if necessary, the range can be extended with a second battery termed as a range-extension swappable battery that would go into a second slot in the EV.

To tackle battery weight issues that can hinder swapping technology adoption in the car market and address two-, three- and four-wheelers, Sun Mobility offers a modular product. As a result, the number of battery packs used will change based on the vehicle type, with heavy vehicles requiring more battery modules that can still be swapped easily by the personnel.

Some of the battery swapping solution providers in India are as follows :

- **Sun Mobility,** a Bengaluru-based joint venture founded in 2017 between Maini Group and SUN Group with a 26% stake being owned by Bosch, is one of the most prominent companies in the battery swapping segment for two-wheelers, three-wheelers, and electric buses . The operating model prescribes the creation of individual swapping facilities, known as Quick Interchange Stations (QIS), which can charge and dispense batteries. Each QIS for a 2W/3W has 15 slots with the capability to charge 14 batteries. The batteries themselves are standardized with a 1.5 kWh capacity. The typical QIS with its battery charging, air conditioning, and monitoring equipment has a connected load of 28 kVA. In 2019, the company collaborated with Ashok Leyland in rolling out their Circuit-S electric buses powered by Sun Mobility's smart swappable battery for Ahmedabad Bus Rapid Transit System, with an automated battery swap station equipped with a robotic arm for fast swapping of the battery. The company has also launched swapping operations in Chandigarh and Bangalore in collaboration with Indian Oil in 2020 and plans to install over 100 swapping stations across Bengaluru in 2021[135].
- **Lithion Power,** a New Delhi-based company founded in 2016, provides an intelligent energy platform for battery swapping infrastructure focussed on electric 2W/3W. With claims to be India's largest battery swapping operator, it provides charged Li-ion batteries through its network of Lithion Swapping Points in Delhi and adjacent areas of Haryana[136].
- **VoltUp** is a Mumbai-based firm founded in 2019, provides a battery swapping and smart charging technology platform for EV owners, logistic companies, and OEMs in a pay-as-you-go model. It has tied up with several OEMs for strategic collaborations and, in 2020, had announced its partnership with Hindustan Petroleum Corporation Limited (HPCL) to open battery swapping centres across India. As part of the

135 Sun Mobility
136 Lithion Power

partnership, the company had unveiled two such centres in Jaipur, Rajasthan, while announcing plans to open 50 battery swapping solutions centres by June 2021[137].

- **Esmito,** a company based in IIT Madras Research Park and founded in 2018, offers B2B Software as a Service (SaaS) platform for EV infrastructure management, including battery swapping facilities. In addition, it offers the facility to charge different forms of batteries in a single rack charger at the operator's location. It is present in six states across India and collaborates with five different operators for multiple pilot projects[138].
- Another IIT Madras-based start-up is **Flowtrik Technologies Private Limited,** founded in 2019 and designs, manufactures chargers for advanced batteries that include bulk charging portals at swapping stations[139].
- **Numocity,** a Bangalore-based firm founded in 2018, provides an enterprise-level solution called ZipSwap for EV battery swapping and has provided its software platforms to many players in the battery swapping segment[140].
- **ChargeUp,** a New Delhi-based company founded in 2019, operates battery swapping stations for electric three-wheelers with Battery as a Service (Baas) solutions to e-rickshaw drivers through its network of dealerships. It sources its indigenously developed Li-ion batteries from Gurugram based Greenfuel Energy Solutions[141].
- **Charge+Zone,** operated by Vadodara-based TecSo ChargeZone, founded in 2018, entered the three-wheeler battery-swapping network in Delhi with SmartE as the enterprise mobility partner. It operates over 120 charging stations (CCS2/GBT) across seven cities in India and has recently forayed into the battery swapping space. It aimed to deliver swapping/charging services to more than 1000 e-rickshaws and e-autos by early 2021 in Delhi across 25 micro hubs.
- **Okaya Power Group,** a New Delhi based company, founded in 2002, commissioned an IoT based battery swap station in Delhi and had planned to install around 300 swapping stations by the end of 2020.
- **Amara Raja Power Systems,** a Tirupati-based company founded in 2002, installed swapping stations for 2W/3W and completed battery-swapping station projects in Tirupati, Kochi, and Lucknow. It has also entered into a battery swapping project with Bharat Petroleum Corporation Limited (BPCL), in Kochi and Lucknow.
- **Race Energy,** a Hyderabad-based start-up founded in 2018, has been working on a battery swapping network for electric 3-wheelers. The start-up is pursuing an approach to create demand and supply by simultaneously working on conversion kits, battery packs, and swapping stations. It is also creating demand by retrofitting combustion engine-based three-wheelers with electric propulsion.

6.3 Fast Charging vs. Slow Charging: A Comparison

An EV user, particularly those using public charging infrastructure would prefer to charge their EV battery as soon as possible, ideally in the same/similar time span that ICE vehicle takes to fill its fuel tank at Petrol/Diesel/gas station. While first generation legacy e-cars had relatively low battery capacity (≈10 kWh) which would normally charge through slow chargers (3.3 kW), the EV models for passenger cars currently (as of April 2022) available in the Indian market have battery capacity of as high as 93 kWh. Globally four wheeler EVs have battery capacity as high as 135 kWh. Due to technology development and falling prices, energy density of battery and EV battery capacity will continue to grow in size. Therefore, as is evident from the global trend of public charging infrastructure deployment, the share of high power rating/fast chargers is rapidly increasing in EV rich countries[142]. EV OEMs, in line with the technology development and the customer demand, have been increasing the battery capacity and offboard charger size of their EVs. However, while fast charging of EVs is highly preferable as desired from waiting time/queuing perspective, there are potential concerns

137 VoltUp
138 Esmito
139 Flowtrik
140 Numocity
141 ChargeUp
142 Z. Rather, A. Nath, R. Banerjee, and C. Juta, "International review on integration of electric vehicles charging infrastructure with distribution grid," GIZ, Tech. Rep., 2021 https://changing-transport.org/publication/international-review-ofelectric-vehicle-charging-infrastructure-and-its-grid-integration/"

related to the impact of fast charging on battery health, grid impact and other issues that need to be considered while comparing fast charging with slow charging of EVs. This section analyses fast charging and slow charging options available, potential influence on battery health, market status of each type of charging, and attempts to educate EV user and other stakeholders to take an informed decision on adoption of appropriate charging option/infrastructure required for EV charging.

Definition: The terms 'Fast' and 'Slow' charging refer to the duration of charging EV battery from minimum permitted to its full capacity, and both the charging types are directly correlated to the power rating of the chargers. However, a distinction needs to be made based on vehicle segment. A fast charger for an e-2W which can charge the 2W in around 30-60 minutes may not be a fast charger for charging of e-4W and vice versa. Depending on the intended end user of the charging infrastructure, a charger needs to be classified as a fast or a slow charger. Typically, a charger that can charge the vehicle from the target segment in less than 1-2 hour can be termed as a fast charger.

Usage: Internationally it has been observed that in countries with a wider public charging infrastructure, EV users utilizing these chargers generally use them to quicky top-up their battery and do not generally keep their vehicles plugged-in for more than 1-2 hours, with the most common duration being 30 minutes as shown in Figure 6.13. Therefore, in such charging locations (shopping complexes, parks and recreational zones, restaurants, etc.), moderate to fast chargers are generally desirable. Therefore, the selection of charger type will be influenced by the location and the service expected of the EV users.

Vehicle Segment: India currently has a much higher proportion of electric 2W and 3W compared to electric 4W segment, so it may seem to be preferable that a higher priority is placed on charging infrastructure to cater to such customer base, which may potentially imply slower charging infrastructure is given priority. However, two important aspects need to be considered while deciding charging infrastructure priority.

a. Despite most of the 2W and 3W EV models currently available in Indian market (April 2022) are equipped with slow charging battery system, the demand for fast charging of both the segments (2W and 3W) is likely to increase in the future. 2W and 3W vehicles with fast charging capabilities are already available in the market including in India as discussed in Section 6.3.3.2. Therefore, a charging infrastructure that takes future scenarios into consideration (next 10-20 years) should be planned accordingly, as in the worst case scenario, added investments would be needed to replace/ upgrade the slow chargers with higher capacity chargers in the future.

b. The battery energy capacity of a typical e4W is almost 10 to 20 times larger than that of e2W. Therefore, looking at the energy content, charging 1 e4W is equivalent to charging of 10-20 e2W simultaneously. Moreover, while the share of e4W in the Indian market is relatively lower compared to e2W and e3W segment, given the ambitious target of electric mobility of India, e-car share in all likelihood will increase in the future. Therefore, the charging infrastructure should be planned accordingly.

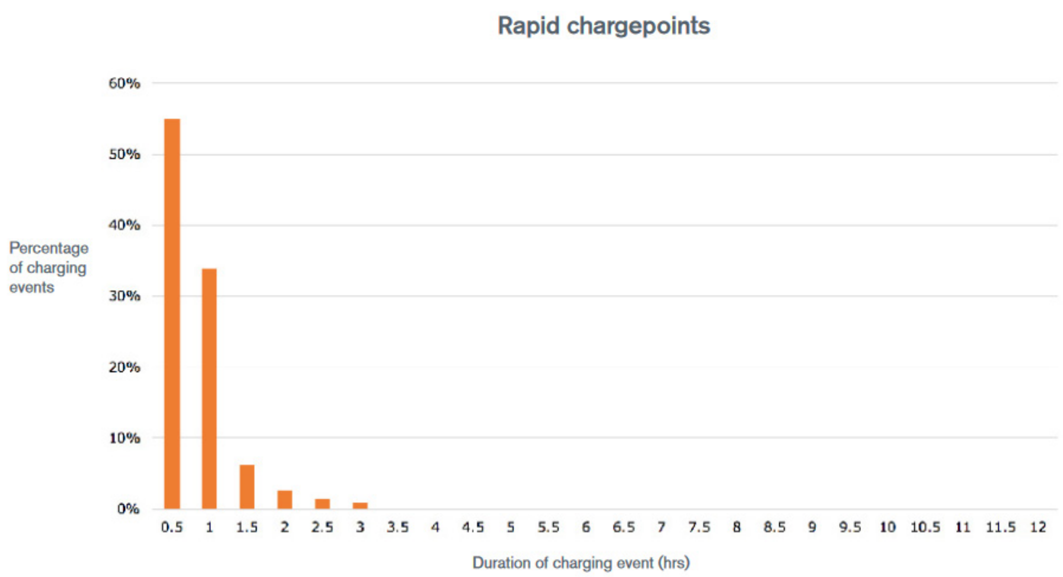


Figure 6.13: Duration of charging at public rapid charge points in UK
Source: Ofgem, 'Future Insights: Implication of the transition to Electric Vehicles'

Charger availability: The availability of chargers in a public charging station will also differ depending on whether the fast or slow chargers are employed in the given station. Considering that the same number of vehicles with same charging requirement come up to the both the slow and fast charging stations, a slow charging station would be able to serve lesser number of EVs, thus potentially denying service to EVs due to lack of availability of chargers,[143,144]

6.3.1 CHALLENGES IN ADOPTION OF FAST CHARGING

6.3.1.1 Impact on battery health

Battery degradation is one of the key performance metrics for an EV, and temperature is one of the primary factors that determine the degradation of the battery. However, it is important to highlight that irrespective of charging type, an EV battery already experiences extreme/fast discharging during driving periods required for accelerating the vehicle.

The effect of temperature on the cycle aging of battery has been shown in Figure 6.14. With the increase in ambient

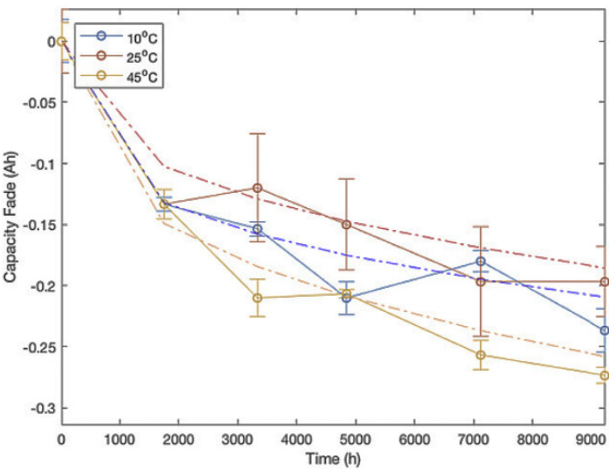


Figure 6.14: Li-ion battery degradation during storage as a function of temperature (Battery capacity is 3 Ah)[144] The dotted line is the fitted exponential curve to represent the capacity fade.

temperature deviation from the room temperature, higher loss in capacity is seen due to calendar aging.[144,145]

The flow of battery current increases in fast charging, which also leads to increased heat generation. This mandates the requirement of advanced thermal management systems in EVs with fast charging option. At higher temperatures, the solid electrolyte interphase (SEI) layer in the anode grows faster and makes it more unstable. While in the cathode, it leads to binder decomposition, metal dissolution and cathode electrolyte interphase (CEI) growth. This leads to very fast capacity degradation and increase on internal impedance of the typical lithium batteries. So, effective thermal management is critical for enabling fast charging in EVs[146]. At fast charging rates, the graphite anodes are also subjected to mechanical degradation (such as cracks and fissures). It can be observed from Figure 6.15, with the increase in charging current (C-rate), there is exponential deterioration in the cycle life of the battery.

The authors in a study[147] used non-destructive electro-chemical approach to monitor degradation of Li-ion batteries under different operating conditions. The considered batteries had graphite negative electrode and nickel-cobalt-manganese oxide + spinel manganese oxide positives. The study results indicated that capacity loss of battery is strongly influenced by the charge/discharge rate, temperature and the depth of discharge. Figure 6.16 shows the capacity loss for five different charge/discharge rates at three different temperatures. The data trend reveals that at lower temperatures (10°C) the capacity loss increases

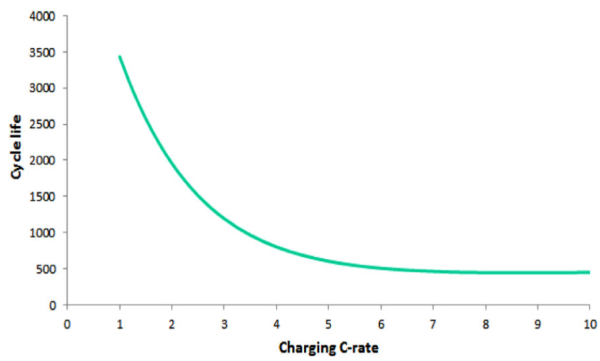


Figure 6.15: Cycle life of battery vs Charging C-rate[145]

143 Details of analysis to this end is provided in the Report 4

144 Kotub Uddin et al., "On the Possibility of Extending the Lifetime of Lithium-Ion Batteries through Optimal V2G Facilitated by an Integrated Vehicle and Smart-Grid System," Energy 133 (August 15, 2017): 710–22, https://doi.org/10.1016/j.energy.2017.04.116.

145 Samuel Pelletier et al., "Battery Degradation and Behaviour for Electric Vehicles: Review and Numerical Analyses of Several Models," Transportation Research Part B: Methodological, Green Urban Transportation, 103 (September 1, 2017): 158–87, https://doi.org/10.1016/j.trb.2017.01.020

146 Anna Tomaszewska et al., "Lithium-Ion Battery Fast Charging: A Review," ETransportation 1 (August 1, 2019): 100011, https://doi.org/10.1016/j.etran.2019.100011.

147 John Wang et al., "Degradation of Lithium Ion Batteries Employing Graphite Negatives and Nickel–Cobalt–Manganese Oxide + Spinel Manganese Oxide Positives: Part 1, Aging Mechanisms and Life Estimation," Journal of Power Sources 269 (December 10, 2014): 937–48, https://doi.org/10.1016/j.jpowsour.2014.07.030.voltage drop, resistance increase, lithium loss, and active material loss during the life testing. The cycle life results indicated that the capacity loss was strongly impacted by the rate, temperature, and depth of discharge (DOD

with increase in charge/discharge current. With increase in temperature, the battery degradation is higher for all rates, but comparatively in 2C (charge/discharge the battery completely in 30 minutes) the degradation is slower. At 46^{0}C the degradation at all the different charge/discharge rates are similar.

The degradation of battery life is also susceptible to battery chemistry[148]. Therefore, the study compared the degradation in three different Li-ion 18650 commercially available cells defined in Table 6.7. From Figure 6.17, it can be observed that the impact of fast charging on the aging of the batteries different for the different cells. Although Cell C showed the least degradation at 3A and 4A charge currents, when the current is increased to 5A a substantial degradation is seen.

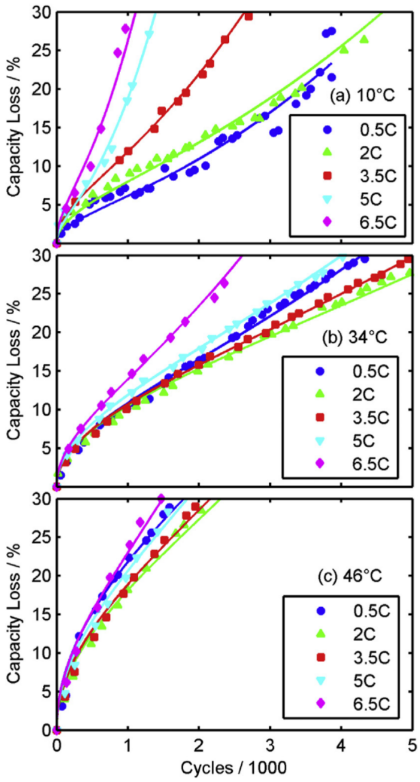


Figure 6.16: Capacity loss for different charge/discharge rates at different ambient temperatures. The depth of discharge is 50% for all corresponding data points. The number of cycles is represented as thousands of cycles[141]

Comparatively, Cell B is impervious to degradation due to charge currents. Cell A showed, significant degradation in battery capacity for each of the different charging currents, but the degradation was significantly higher at 4A and 5A currents.

Table 6.7: Specifications of Li-ion cells[148]

Battery degradation at different ambient temperatures

Cell	A	B	C
Make	LG INR18650HG2	SAMSUNG INR1865025R	A123 APR18650M1B
Positive Material	$LiNi_{0.8}Mn_{0.1}Co_{0.1}O_2$ MC)	$LiNi_{0.8}Co_{0.1}5Al_{0.05}O_2$ (NCA)	$LiFePO_4$ (LFP)
Negative material	Graphite + SiO (G+SiO)	Graphite (G)	Graphite(G)
Nominal capacity (mAh)	3000	2500	1100
Voltage range	2.5 to 4.2 V	2.5 to 4.2 V	2 to 3.6 V

is shown in Figure 6.18. Cell A showed a significant deterioration at temperatures up to 250C, but at high temperature of 450C, it showed the least degradation among all the three cells, which implies that this cell type is suitable for warm climates, such as India. Cell B showed better performance at lower temperatures while Cell C showed significant deterioration at high temperatures.

6.3.1.2 Technical impacts on electrical grid

The next significant challenge in adoption of fast charging is its impact on the electrical power network. EV charging being a power intensive load, introduces different challenges to the grid operator including network congestion, transformer overloading, poor voltage profile, increased losses, power quality issues etc. These challenges are generally directly corelated to the power rating of the

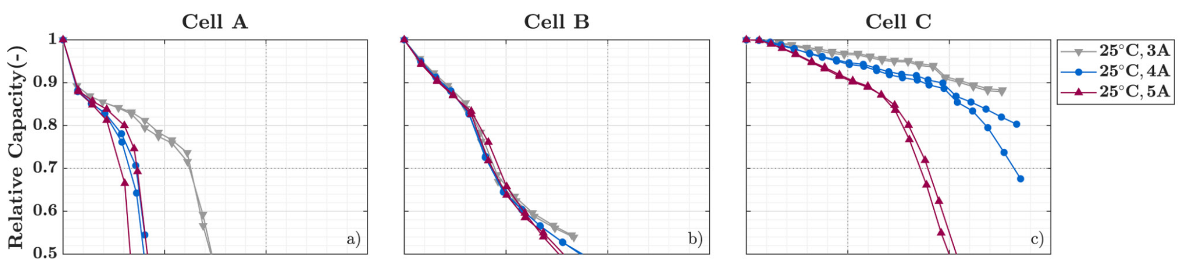


Figure 6.17: Impact of charge current on cycle life[148]

148 Romain Mathieu et al., "Comparison of the Impact of Fast Charging on the Cycle Life of Three Lithium-Ion Cells under Several Parameters of Charge Protocol and Temperatures," Applied Energy 283 (February 1, 2021): 116344, https://doi.org/10.1016/j.apenergy.2020.116344.

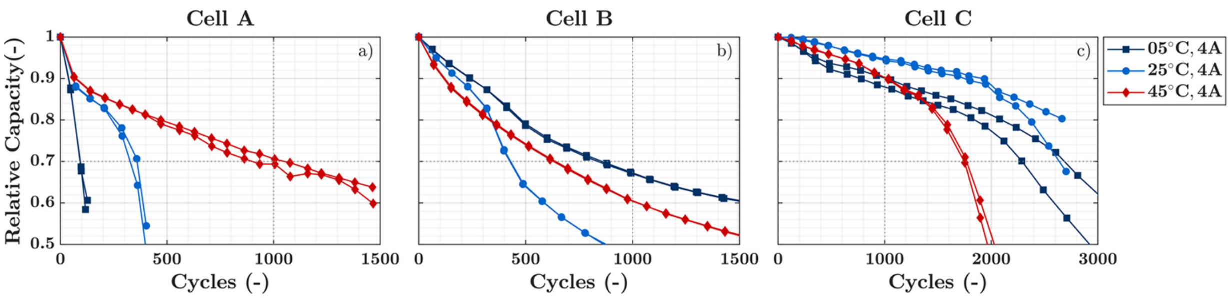


Figure 6.18: Impact of ambient temperature on cycle life[148]

chargers, with high powered chargers having potentially higher impact on the grid. Different technical challenges associated with EV charging on the grid have been elaborated in detail in Chapter 6 of Report 1 of this study[149]. For example, the Norwegian Water Resources and Energy Directorate (NVE) has reported that although a few percent of the transformers are currently operating at the margins or slightly overloaded, an increase in power consumption by 1-2 kW per household would lead to overload in nearly 10% of all transformers. Further, if the average power added to each household is 5 kW, then over 30% of the transformers and 10% of high voltage cables would be overloaded[150]. However, with the advent of smart charging technologies, such technical impacts can be tackled to a great extent, even coupled with potential grid support services.

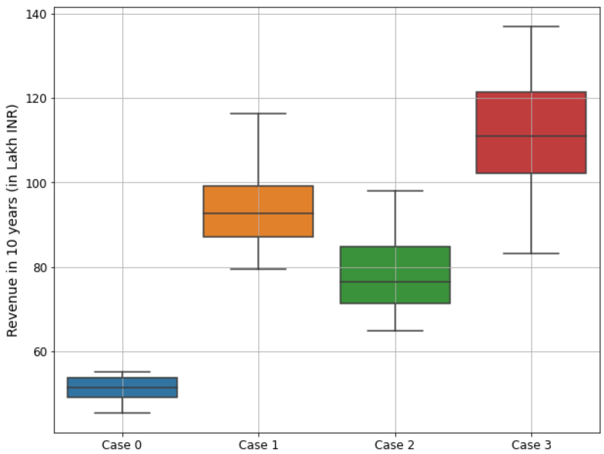
6.3.1.3 Economic Challenge

The upfront cost of installation of fast chargers is significantly higher compared to slow chargers. Typical cost of chargers and transformers used in PCS are given in Table 6.8. However, over a 10-15 year life period, the economic analysis may significantly favour the installation of fast chargers (shown in Figure 6.13) as the fast charging station would be able to serve a higher number of customers per day[151].

Table 6.8: Typical costs of chargers, transformers and cables used in PCS[152]

Equipment	Capital Cost (INR/EUR)
3 kW AC charger	11,000 (124.88)
7 kW AC charger	42,000 (476.84)
22 kW AC charger	60,000 (681.2)
50 kW DC charger	11,00,000 (12,488)
150 kW DC charger	15,00,000 (17,029)
200 kW DC charger	20,00,000 (22,706)
100 kVA Distribution Transformer	1,43,000 (1623.52)
120 kVA Distribution Transformer	1,75,000 (1986.83)
250 kVA Distribution Transformer	3,82,000 (4336.97)
850 kVA Distribution Transformer	9,00,000 (10,217.98)
11 kV XLPE 3 core 95sqmm cable (per metre)	990 (11.24)

Figure 6.19: For 25 EVs arriving on average per day at the PCS, its NPV of PCs considering 10 years of operation[153]



The different cases shown in the above figure are different configurations of a PCS with 10 chargers. Case 1: Slow

149 Zakir Rather, Rangan Banerjee, Angshu Nath, Payal Dahiwale, 'Integration of Electric Vehicles Charging Infrastructure with Distribution Grid: Global Review, India's Gap Analysis and Way Forward, Report 1: Fundamentals of Electric Vehicle Charging Technology and its Grid Integration', GIZ, NITI Aayog, 2021. https://changing-transport.org/publication/fundamentals-of-electric-vehicle-charging-technology-and-its-grid-integration/?nowprocket=1
150 Torfinn Jonassen, Status of NVE's Work on Network Tariffs in the Electricity Distribution System, ed. Jonassen_norway (Norges vassdrags- og energidirektorat, 2016)
151 Details of analysis is provided in Report 4.
152 Source: IESA, Stakeholder discussions, IITB research
153 IIT Bombay Research

charging station with 8 nos. of 3 kW chargers and 2 nos. of 22 kW chargers; Case 2: 9 nos. of 7 kW chargers and 1 no. of 50 kW charger; Case 2: 7 nos. of 22 kW chargers and 3 nos. of 50 kW chargers; Case 3: 7 nos. of 50 kW chargers, 2 nos. of 150 kW chargers and 1 no. of 200 kW charger. Transformer costs based on the minimum ratings of the transformer required have been considered.

6.3.2 FAST CHARGING OF 4-WHEELER ELECTRIC VEHICLES

The growth of electric 4-wheeler segment is critical for the e-mobility sector. Internationally among the EV rich countries, it has been observed that the development of effective charging infrastructure is vital for the growth of this sector. A study in California has found that around 20% of people who purchased an electric vehicle in California switched back to conventional vehicles as their next vehicle. The primary reason cited for this is the lack of access to fast charging infrastructure. The 70% of the people who went back to ICE vehicles from EVs did not have access to Level 2 charging, which made the ownership experience very cumbersome, as they could only charge their vehicles for around 60 kms range using overnight charging with a Level 1 charger[154]. In public charging infrastructure, internationally a transition towards fast charging infrastructure has been observed in most EV rich countries as shown in Figure 6.20. Germany has in fact issued a fast charging policy 'Schnellladegesetz' in order to create a dense fast charging network in the country. INR 17,593 crores (EUR 2 billion) has been earmarked for this policy, which mandates the installation of at least 150 kW chargers at all fast charging stations. Similarly, USA has also come up with the National Electric Vehicle Infrastructure (NEVI) Formula Program in February 2022, to create a nationwide network of 5,00,000 EV chargers by 2030. As per this policy, EV charging infrastructure would be installed every 80.47 km (50 miles) in the Interstate Highways and each EV charging station must include at least four 150 kW DC Fast Chargers capable of being used simultaneously, thus amounting to minimum of 600 kW capacity. The stations should also include design considerations to allow 350 kW or higher charging capacities through future upgrades[155].

In India, the first generation of electric vehicles (e-cars) were incapable of fast charging as they had sub 100V DC systems[156]. This made the use of slow charging infrastructure such as Bharat AC001 and Bharat DC001 relevant for these vehicles. However, the EV models have relatively matured since then, with battery capacities of three of India's top selling EV models (as of Q4 2021), the Tata Nexon EV, Hyundai KONA and the MG ZS EV having 30.2 kWh, 39.2 kWh and 44.5 kWh respectively, and all these EVs are with >200 V DC systems. These vehicles are also equipped with fast 50 kW DC charging provision using CCS2, as are most of the upcoming EV models in India[153]. The impact of fast charging on the battery aging have also been minimized as these vehicles have well designed battery thermal management systems[157] in place. So, the EV users in general, and particularly those using public charging infrastructure, are likely to utilise the fast-charging facility for their vehicles. The cost of EVs normalized by their battery capacities have been provided in Figure 6.21, which shows that EVs with slow chargers are priced at par with

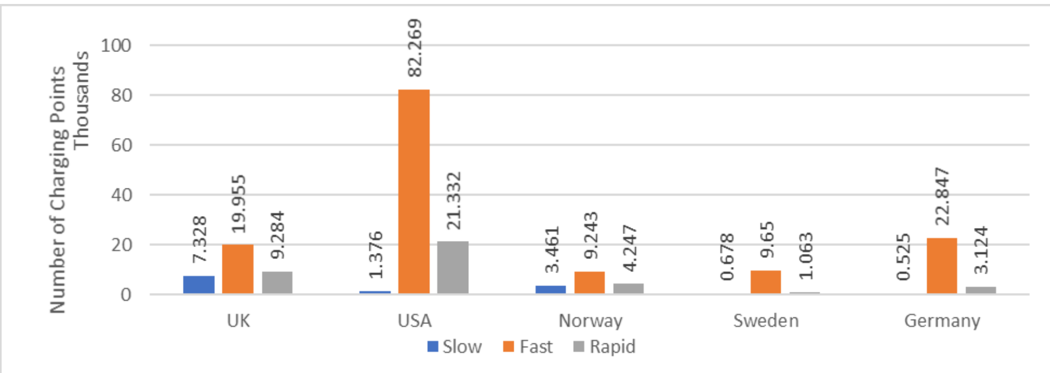


Figure 6.20: Public charging infrastructure statistics in few EV rich countries 153 (Slow: <7 kW, Fast: 7-22 kW, Rapid:>22 kW) (till August 2021)

154 Andrei Nedelea, "Study Finds 1 In 5 EV Owners In California Returned To Gas Power", InsideEVs (May 04, 2021), https://insideevs.com/news/505232/study-evs-california-return-ice/
155 U.S. Department of Transportation, "The National Electric Vehicle Infrastructure (NEVI) Formula Program Guidance" (February 10, 2022), https://www.fhwa.dot.gov/environment/alternative_fuel_corridors/nominations/90d_nevi_formula_program_guidance.pdf
156 DST, "Report on Indian Standards for EV Charging Infrastructure," August 2021.
157 Liquid cooling is often used for battery thermal management in e4W.

EVs with faster charging, except Brands E, F and G, which are significantly higher priced as these vehicles are more on the luxury side of the market.

For short range daily usage, use of moderate chargers (7-22 kW) may be sufficient to address the charging needs of the users, however, for longer distance travels, fast charging infrastructure is expected to be the key intervention for success of e-mobility. Chargers below 7 kW may find its use in home charging with a dedicated charger for each EV, however for public charging station, fast chargers are expected to be the primary choice. Further, fast charging can significantly increase the number of EVs that can be served by the PCS. So, for PCS in cities which are expected to have higher EV traffic, slow chargers can reduce the potential number of EVs that can be charged (as chargers would be in use for longer durations). Similarly, for RWAs, fast chargers can potentially serve a larger number of users with lower number of chargers compared to slow chargers. However, for the locations where an EV is expected to be parked for a longer duration (for example, roadside night parking), slow chargers such as kerb side chargers can be potentially more economical and easily accessible charging infrastructure.

One of the initial sectors to transition to electric mobility are the fleet operators and ride hailing companies. Since such EV users would eye at minimising their idle time to serve more customers, fast charging infrastructure is critical for such type of stakeholders. Currently, these sectors constitute the major section of users of the existing fast charging infrastructure available in different cities of India[158].

It is important to mention that fast chargers are backward compatible, a higher power charger can always charge an EV with lower charging capability subjected to charging standard/connector compatibility. For example, a 44 kW Type 2 AC charger can be potentially used to charge all vehicles with up to 44 kW on-board charger capability provided the vehicle also has the Type 2 socket. Similarly, a 150 kW CCS2 charger can potentially charge all vehicles with CCS2 connector up to 150 kW capacity.

6.3.3 FAST CHARGING OF 2-WHEELER AND 3-WHEELER ELECTRIC VEHICLES

The electric two-wheeler market in India has been growing rapidly, primarily driven by favourable government policies supporting the adoption of battery powered EVs. The two-wheeler segment is one of the fastest growing automobile sectors with a large number of start-ups stepping into the market, and the mainstream brands releasing state-of-the-art models to stay on top of the ongoing change. Some of the currently (as of 2021) leading manufacturers in the two-wheeler electric vehicle segment are Hero Electric and Okinawa Scooters. The other brands making strides in the market include Ampere Vehicles, Ather Energy, Ola Electric Mobility, PURE EV, Benling India, Bajaj, Revolt, and TVS among others.

Among the electric two-wheelers currently available in the Indian market, the typical ratings of the batteries with higher capacities range between 2.7 – 4.3 kWh. Currently (as of December 2021), the two-wheeler models with the highest battery capacities are the Odysse Evoqis and the Ultraviolette F77, with a nominal capacity of 4.32 kWh and 4.2 kWh, respectively. However, on the contrary, these numbers are comparatively lower than the battery capacities

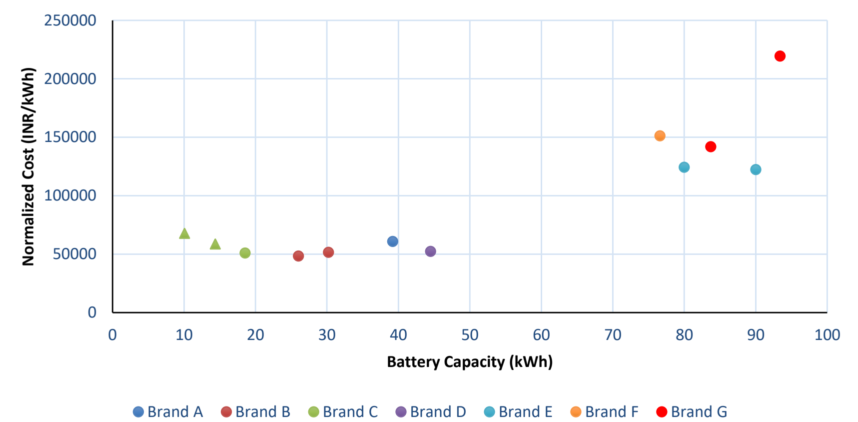


Figure 6.21: Normalized cost of 4W EV models available in India. The triangle markers represent EV models with slow charging capability

158 Stakeholder consultation

of some of the e-bikes available internationally in the market. For example, electric bikes with the highest battery capacities are made by Energica Motor Company, an Italian brand, the most prominent one being the Eva Ribelle with a 24.8 kWh Li-ion polymer battery, and the Evoke 6061, by Evoke motorcycles, a Chinese manufacturer, with a 24.8 kWh battery. In addition, Harley-Davidson, the American motorcycle giant, has recently introduced an electric 2-wheeler of its own, named LiveWire with a 15.5 kWh battery. However, most of these high-end two-wheelers fall under the performance vehicle category and may not find large customer base in the Indian market. Nevertheless, due to the advancement of battery technology and its falling price, battery capacity of e-2W and e-3Ws is very likely to increase in the future, thereby necessitating the need for fast charging.

6.3.3.1 Solutions for implementation of fast charging in 2W and 3W

It is possible to design thermal management systems to accommodate fast charging in 2W and 3W as is evident from various research studies and commercially available fast charging 2W in the market. However, for wide adoption of 2W with fast charging may need higher amount of more research and development which may marginally increase the price of EVs with fast charging options as compared to EVs without fast charging capability. Thermal management system include both hardware and software additions to estimate and control the battery temperature, by controlling the current flow. The cooling media commonly used for cooling of EV battery packs can be categorized into air, liquid and phase change materials (PCM). While air cooling is low cost and relatively simple option, they are limited in achieving sufficient cooling rates due to the low heat capacity and thermal conductivity of air. Liquid cooling is significantly more effective than air cooling, but its cost is relatively higher than air cooling, while being more complex to implement. These liquids are generally dielectric to prevent short circuits, such as deionized water and mineral oils. In PCM cooling, the latent heat of phase change of the cooling medium is used to absorb heat produced by the battery. However, PC cooling has some limitations. At high ambient temperatures, PCM could potentially melt away without any heat produced by the battery, and then the liquid which typically has a low thermal conductivity would act as a barrier to heat transfer[159].

As an alternative to the standard Li-ion batteries used in EV battery packs, Lithium Titanate Oxide (LTO) batteries are recently being considered as potential replacements. These batteries are characterized by their very long cycle lives, high charge/discharge rates, high temperature tolerance and high safety, but their energy density is slightly lower than carbon anode based Li-ion batteries. For example, the Toshiba Lithium Titanate rechargeable battery is capable of charging up to 90% of its full capacity in less than 5 minutes and has a lifetime of 6000 cycles of full DoD to 90% of initial capacity[160]. However, the cost of LTO battery packs is slightly higher than other Li-ion battery chemistries. Typical range of costs of different Li-ion batteries are given in Table 6.9.

Table 6.9: Capital costs of Li-ion based battery systems[161]

Battery Chemistry	Cost (INR/kWh(EUR/kWh))
Lithium iron phosphate (LFP)	26,000-39,000 (EUR 295.18 – 442.78)
Nickel manganese cobalt oxide (NMC)	24,147-33,435 (EUR 274.15 – 379.59)
Lithium titanate oxide (LTO)	31,949-74,300 (EUR 362.73 – 843.55)

6.3.3.2 Commercially available e-2W and e-3W vehicles with fast charging capability

6.3.3.2.1 International market

The Evoke 6061 motorcycle by the Chinese manufacturer, Evoke Motorcycles, is one of the few quick charging e-bikes available in the international market . Apart from a 1.8 kW onboard AC charger, it can also be charged with 125 kW DC input, with which it is reportedly taking just around 15 minutes to charge the battery from zero to 80% SOC level. In 2019, the manufacturer had reported plans to enter the Indian market with its range of bikes at aggressive pricing . It had also planned to create a design and production hub and help supplement the two-wheeler charging infrastructure by installing an adequate number of ultra-fast and fast charging stations nationally. However, as of 2021, the company is yet to enter the Indian market.

159 Anna Tomaszewska et al., "Lithium-Ion Battery Fast Charging: A Review," ETransportation 1 (August 1, 2019): 100011, https://doi.org/10.1016/j.etran.2019.100011
160 Shmuel De-Leon, "Ultra Fast Charging Lithium Battery Market," https://www.nasa.gov/sites/default/files/atoms/files/ultra_fast_chg_li_batt_mkt_sdeleon.pdf..
161 K Mongrid et al., "Energy Storage Technology and Cost Characterization Report" (U.S. Department of Energy, July 2019), https://www.energy.gov/sites/default/files/2019/07/f65/Storage%20Cost%20and%20Performance%20Characterization%20Report_Final.pdf

Harley Davidson is one of the most popular motorcycle manufacturers in the world. In 2020 the OEM released the Harley Davidson LiveWire[162], with a CCS charging port (CCS1 for North America and CCS2 for Europe). The motorcycle can be charged using a Level 1 charger at 21 kms per hour of charging or by using DC fast charging, which can charge the vehicle 309 km per hour. The Energica Eva Ribelle is another motorcycle with fast charging capability[163]. With a battery capacity of 21.5 kWh, the e-2W can be fast charged using a DC charger at 400 km per hour. In addition, it also has an onboard charger that allows the user to charge the vehicle using a standard SAE J1772 charging cable at 3 kW. The LS-218 by Lightning Motorcycles is also capable of fast charging. Using a DC fast charger the user can completely charge the 12/15/20 kWh battery pack in 30 minutes[164].

6.3.3.2.2 Indian Market

In India, Ather Energy has come out with its electric scooter, Ather 450X, claimed to be the fastest two-wheeler in the 125-cc category, and the Ather 450 with battery capacities of 2.9 kWh and 2.71 kWh, respectively. Both the models have fast-charging features. The company is also actively pursuing the challenge of developing an extensive countrywide public fast-charging network named Ather Grid that will be open for all EVs. Apart from being already present in Bengaluru and Chennai, Ather Energy is also in the process of setting up its charging network in Mumbai, in collaboration with start-up Park+, with as many as 10 charge points being already completed with a further 30 more charge points coming in the near future[165]. As of April 2022, the company has installed more than 350 public fast charging points across 30+ cities in India[166].

Log 9 Materials, a Bangalore-based nano-technology start-up has worked on demonstrating rapid charging battery packs for two and three-wheeler EVs[167]. The battery packs are claimed to be fully charged in under 15 minutes, with the pilot runs being executed as of February 2022. The batteries are based on graphene-based supercapacitor technology instead of Lithium-ion. They are supposed to be highly resistant to fire and impacts, and extremely long-lasting. The company targets the intra-city B2B segment, including two-wheelers that are used for food delivery services.

The Indian electric vehicle manufacturer Omega Seiki Mobility has introduced its three-wheeler range based on the rapid charging battery pack from Log 9 Materials named the RapidX battery technology[168]. For the first two models, the Omega Seiki Rage and Rage+ are expected to be equipped with battery capacities of 6 kWh and 7.5 kWh respectively, with estimated charging times of 40 and 45 minutes for full charging of the batteries under the Rapid Charge technology. Log 9 Materials has also introduced the Rapid Charge technology in the two-wheeler segment, which offers full charging in 15 minutes for a 2-kWh battery. It is soon expected to be introduced in the market in partnership with a two-wheeler manufacturer.

Tork Motors, another Indian manufacturer, has launched one of its first models, the Tork T6X, targeted towards the performance category, with a battery capacity of 3.2 kWh. It has set up its first fast-charging station in Pune, Maharashtra in 2019, in compliance with the government-enforced EV regulations, and can support any EV with a GB-T plug and has further plans to expand .

Ola Electric Mobility, the SoftBank supported EV arm of Ola, launched its electric Ola scooter on 15th August 2021 and has also disclosed its plan to invest INR 147.4 crore (EUR 1.67 billion) in creating a fast-charging network in India named the Ola Hypercharger Network for all its two-wheeler EV customers[169]. It has plans to set up a network of 100,000 EV charging points across 400 cities, of which 5,000 charging points will be installed in 100 cities during 2021-22. The Hypercharger Network is also considered to be one of the fastest-charging 2-wheeler networks.

A Mumbai-based start-up, Earth Energy EV, touted as India's first electric cruiser motorcycle company, had launched three electric two-wheelers, the Glyde+ electric

162 Harley Davidson Livewire
163 Energica Eva Ribelle
164 Lightning LS-218
165 PTI, "Electric Vehicle Maker Ather Energy Sets up Fast Charging Network in Mumbai - ET Auto," Https://Auto.Economictimes.Indiatimes.Com/, 2021, https://auto.economictimes.indiatimes.com/news/two-wheelers/scooters-mopeds/electric-vehicle-maker-ather-energy-sets-up-fast-charging-network-in-mumbai/81933387.
166 AtherGrid.
167 Log9 Materials
168 Punith Bharadwaj, "Omega Seiki Electric Three-Wheelers with Log 9 Battery Pack Takes 30 Minutes for Full Charge," www.drivespark.com, May 12, 2021, https://www.drivespark.com/four-wheelers/2021/omega-seiki-electric-three-wheelers-with-new-rapid-charging-log-9-battery-pack-034167.html.
169 Peerzada Abrar, "Ola Electric to Set up World's Largest EV Two-Wheeler Charging Network," Business Standard India, April 22, 2021, https://www.business-standard.com/article/companies/ola-electric-to-set-up-world-s-largest-ev-two-wheeler-charging-network-121042200645_1.html.

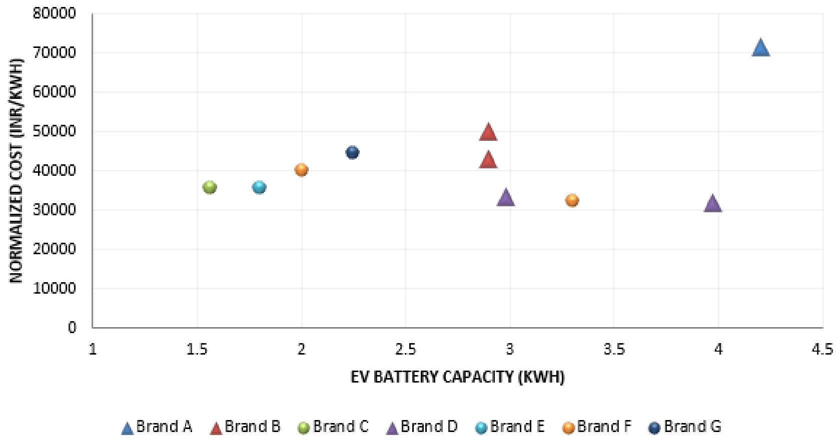


Figure 6.22: Normalized cost of popular 2W EV models in India. The triangle markers represent EV models with fast charging capability

scooter, Evolve Z, and Evolve R models. The novel feature of the EVs is the fast charge facility with a 40-minute charge time[170]. It has also set up fast-charging facilities at each of its dealership locations, with plans to open more dealerships around the country.

EV Motors India (EVM) and Hero Electric had announced a partnership in 2020 under which EV Motors will be integrating their hi-tech battery solutions and charging infrastructure with Hero Electric bikes . These batteries, which come in 1.295 kWh and 2.175 kWh variants, can be charged in under 30 minutes using the rapid charging station network "PlugNgo" set up by EV Motors. Some of the critical challenges of EVM includes the ownership of vehicles around the country, adequate financing, expansion of EV charging infrastructure, battery performance, and service-related issues.

In the three-wheeler segment, the Singapore-based Shado Group had launched its electric three-wheelers under the 'Erick' brand name in India in 2019, developed by the Bengaluru-based Adarin Engineering Technologies, a Shado Group company[171]. It was claimed to be the first instant-charging electric three-wheeler in India with only 5 minutes of charging time and came in both passenger and cargo variants. The company had plans for further expansion and to manufacture up to 1000 units per month for Indian consumers at a yearly investment of INR 73.7 crore (EUR 8.3 million).

From the above analysis it can be observed that in the current Indian EV space, the number of e-2W and e-3W vehicles with support for fast charging is already existing in the Indian market, although with lower penetration. However, with rapid development of battery technology, new 2W/ 3W models with fast charging feature have been launched, with more expected to be launched in the future. Therefore, to cater electric 2W and 3W segment with fast charging capability, charging infrastructure for 2W and 3W be adequately planned. A cost comparison of some of the popular e-2W models available in India (with their actual names being masked) have been provided in Figure 6.22. It can be observed that while the general trend is that the cost of e-2W with fast charging capability is slightly higher than those without fast charging, one model Brand D which has fast charging option is even cheaper than those with slow charging option. It is important to note that the vehicles with fast charging capabilities are generally provided with advanced features which may also contribute to the higher cost.

Therefore, it can be concluded that although fast charging of e-2W and e-3W is not yet predominant in the country, the recent release of cost competitive, economically attractive models with fast charging capability may change the tide of the charging infrastructure requirement for 2W and 3W in the near future.

170 Earth Energy EV
171 Pradeep Shah, "Erick Electric Three-Wheeler Unveiled with Just 5 Minutes of Charging Time," The Financial Express (blog), August 14, 2019, https://www.financialexpress.com/auto/car-news/erick-electric-three-wheeler-unveiled-with-just-5-minutes-of-charging-time/1675452/.

6.4 Analysis of Recent EV charging infrastructure related Tenders

6.4.1 TENDER FOR PCS FLOATED BY DELHI TRANSCO LTD.

Delhi Transco Limited (DTL) which is the State Transmission Utility (STU) of NCT of Delhi is designated as State Nodal Agency for setting up of charging infrastructure in the entire NCT of Delhi. In February 2021, DTL released tender "Establishing/setting-up of EV charging & battery swapping stations at various Locations under Package – A to J across NCT of Delhi". This tender is for setting up public electric vehicle charging stations and battery swapping stations at 100 locations across the city, with five charging points at each station. This tender was re-notified with an addendum on 01 December 2021[172].

According to the records the recent tender for installation of charging stations in Delhi, floated by Delhi TRANSCO Ltd. in 2021, is one of the biggest tenders for EV charging stations in the country where a total of 500 chargers are to be installed in 100 locations. These stations will be installed at the Delhi Metro Rail Corporation (DMRC) premises, DTC bus depots and markets, among others. These installations are to be ready in a year.

> Any charger type with power output less than or equal to 3.3 kW is termed as Slow Charger. Each slow charger PCS must have a minimum of 3 charging points, each with a maximum 3.3 kW power.

> A moderate/fast Charger as defined in the tender includes DC-001, Type 2 AC (22 kW) and other charger types that can deliver output powers between 15 kW-22 kW.

Locations for setting up the public charging stations (PCS)/ battery swapping stations will be allotted on concessional basis initially for a lease period of five years.

Each location mentioned in the tender would have a minimum of 1 slow charger PCS, and a package of locations will have a minimum of 5 moderate/fast PCS shared among the locations of the package. Also, the required electrical infrastructure for setting up the charging station would be provided by the Delhi government up to 100 kW.

> The CPO may penalize an EV user for keeping the vehicle plugged-in beyond 80% SOC or for parking in the space allocated for EV charging, without charging their vehicle.

Charging Station Functionalities:

The tender has mandated a few requirements that a charging station must fulfil as listed below:

1. Provision of information
   a. The location of charging station along with GPS coordinates must be provided to the EV users.
   b. The operating hours of the charging station shall be made known to the EV users
   c. The types of chargers available (for charging stations) and types of batteries (for battery swapping facility (BSF))
   d. The data on availability of a charged battery should be publicly available (for BSF)
   e. In periods of congestion, the waiting time and also the option of pre-booking a slot should be available
   f. The cost of charging for all types of chargers should be provided to the EV users

> For an AC001 slow charger, 1 PCS is equivalent to 3 charging guns, each with capacity of 3.3 kW.
>
> 1 PCS is equivalent to 1 charging gun for moderate chargers (15-22 kW).
>
> For a 50 kW fast charger with multiple guns, 1 PCS = 1 charging gun, if all guns can be used simultaneously
>
> A battery swapping station is recognized as 2 PCS.

2. To fulfil the above-mentioned points, the CPO should utilize an authorized IT and Internet of Services (IOS) service provider so that the EV user can access the relevant services information/query/service via a mobile application.

3. Communication Requirements
   a. For DC charging, IEC 61851-24 standard must be followed for communication between EV and EVSE.

172 Public charging tender (re-notified)

b. The communication between charger and CPO must use the communication protocol OCPP 1.6 (or later version) or IEC 61850-90-8. The interface between the charger and the CPO must be a reliable internet connection (Ethernet/ 3G/ 4G). The telecommunication network should adhere to the IS 13252 (Part 1): 2010 standard.

c. Communication between charger management system and the DISCOM shall be via OSCP 1.0 or (OpenADR + IEEE 2030.5) or IEC 61850-90-8 protocol or higher.

d. The communication between two charging stations shall be either using the OCPI 2.1 protocol or OCHP direct 0.2 or higher versions.

4. Information to be sent to the DISCOM on a regular basis as decided by the respective DISCOM

a. Peak hours of EV charging

b. Real-time power consumption for each charge point using smart meters

c. Instantaneous current flow to EV

d. Instantaneous AC RMS supply voltage

e. Instantaneous active power imported by EV (W or kW)

f. Instantaneous reactive power imported by EV (VAr or kVAr)

g. Instantaneous power factor of total energy flow

h. Charger ID

i. Location (GPS coordinates)

j. Emergency Stop (along with reasons) if any

k. Frequency of any voltage fluctuation issue

5. Information to be submitted to an open database manged by Delhi Transco Ltd.

a. Name of the charging station

b. Location (latitude, longitude)

c. Operator name and contact details

d. Modes of payment accepted

e. Maximum Number of Vehicles that can be charged simultaneously

f. Advance booking availability

g. Operating hours and days

h. Operating status (operational or upcoming)

i. Fare structure

j. Number of EVs charged of each category per day, number of batteries swapped per day and number of batteries available for swapping in a day

6.3.3.3 Key observations from the tender

Although the tender is the first of its kind in India in terms of scope considering the emerging market of EV, there are few key points that needs to be highlighted.

Each package of locations has a minimum requirement of slow and moderate/fast chargers. The contract for setting up of charging stations for each package would be awarded out to those bidders who, while fulfilling the required minimum specifications, can offer the services in the lowest cost possible. The cost of slow chargers is much less compared to the cost of moderate/fast chargers. So, this could lead the bidder to be more inclined to install slow chargers, while just fulfilling the bare minimum required number of fast chargers. Therefore, it is very likely, the contractor will end up installing only minimum number of medium/fast chargers, thereby rendering the tender primarily and predominantly slow charger tender.

In countries with a wide public charging infrastructure, it has been observed that EV users utilizing these chargers generally use them to quicky top-up their battery and do not generally keep their vehicles plugged-in for more than 2-3 hours, with the most common duration being 30 minutes. So, if a slow 3.3 kW charger is used for this purpose, the EV would not be charged by a considerable amount over such short time periods.
The battery capacities of three of India's top selling EV models, the Tata Nexon EV, Hyundai KONA and the MG ZS EV are 30.2 kWh, 39.2 kWh and 44.5 kWh respectively. If a 3.3 kW slow charger is used to charge these EVs (assuming they are compatible with slow chargers), then in 1 hour, the EV would be only charged by 10.9%, 8.4% and 7.5% respectively, compared to completely filling their battery capacities in less than an hour with 50 kW fast charging. These vehicles are also equipped with fast 50 kW DC charging provision using CCS2, as are most of the upcoming EV models in India. So, a public charging infrastructure with high share of at least 50 kW DC charging or 22 kW AC charging would be much more beneficial to cater to the public charging requirement of EV users. As a comparison, the share of charger types by power

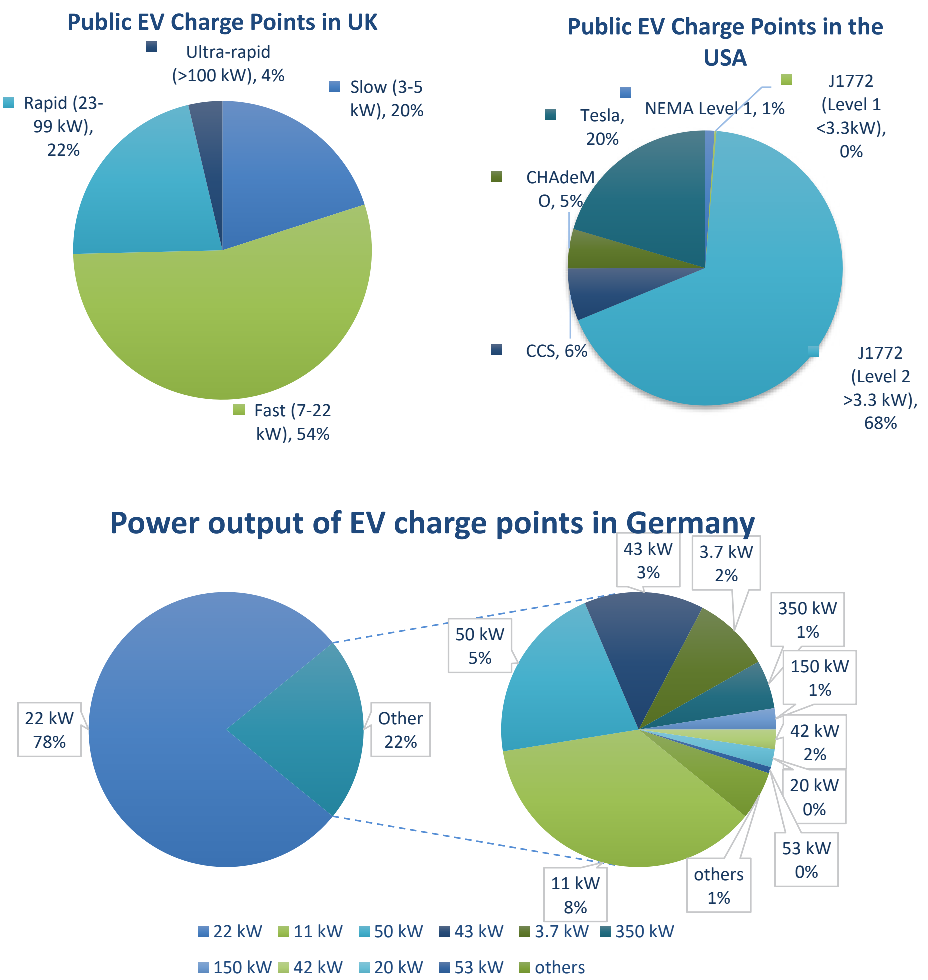


Figure 6.23: Power ratings of public chargers in UK, USA and Germany as of Q2 2021

ratings in three countries with advanced public charging infrastructure as of Q2 2021 is shown in Figure 6.23.

As seen in Figure 6.23, the most common charger type in the public charging stations is the (7-22) kW fast charging using Type 2 AC chargers. The share of slow chargers with less than 3.3 kW is significantly low for all the countries shown above.

It has been mentioned that in Clause 8.3, that instantaneous current, voltage, power needs to be communicated to the DISCOM by the charge point operator. Now, considering the Nyquist sampling rate, for a 50 Hz signal, we need a minimum sampling rate of 100 Hz. So, for each second, each charger in use would create 3x100 data points (100 data points per phase for 3 different phases). For an hour of use this would equate to, 3x100x60x60 = 10,80,000 data points and for a day, this would be 2,59,20,000 data points. This is the amount of data created per charger for a single parameter. For a total of 500 chargers, the amount of data points would scale up accordingly. For communication of this huge data set, the communication and data storage infrastructure would also need to be designed accordingly, which may increase the cost both for the CPO and the DISCOMs. The potential insights that these instantaneous values would provide the DISCOM should then be considered. It needs to be looked into, if the values of the insights provided by instantaneous measurements justifies the added costs. It is important to highlight that a balanced view on data requirement from the charging stations need to be adopted. Handling huge data, and whether such high sampled data would be worth to receive, store and analyse are important questions to be considered while fixing data requirement from the CPOs/chargers.

As mentioned in Clause 7.4 of the tender, for chargers which do not fall under the definition of slow and fast chargers as defined in Clause 2.6 and Clause 2.7, the bidder is free to fix the service charge levied from the EV user. So, this may lead to a scenario where a bidder with a charger of power higher than 22 kW, can potentially levy high unregulated service charges on the EV user.

The communication protocol between EV and EVSE for AC charging has not been mentioned.

6.4.2 TENDER FOR 270 SLOW AND FAST CHARGERS FLOATED BY RAJASTHAN ELECTRONICS & INSTRUMENTS LIMITED

Rajasthan Electronics and Instruments Ltd. which is a public-sector enterprise operating in the electronics, information technology, and renewable energy segment, has issued a tender in 2019 to set up 270 electric vehicles (EVs) charging equipment across various locations in the country. The scope of work includes installing 70 normal AC chargers, 170 DC fast chargers, and 30 DC fast chargers with 100 kW charging stations in the cities of Ranchi, Bengaluru, Goa, Shimla, Hyderabad, Agra as well as on the Delhi-Jaipur-Agra and Mumbai-Pune highways. The exact scope of the tender is given in Table 6.10.

The technical specifications of the charger types have been detailed in Annexure 3. The tender also had an added clause that, preference would be given to those bidders who utilize equipment manufactured under the Make in India initiative.

Key Observations

1. The provision of fast charging stations for the highways is appreciable, however DC-001 with 15 kW charging power may not be satisfactory for quick charging of EVs with high battery capacities. The 100 kW fast chargers are better suited for this purpose.

2. The exact locations for installation of these chargers have not been defined in the tender. So, optimization of the location of these chargers is left up to the bidding agency.

3. The cost of electrical infrastructure has to be borne by the bidding agency. This is in contrast to the recent tender floated by Delhi Transco Ltd., where the cost of electrical infrastructure up to 100 kW is provided by the Delhi government.

Table 6.10: Bill of Quantity

Sl. No	Item	Location	Quantity
1	Supply, erection and commissioning of AC Smart Charger confirming to Bharat AC 001	Ranchi, Bengaluru Goa Shimla Hyderabad Agra	10 20 10 05 20 05
2	Supply, erection and commissioning of DC Fast Charger confirming to Bharat DC 001	Delhi-Jaipur-Agra-Delhi Highway Mumbai-Pune-Mumbai Highway Ranchi Bengaluru Goa Shimla Hyderabad Agra	25 15 20 30 20 10 40 10
3	Supply, erection and commissioning of Fast Charger of 100 kW with 3 Guns (CCS, CHAdeMO, AC Type 2) with transformer as required	Delhi-Jaipur-Agra-Delhi Highway Mumbai-Pune-Mumbai Highway Ranchi Bengaluru Goa Shimla Hyderabad Agra	07 02 02 08 02 02 05 02
4	5 Core 16 sq. mm armoured copper cable		2000 m
5	11 kV Cable (Fault current 12.5 kA, 0.5S): 3CX 95 sq.mm		1500 m
6	1.1 kV Cable (Fault current 12.5 kA, 0.5S): 3CX 240 sq. mm-3000 M		1500 m

6.4.3 TENDER FOR LOCATION SURVEY, PLANNING, ENGINEERING, MANUFACTURING, SUPPLY AND ERECTION AND COMMISSIONING WITH 5-YEAR ON-SITE WARRANTY OF 3000 AC SLOW CHARGER AND 1000 DC FAST CHARGING EQUIPMENT BY EESL

Energy Efficiency Services Limited (EESL), a joint venture of NTPC, Power Finance Corporation, Rural Electrification Corporation and PowerGrid, set up under the Ministry of power to facilitate implementation of energy efficiency projects issued a tender in August 2017 for EV charging infrastructure requirement. This tender has been floated in two phases to cater to the 10,000 e-sedans to be procured by the Ministry of Power.

- **Phase I:** 250 AC-001 and 50 DC-001 chargers are commissioned primarily for Delhi NCR region
- **Phase II:** 2750 AC-001 chargers and 950 DC-001 chargers to be deployed in different locations throughout India.

The scope of the bid also included the necessary planning of the location and the charging equipment provided should be type tested as per AIS 138 at ARAI (Automotive Research Association of India) or National Accreditation Board of Testing and Calibration Laboratories (NABL) or any International Laboratory Accreditation Corporation (ILAC) accredited laboratories in the world.

Key Observations:

1. The exact locations for installation of these chargers have not been defined in the tender. So, optimization of the location of these chargers is left to the bidding agency.
2. This tender too is heavily focussed on slow chargers, with all chargers having less than or equal to 15 kW charging power.
3. Similar to the earlier tenders, this tender too is heavily focussed on Bharat DC001 and Bharat AC001 chargers. Although AC001 could be used by different EVs with an adequate adapter, DC001 would likely be obsolete soon.

6.4.4 TENDER ON PRIVATE CHARGING INFRASTRUCTURE IN DELHI

To facilitate the growth of private charging infrastructure, the Government of the National Capital Territory of Delhi (GNCTD) invited bids for participation in Request for Selection (RfS) for empanelment of bidders for deployment of private charging stations[173]. The tender was floated in July 2021 and it was for the coverage of spaces as listed below,

- Semi-public areas
  - Commercial buildings like malls, offices etc
  - Institutional buildings like hospitals, RWAs, colleges etc.
  - Kirana stores, shops, etc
- Private property owners like bungalows, apartments etc.

The tender has included two main models of ownership of the chargers,

- CAPEX model in which the user makes a one-time payment for the charger cost with subsidy + GST + 5-meter wire. The user also gets maintenance for 3 years.
- OPEX model in which the user pays a subscription fee for 36 months. The user can use this model only if they procure a minimum of 10 chargers.

6.4.4.1 Subsidies

Under this tender, the user can also avail subsidies, but the terms and conditions for availing the subsidy is based on the user type.

For a private property owner, subsidy would be provided for only 1 charging point per customer. However, if they want to install more than 1 charging point, no subsidy would be provided for the additional chargers.

For a semi-private property owner (which includes commercial buildings, RWA society, Govt. offices, Kirana shops, etc.), subsidy would be provided to up to 20 charging points in the CAPEX model. Under the OPEX model, the subsidy would be allowed for minimum 10 and maximum 20 charging points. If the semi-private property owner wants to install more than 20 charging points, no additional subsidy would be provided.

173 Empanelment of private charging infrastructure vendors Tender

The amount of subsidy that is given is dependent on the charger type,

The GNCTD would provide up to 100% of the price of slow chargers limited to INR 6000 (EUR 68.11) per charging point for the first 30,000 charging points.

The subsidy is only for the charger, with no subsidy for installation cost, additional wiring etc.

6.4.4.2 Issues with the tender

Although the above tender is likely to boost the private charging infrastructure in Delhi, however the following observations are worth looking,

1. The tender provides subsidy to only AC001 chargers and LEV AC chargers. The tender specifically mentions that no subsidy would be provided for chargers of any other type. Hence, Type 2 AC chargers, which are generally provided with newer e-4W models, are not covered by this tender, which can demotivate the customers to purchase an electric vehicle.

2. The new and upcoming EV models are equipped with Type 2 connectors, which limits the use of, and hence the sustenance of AC001 and DC001 in the long run. Therefore, the provision of subsidy to only AC001 and LEV AC charger is unlikely to help in building robust and sustainable charging infrastructure required for smooth EV adoption.

3. For LEV AC chargers, it has been mentioned that the chargers must use an IEC 60309-1:2002 outlet, but the use of such industrial sockets and plugs for e-2W and e-3W may not be feasible. The currently available e-2W and e-3W on the Indian market all have their own proprietary chargers than can be plugged into any domestic 15 A socket. However, if a IEC 60309-1:2002 outlet is provided in the LEV AC chargers, the EV users would have to use an adapter to connect their chargers to the LEV charger.

4. Use of AC001 and DC001 chargers in semi-private areas may not be worthwhile as the vehicles would only be parked in these locations for a limited period of time, so faster chargers (such as Type 2 AC chargers (22 kW)) would be a more suitable future-proof solution.

6.4.5 SUMMARY

From the tenders discussed in Section 6.4, a general pattern emerges that the Indian standardized AC-001 and DC-001 have been the focus of deployment. However, the main potential issue is that these chargers may get redundant soon, depending on the growth of the EV market. There are two primary reasons for this,

The first is the low power throughput of these chargers. As already mentioned above the Bharat AC-001 provides a maximum power output of just 3.3 kW, which may be fast enough for a 2-wheeler or a 3-wheeler with a smaller battery capacity. But for an EV with larger battery capacity (which is expected of modern 4-wheeler EVs) a charging power of 3.3 kW may not be sufficient for use in public charging stations. The focus should be on the development of charging infrastructure with fast AC chargers with Type 2 connectors and fast DC chargers with CCS2.

The second issue is compatibility of chargers. The Bharat AC-001 uses an IEC 60309 industrial connector, which is used by a select few EV manufacturers like Mahindra. The same is true for Bharat DC-001 chargers. The EVs manufactured by international brands like Tata, Hyundai however use the internationally accepted CCS or Type 2 connectors. Even 2-wheelers and 3-wheelers generally have their own proprietary connectors or charge through a standard 15A/5A socket. Although AC-001 can be potentially used by using adapters, the same cannot be said for DC-001. Moreover, the Bharat DC001 has been designed for initial EV car models such as Mahindra E20 and the Mahindra eVerito both of which operates on sub 100 V systems[174]. Since the newer crop of EVs are designed on high voltage systems, the Bharat DC001 has less relevance in today's EV market.

The relevant authorities have started to expand the public charging infrastructure in India, but proper thought needs to be put on who is the intended target user of these charging stations. If the intended target is the 2-wheeler and 3-wheeler customer base, it may be better to allocate standard 15A/5A sockets (or adapters for AC-001) along with the chargers. If the tenders continue to focus more on DC001, then invariably the OEMs would be forced to provide DC001 connector for EVs, which could lead to lack of innovation in the market. So, instead of DC001, more focus should be put on popular connectors such as Type 2 and CCS. For maximum utilization of PCS, widely compatible chargers such as fast AC chargers with Type 2 connectors and CCS chargers should be installed in PCS.

174 DST, "Report on Indian Standards for EV Charging Infrastrcture," August 2021.

6.5 Smart meter rollout

In order to avail dynamic tariff for smart EV charging, the meter needs to be able to have the capability to log the energy use along with the time of energy use. An Indian made smart meter typically costs around INR 6000 – INR 7000 (EUR 68.12 – EUR 79.47), however, with aggressive targets from the government, the price of smart meters is expected to fall to INR 2000 – INR 4000 (EUR 22.706 – EUR 45.413) for bulk procurement. With DISCOMs bearing the price of installation of smart chargers, it is expected that the total cost of replacing all traditional energy meters with smart meters would be around INR 65,000 crore (EUR 7,379 million) . Comparatively, a traditional digital energy meter costs around INR 1000 – INR 3000 (EUR 11.35 – EUR 34.06) .

With the National Smart Grid Mission by the Government of India the aim is to replace the 25 crore conventional meters with smart meters in India. These meters would be connected through a web-based monitoring system, enabling them for transparent information of energy usage. Under this scheme already 43,56,417 smart meters have been installed in the various states as shown in Figure 6.24 and NDMC has become the first DISCOM in India with 100% smart meters installed . Tata Power DDL has also installed around 2 lakh smart meters among its consumer bases.

EV charging is a power intensive process, and thus charging of large fleets of EVs simultaneously will have a significant impact on the entire power system, however its effects will be more pronounced in the distribution networks. Further, the existing distribution networks are designed to primarily cater to the conventional domestic load. Therefore, to accommodate EV demand, the network infrastructure would potentially necessitate upgradation or coordinated smart charging. The main impacts of EV integration on the distribution system are described below.

6.6 Protection schemes with EV integration

The increase in penetration of EVs has a significant impact on the control and operation of distribution networks. The protection of such a system becomes much more challenging with random charging patterns of the EV and V2G capability of EV.

6.6.1 CHALLENGES IN PROTECTION

The conventional protection system is mainly based on unidirectional flow of power, however with integration of distributed generations (DG) and EV, the power flow

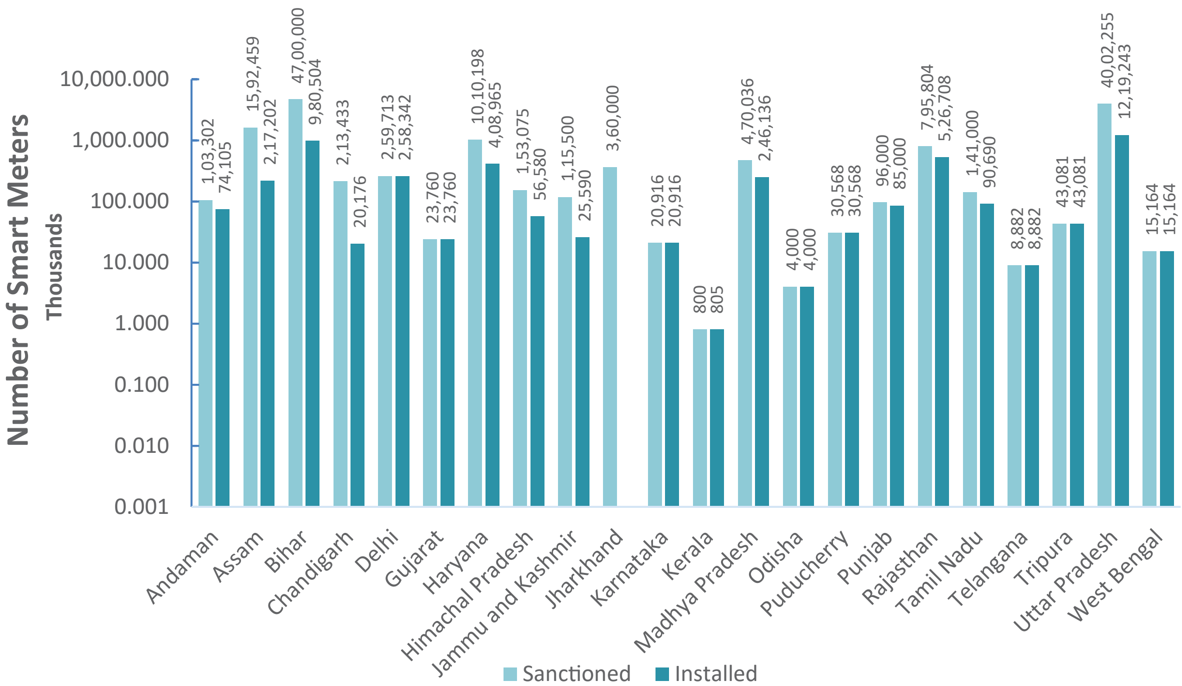


Figure 6.24: Semi log graph of total smart meter installations in the different states till Feb 2022 (Source: National Smart Grid Mission)

has become bidirectional in nature. The fault current magnitude is also dynamic in nature depending on the operations of the network (grid connected or islanded). This has led to various issues ranging from coordination of relays to false tripping and blinding of protection.

6.6.1.2 Co-ordination of relays

The traditional protection scheme is based on unidirectional flow of power. With the integration of EV's capable of V2G service in the network, the selectivity of relays is compromised due to the reverse power flow. The reliable coordination between the relay, fuse, and recloser is also a complicated challenge in such a protection scheme.

6.6.1.3 Unnecessary disconnection or false trips

In a distribution network, the case for false tripping of healthy lines may increase if fault occurs on the neighboring feeder of an EV fleet or a charging station with DG. If V2G compatibility is available, then most of fault current is fed by the EVs and thus can cause relay to trip the healthy line, as shown in Figure 6.25.

6.6.1.3 Blinding of protection

Certain zones in the network may be blinded with higher penetration of EVs and charging stations with DG. For a fault occurring in the farther end of the network, as shown in Figure 6.26, blinding can occur as the fault current shared by the EV or charging station with DG would be higher. Hence, such conditions can lead to non-tripping of the desired relay for protection.

6.6.2 PROTECTION STRATEGIES

The challenges presented due to EV integration in conventional protection schemes can be mitigated by modifying the existing schemes or by developing novel schemes. The various schemes that can be implemented for distribution networks with EVs and DG integration include adaptive, differential, distance, voltage based, variables based, and pattern-recognition based protection schemes. Table 6.11 summarizes the advantages and disadvantages of the listed schemes.

Table 6.11: Advantages and disadvantages of different protection schemes

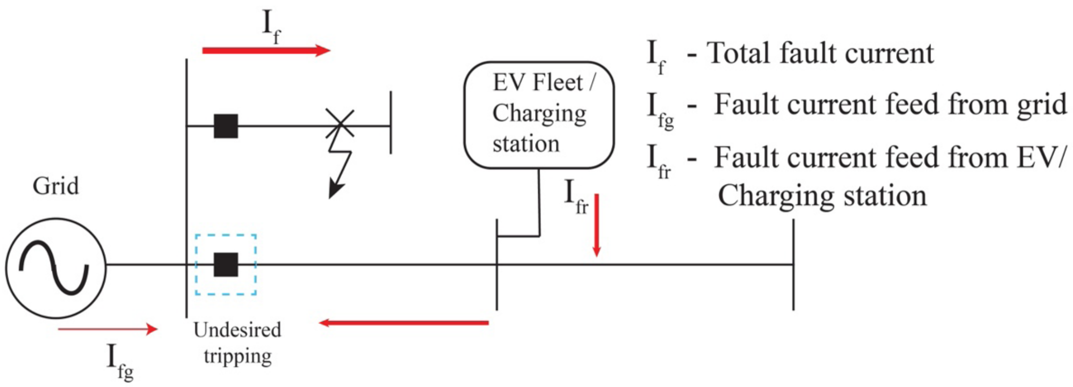


Figure 6.25: Sympathetic tripping of relay

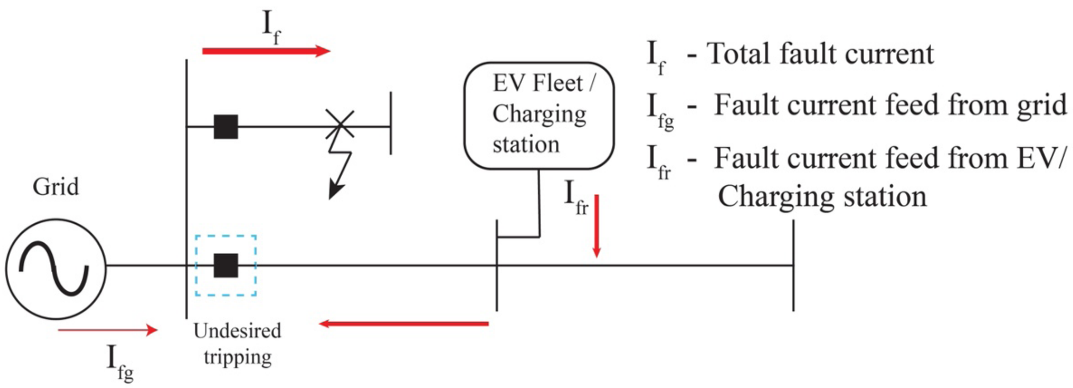


Figure 6.26: Protection blinding due to no tripping of desired relay

Scheme	Advantages	Disadvantages
Adaptive	• Dynamic setting of relay possible • Higher operational speed • Use of universal protocol language for communication	• Higher cost • Dependency on communication link
Differential	• Immune to bidirectional power flow effects • Can be implemented for radial as well as meshed network	• Expensive in implementation • Effective for line protection only • Dependency on communication link
Distance	• Constant relay setting for various changes • Suitable for meshed network due to its directional element	• Complex procedure for relay setting • Relay characteristics has minimal range • Additional voltage transformer required
Voltage based	• In zone and out zone protection • Faster fault identification	• Susceptibility to voltage deviations • Not suitable for complex networks • Unable to detect high impedance fault
Variables based (sequence components, harmonic distortion, etc.)	Compatible for bidirectional power flow	Threshold setting is a tedious task
Pattern recognition based	• No precise relay setting required • Operates for various modes of network	• Dependency on data • Some techniques are computationally expensive

6.7 Some key metrics for assessing of grid readiness for EV integration

Several parameters need to be analysed to determine the readiness of the electricity grid for mass EV integration. These metrics measure the impact of the emerging technologies on the network's reliability under varied charging condition, shifting demand patterns, composition of demand, etc .

6.7.1 SYSTEM AVERAGE VOLTAGE MAGNITUDE VIOLATION INDEX: M1

System average voltage magnitude violation index (SAVMVI) provides the severity of voltage violations at a given bus. Separate bounds are generally allotted for primary (high voltage) nodes and secondary (low voltage nodes) by the utility. The average bus voltage is calculated as

Where n is the number of buses in any node i. For each bus i at each time t, the violations are defined as

Where Vl and Vu are the lower and the upper thresholds. All voltages are

$$V_i^{avg} = \frac{1}{n}\sum_{k=0}^{n} V_i^k$$

The time averag determined using

The SAVMVI for the feeder is then obtained by

$$V_i^{viol}(t) = \begin{cases} V_{avg}(t) - V_u, if\ V_{avg}(t) > V_u \\ 0, if\ V_l < V_{avg}(t) < V_u \\ V_l - V_{avg}(t), if\ V_{avg}(t) < V_l \end{cases}$$

The value of SAVMVI is the index that relates to the number of voltage violations at each node, throughout the period under consideration. For a stable system with

$$V_i^{violavg} = \frac{1}{T}\sum_{t=0}^{T} V_i^{viol}(t)$$

$$SAVMVI = \frac{1}{N}\sum_{i=0}^{n} V_i^{violavg}$$

minimum violations this value should be as close to 0 as possible.

6.7.2 SYSTEM AVERAGE VOLTAGE FLUCTUATION INDEX: M2

System average voltage fluctuation index (SAVFI) provides the measure of the differences between average voltages at a current operating time interval and the preceding one, i.e., it determines the voltage fluctuations. Voltage fluctuation for any bus ‘i’ can be written as

The SAVFI, gives the average magnitude of all voltage fluctuations, so for a stable distribution system with n=minimum fluctuations in the voltage, this value should also be as low as possible.

$$V_i^{fluc}(t) = |V_i^{avg}(t) - V_i^{avg}(t-1)|$$

$$V_i^{fluc_{avg}} = \frac{1}{T}\sum_{t=0}^{T} V_i^{fluc}(t)|$$

$$SAVFI = \frac{1}{N}\sum_{i=0}^{n} V_i^{fluc_{avg}}$$

6.7.3 SYSTEM AVERAGE VOLTAGE UNBALANCE INDEX: M3

System average voltage unbalance index (SAVUI) provides a measure of the voltage unbalance between the individual phases and is defined by

$$Voltage_{unbalance} = \frac{(Maximum\ deviation\ from\ the\ average\ voltage)}{Average\ voltage} \times 100\%$$

$$V_i^{unb_{max}}(t) = |\max(V_i^k(t) - V_i^{avg}(t)|$$

$$V_i^{unb_{min}}(t) = |\min(V_i^k(t) - V_i^{avg}(t)|$$

$$V_i^{unb}(t) = \frac{\max\left(V_i^{unb_{max}}(t), V_i^{unb_{min}}(t)\right)}{V_i^{avg}} \times 100$$

$$V_i^{unb_{avg}} = \frac{1}{T}\sum_{t=0}^{T} V_i^{unb}(t)$$

The system control ($SAVFI = \frac{1}{N}\sum_{i=0}^{n} V_i^{unb_{avg}}$ (SCDOI) is the measure of the average number of operations of control devices in a day such as operation of voltage regulators, capacitor banks etc. If the number of utilization of control operation in a day is given by TOCO,I for each control device and the number of control devices is then the SCDOI for the system is

A higher value of SCDOI indicate that control devices are operating more frequently to keep the grid in stable operating condition.

$$SCDOI = \frac{1}{N_{CO}} \times \frac{1}{T_{day}} \sum_{i=1}^{NC} TO_{CO_i}$$

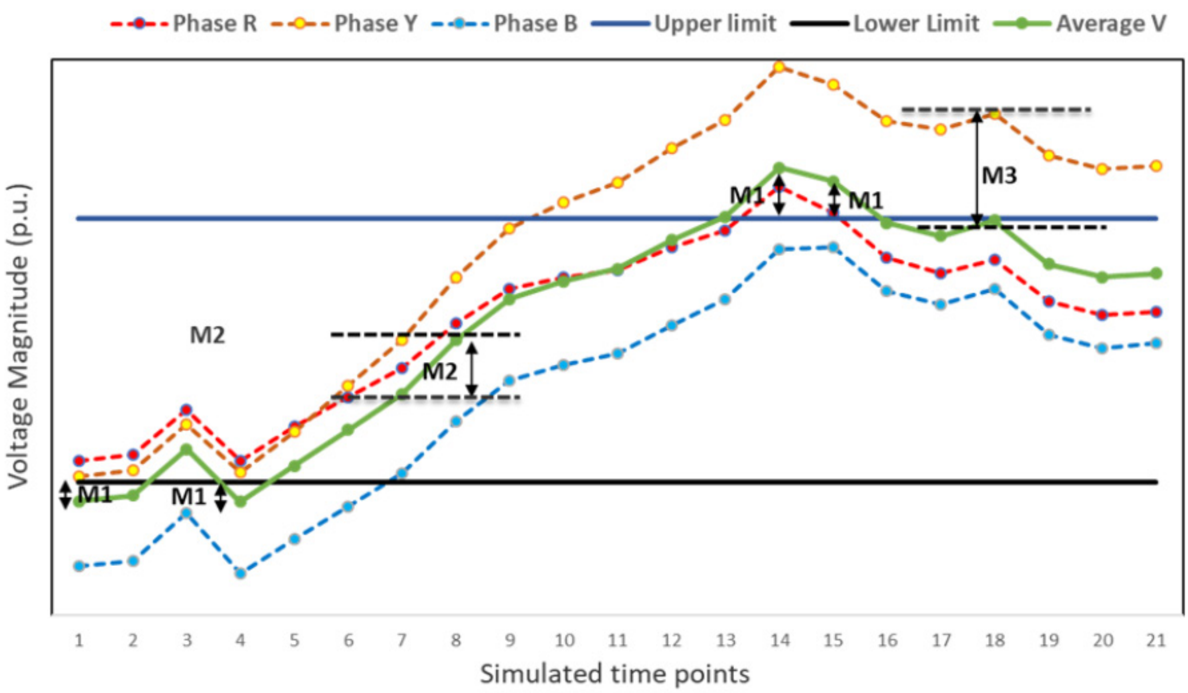


Figure 6.27: Representation of technical indices M1, M2 and M3 (Nagarajan et al., 2020)

6.7.5 SYSTEM REACTIVE POWER DEMAND INDEX

System reactive power demand index (SRPDI) is a measure of the power factor at the substation and consequently the additional loading on the substation transformer because of reactive power demand/injections of the feeder. If Qsub(t) is the reactive power injection/demand at the substation at time t

$$SRPDI = \frac{1}{T}\sum_{t=0}^{T} Q_{sub}(t)$$

6.7.6 SYSTEM ENERGY LOSS INDEX

The system energy loss index (SELI) is the ratio of total energy loss in the feeder to the total energy demand of all the loads.

$$E_{loss} = \frac{1}{T}\sum_{t=0}^{T} kW_{loss}^{sub}(t) \times \frac{\Delta t}{60}$$

The total energy demand is

$$E_{loss} = \frac{1}{T}\sum_{t=0}^{T} kW_{loss}^{sub}(t) \times \frac{\Delta t}{60}$$

Case Study: Cost Benefit Analysis of BESS and EV integration in two feeders of BRPL

This partnership project which is a joint effort between USAID and Ministry of Power, Government of India tried to assess different metrics to assess the preparedness of Indian distribution grids for integration of grid scale storage and EVs. BESS were evaluated based on their effectiveness for mitigation of feeder overloading scenarios and their costs were compared to distribution network upgradation costs. The effects of EV density on the grid infrastructure and the management of EV charging with BESS was also studied[175]

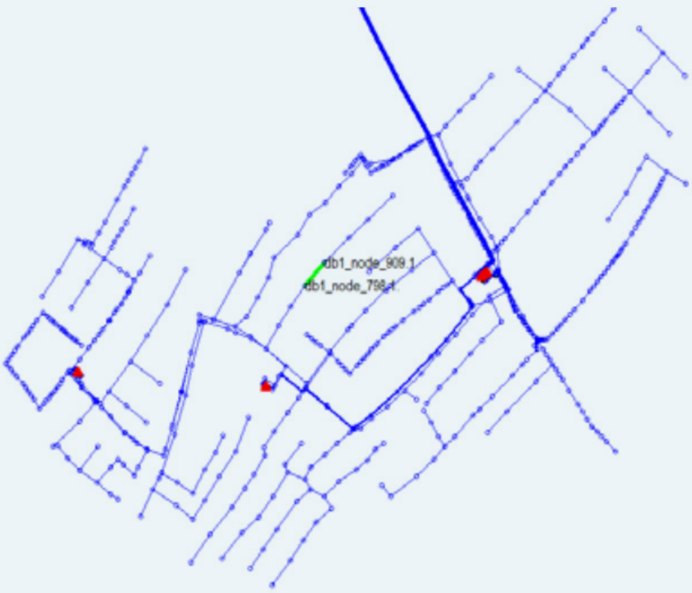


Figure 6.28: OpenDSS Model of a part of the selected distribution grid of BRPL[176]

The study considered 300 chargers clustered among 10 public/workplace charging stations. There were 2000 EVs with each EV having their own charging behaviour.

EV scenarios

- **Low:** residential, overnight charging, 3.3 kW chargers, new EV users are added every year and the number of vehicles in the 10th year is double the number of EVs in the first year.

175 Adarsh (NREL) Nagarajan et al., "Preparing Distribution Utilities for Utility-Scale Storage and Electric Vehicles: A Novel Analytical Framwork," USAID, 2020, https://www.nrel.gov/docs/fy20osti/75973.pdf.
176 Nagarajan et al.

- **Medium**: residential+workplace charging, overnight+afternoon peak charging, 3.3kW+10kW DC chargers, new EV users added every year with four times the number of vehicles in the 10^{th} year.
- **High**: residential+workplace+public charging, overnight+afternoon peak+intermittent topping, 3.3kW+10kW DC+50kW CCS/CHAdeMO chargers, new EV users added every year, with 8 times the number of vehicles in the 10^{th} year.

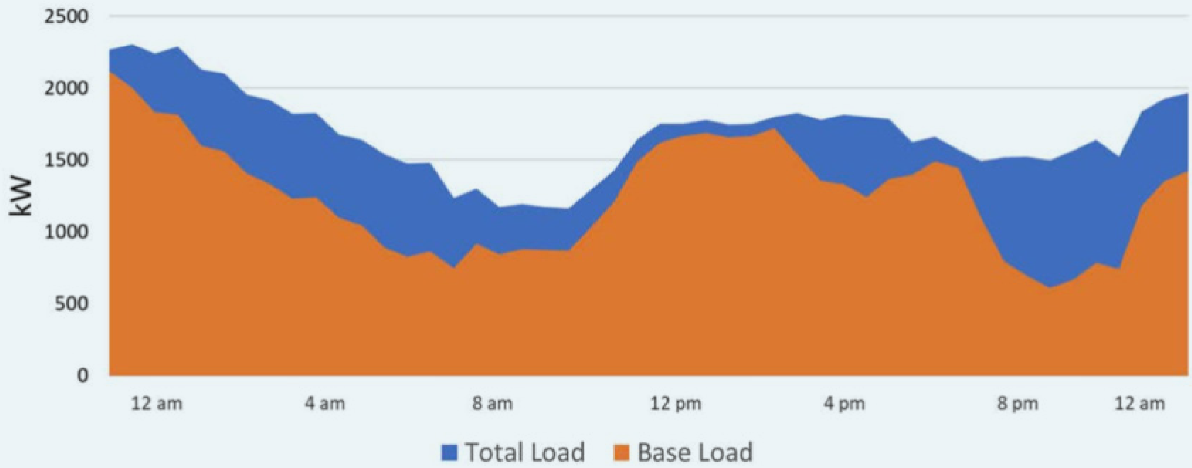


Figure 6.29: Baseload and total load after EV integration for a summer day[177]

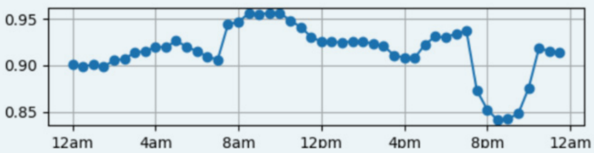


Figure 6.30: Voltage profile of a selected feeder with EV integration [177]

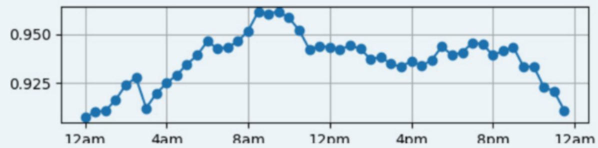


Figure 6.31: Voltage profile without EV integration[177]

The battery capacities were optimized based on the existing overload duration in the transformers. An analysis was carried out which estimated the peak power during overload and also the energy flow during the overload period. The instances of over-loading of distribution transformers over a year was then plotted and the battery size was selected so as to mitigate at least 70% of these overloading instances.

The battery sizes for the different distribution transformers are given in Table 6.12.

Table 6.12: Battery Sizes for the different distribution transformers[177]

Distribution Transformer	Power rating (kW)	Energy rating (kWh)
29508683	0	0
29510008	177	707
29510532	49	198
29511218	157	630
29511236	139	558
29601121	122	188
29601126	0	0

Two different cases have been modelled for the charging/discharging of BESS. If the SoC of the BESS reaches 70%, then the BESS starts discharging and it starts charging again if the SoC reaches 50% for case 1 and reaches 65% for case 2. So, for case 2 there is more frequent charging/discharging cycles.

177 Adarsh (NREL) Nagarajan et al., "Preparing Distribution Utilities for Utility-Scale Storage and Electric Vehicles: A Novel Analytical Framwork," USAID, 2020, https://www.nrel.gov/docs/fy20osti/75973.pdf

Figure 6.32 shows the instance of transformer overloading over a period of 10 years. The integration of EVs increased the instances of overloading by 35% more than the baseline as shown in Figure 6.32. Using BESS 65% of the overloading issues were mitigated.

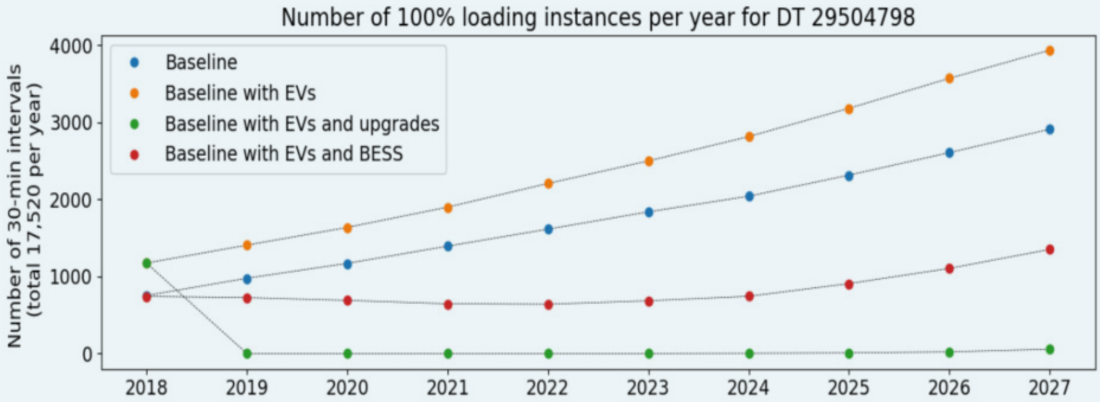


Figure 6.32: 100% Loading instances [177]

Figure 6.33: Line loading due to high EV penetration. Overloaded line segments are shown in red[177]

Figure 6.34: Relief in line loading due to BESS integration under the high EV penetration scenario[177]

The grid readiness metrics for different scenarios have been given in Table 6.13, which shows that SAVMVI has a value of around 0.000028, which is almost negligible, SAVFI has a value of around 0.0024 p.u. which implies that the average voltage fluctuation in around 0.0024 p.u. So, the feeders are robust enough for EVs to be integrated.

Table 6.13: Grid readiness metrics[177]

	Baseline + EV	Grid upgrades + EV	BESS + EV
SAVMVI	2.8×10^{-5}	1×10^{-5}	2.8×10^{-5}
SAVFI	0.00247	0.00188	0.00245
SAVUI	0.343	0.333	0.343
SRPDI	765.61	775.37	764.1
SELI	0.02407	0.0238	0.02408

6.8 Impacts of EV Integration on the Indian Distribution System

The impact of EV load on the distribution system, is dependent on different parameters and factors such as,

- Local EV penetration level
- Rating of EV chargers
- EV user travel behaviour
- Charging needs
- Grid operational parameters (loading, voltage level etc)
- Local distributed generation status

Accordingly, a holistic approach is necessary to analyze the impact of EV charging under different EV penetration and charging behaviour scenarios as well as different grid operating conditions.

As most DISCOMs are the state nodal agencies for EV integration into the grid, the necessary planning activities should be carried out by the respective DISCOMs. Such planning activity would help the DISCOMs identify various important factors such as the exact locations where grid upgradation would be required, optimal location for placement for public charging stations with fast chargers, and locations at which additional measures may be required to support voltage. Such planning and operational studies can also help understand the impact of smart charging on the distribution system and how the EVs can help in providing grid support services. The various studies that need to be incorporated to have a holistic view on the impact of EVs on distribution system include,

1. Obtaining statistical data of travel behaviour for the vehicular fleet in the area of study. This would shed light on how much a single EV travels and at what time period it starts and ends the journey, which would in turn given an estimate on the probable time of the EV being charged.
2. A study on the forecast of EV growth. Based on the locality, the economic condition of its residences, their preference towards adoption of newer technologies based on historical data needs to be undertaken so that the expected EV growth, 5 to 10 years down the line, can be estimated and planned for accordingly.
3. Based on the existing EV proliferation in the study area and future expected EV load, the hosting capabilities of the different distribution feeders need to be estimated, and necessary measures need to be planned. Load flow studies may also be carried out at the distribution system level, for different grid operation scenarios such as during peak time periods, during off-peak time periods, scenarios with high EV penetration etc. These load flow studies would intimate the DISCOMs on which feeders are likely to be overloaded and which distribution system equipment would need additional support to cater to the EV charging demand.

Some of the key case studies on EV integration in the Indian power system have been discussed below.

6.8.1 CASE STUDY 1

In this case study, BSES Yamuna Power Limited (BYPL) in New Delhi selected three feeders for studying the impact of EV charging on the distribution network , the list of which along with the reasons are:

- Janta Colony Feeder, since it is loaded up to 69% and there is the presence of e-rickshaw charging stations on it

- Arya Samaj Road Feeder, since the voltage profile at its last distribution transformer (DT) was recorded to achieve very low voltages and the feeder is also loaded to around 76%
- MVR Sadar Feeder, since the DC charging stations are about to be rolled out in the feeder.

Apart from the peak loads, number of DTs, the total number of customers catered, and maximum energy consumed, the other data that was collected on these feeders were the annual feeder load profile, load growth for the past five years, annual voltage profile, DT capacity, annual DT phase-wise loading, annual DT phase-wise voltage, consumer mix connected on each DT, the monthly energy consumption of each DT for a year, DT-wise monthly peak for a year and location and capacity of existing domestic EV charging stations in the feeder. A methodology was formulated to find the near term and the long-term distribution impacts in response to customer behaviour and EV penetration along with solar rooftop PV generation[178]. The considered scenarios and the obtained results for the case of Arya Samaj Feeder are listed below:

- Base Case: The distribution network of the Arya Samaj feeder from the 11-kV side is modelled with loads as per the selected day's load profile shown in Figure 6.35. The corresponding voltage profile at the DT's LV side showed that the voltage is within the voltage limits throughout the day without any EV penetration.
- **Case 1:** In this case, the starting SoC of the EV loads has been assumed to be 25% since the charger draws more power in constant current mode until the SoC reaches a certain level and switches to constant voltage mode, which consumes low power. The case study is executed for 24 hours with the selected load profile, including the EV loads plugged in at different times in a day. It is observed that the feeder load profile changes with the addition of EVs and adds to the existing system loading. The simulation results show that high EV penetration is during the morning and evening. The impact of loading on each DT varied as per the charging behaviour and connected EVs under DTs, which follows a random distribution.
- **Case 1A:** In this case, the starting SOC of the EV loads has been assumed to be 60% to understand the impact of EV charging with a higher SoC. EV, when plugged into the system with a higher SoC, the power consumption is lesser, but the frequency of charging the EV also increases. It is observed that when EVs are plugged into the grid at higher frequencies with higher SOC, the impact is less on the grid.
- **Case 2:** The feeder network is considered with both EV and rooftop PV penetration. A typical solar generation profile is considered with a total installed capacity of PV generation of 2.37 MW. Based on the historical solar rooftop data, it is observed that 90% of the solar installed capacity will be connected to the

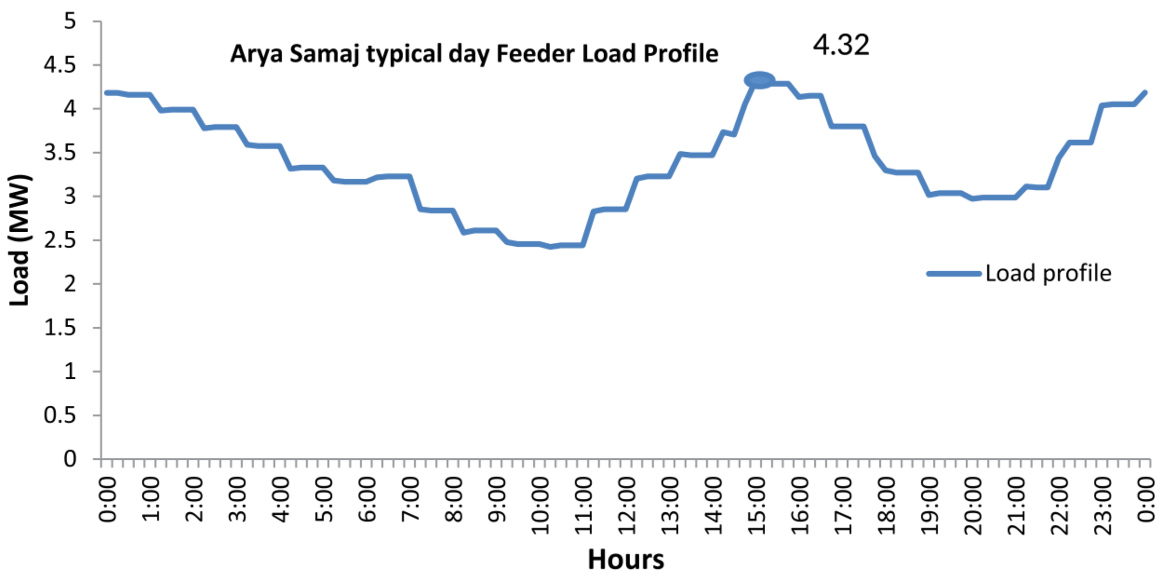


Figure 6.35: Arya Samaj Feeder typical load curve [178]

178 Chandrasekhar Reddy Atla et al., "Impact Assessment of Large-Scale Integration of Electric Vehicle Charging Infrastructure in the Electricity Distribution System" (GIZ, 2019).

grid at its maximum power generation, and the same is considered in the simulation studies.

- With typical solar generation profile: It is observed that energy drawn from the grid reduces significantly with solar generation in the feeder. The impact of EV charging during PV generation is minimum or nil, and the feeder can take up more EV charging scenarios during PV generation. There is also a reverse power flow in the transformer during peak solar time. Hence if the DISCOM wishes to control the reverse power flow at 33/11 kV grid transformer, the maximum solar PV penetration can be limited to minimum loading of grid transformer with proper configuration of protection coordination. This allows more PV penetration above 40% of DT capacity under each DT and maintains no reverse power flows at the grid transformer. In brief, enhancing protection settings and maintaining harmonics within the limit allows further PV rooftop penetration.
- With variable solar generation profile: It is observed that energy drawn from the grid reduces significantly with solar generation in the feeder. The pattern of power consumed from the grid reflects the rooftop solar generation pattern. Percentage loading of the distribution transformers is similar to the earlier case.

- **Case 3:** Here, the penetration of EV loads on the base case and one public charger located in the middle of the feeder is considered. Power consumed is significantly less in the early hours due to 1 or 2 vehicles being scheduled for charging. As the day progresses, the DT loading increases due to multiple vehicles charging at the PCS. Since the initial SoC of 25% is considered, and the EVs are plugged in for the entire duration of the simulation, the vehicles draw more power initially in constant current mode until the SoC reaches a certain level and switches to constant voltage mode where power consumed is less. Compared to Case 1, the public charger has a much higher impact on the feeder loading, which can be attributed to its fast-charging capability.
- **Case 4:** Here, the penetration of EV loads on the existing base case condition is assumed with twice the number of EVs of Case 1 (more than anticipated). It is observed that the feeder load profile changes with the addition of EVs and adds to the existing loading in the system. From the simulation results, it is observed that higher number of EVs impacts loading on some of the DTs compared to others. Also, the impact of loading varied as per the charging behaviour and connected EVs under DTs.
- **Case 5:** In this case, the penetration of EV loads on the existing base case condition is considered with twice the number of EVs of Case 1 (more than anticipated) along with one public charger.
- **Case 6:** Here, the penetration of EV loads on the existing base case condition with twice the number of EVs of Case 1 (more than anticipated) along with one public charger and Time of Use (ToU) tariff is considered. Some vehicles get charged in public charging stations, and charging time is aligned with solar generation. It has been assumed that 80% of EVs will connect to the grid during the high solar period. It can be observed that energy drawn from the grid reduces significantly with solar generation, and the system stress is reduced.
- **Case 7:** The penetration of EV loads on the existing base case condition with twice the number of EVs of Case 1 (more than anticipated) along with one public charger and grid battery storage system is considered here. The battery is charged during the peak solar time and discharged during peak EV charging time. Here, the battery charges during the peak solar time and then discharges during the peak load time. This helps reduce the stress on the system during peak hours while also absorbing the solar generation, thus reducing the probability of energy curtailment.
- **Case 8:** The penetration of EV loads onto the existing base case condition with lower EV battery size (present battery technologies in India) is considered here. With lesser battery capacity in EV, the range is lesser, and the vehicle's frequency is high. The total number of EV charges per day for different vehicle categories is distributed throughout the day in different time slots. The EVs are plugged in at different poles under different DTs randomly. The random distribution has been selected since EV penetration under each DT will not follow uniform distribution in the future. The results of Case 1 and Case 8, where higher and lower capacity batteries are considered, show that the impact on the grid is more with high-capacity battery EVs. This is due to the consumption of large current from the grid when high capacity EVs are connected even though high capacity EVs are lesser than low capacity EVs.

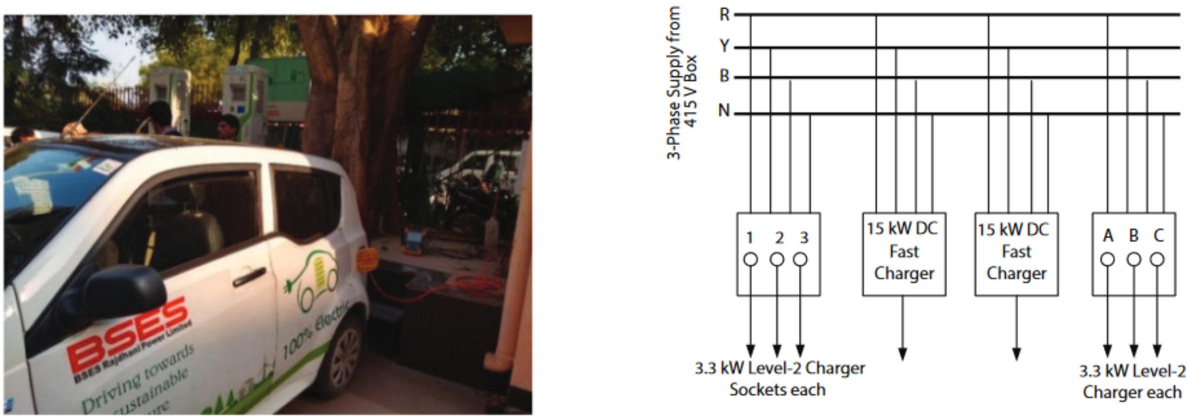
6.8.2 CASE STUDY 2

Measurement and analysis of EV chargers installed in parking lot of BRPL Corporate Office

Four EVSEs (2 AC Level 2 and 2 DC Fast Chargers) are installed in the corporate office of BSES Rajdhani Power Limited, whose power quality during EV charging has been[179] studied. The duration of measurement was 1 hour with a sampling time of 10 seconds .[179]

Figure 6.37 shows the difference in the power flows among the three phases.

By comparing Figure 6.37 and Figure 6.38 it can be seen the current harmonics is inversely proportional to the power demand. In the initial period when the current drawn was low, the harmonics peaked, while they decreased as the power flow through the phases increased.



(a) (b)

Figure 6.36: a) EV charging station in BRPL and b) Connection diagram of the 4 chargers[179]

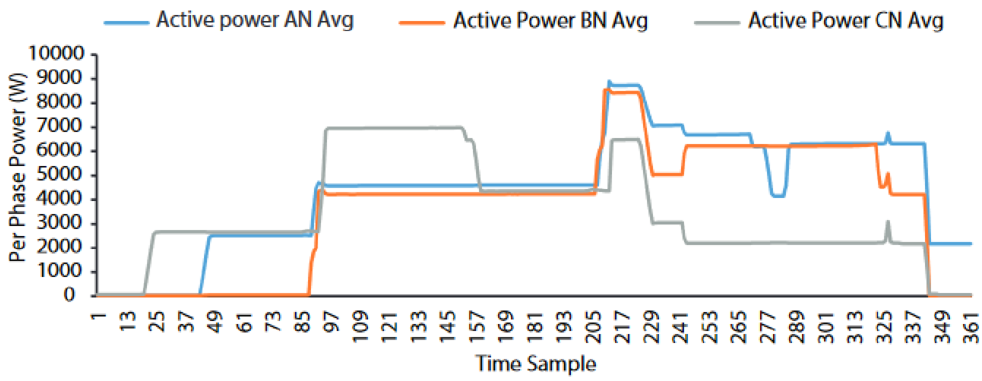


Figure 6.37: Observed per phase power[179]

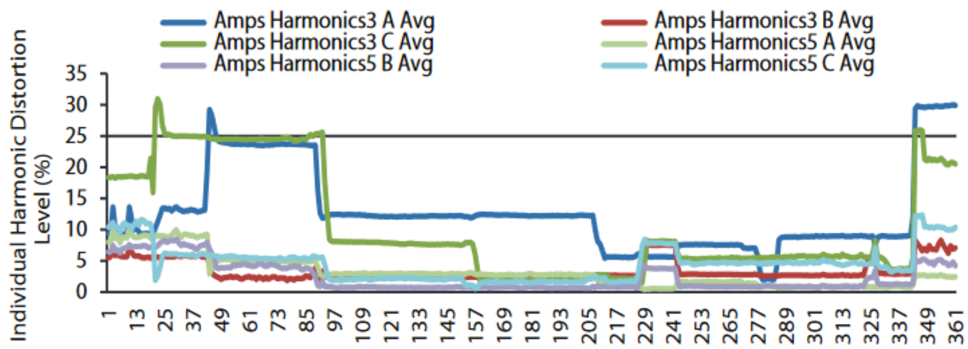


Figure 6.38: Variations in 3rd and 5th order harmonics in the different phases [179]

179 TERI, "Electric Vehicles: Perspective of DISCOMs and Stakeholders," 2020, https://www.teriin.org/sites/default/files/2020-09/DUF_EV_Report.pdf.

6.8.3 CASE STUDY 3

Case Study: Role of distribution utilities as fleet operators and implementation of controlled and uncontrolled EV charging

This study has been carried out in a residential network of the Calcutta Electricity Supply Company (CESC), consisting of a 20 MVA transformer stepping down the voltage from 33 kV to either 11 kV or 6 kV. The transformer has six outgoing feeders each consisting of eight to ten 11 kV or 6 kV/415 V DT with a rating of 315 kVA or 400 kVA. The total number of DTs in the network is 50 and the EVCSs are connected to the secondaries of the DTs as shown in Figure 6.39[179].

The EV charging has been modelled to be dependent on the SOC and the charger rating, as shown in Figure 6.40. The charger ratings considered are 3.3 kW for slow charging and 15 kW for DC fast charging. Based on a survey of 30 working individuals, the behaviour of the EV users have been modelled as a probability distribution given in Figure 6.41. Similarly, the average distance travelled by user has also been modelled as probability distribution.

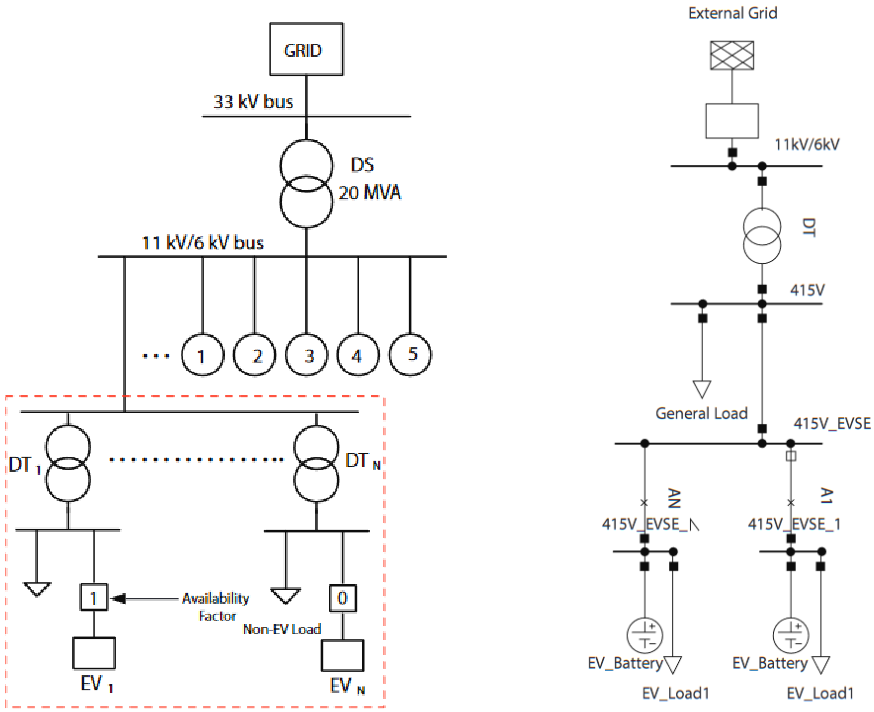


Figure 6.39: Single line diagram of the test network[179]

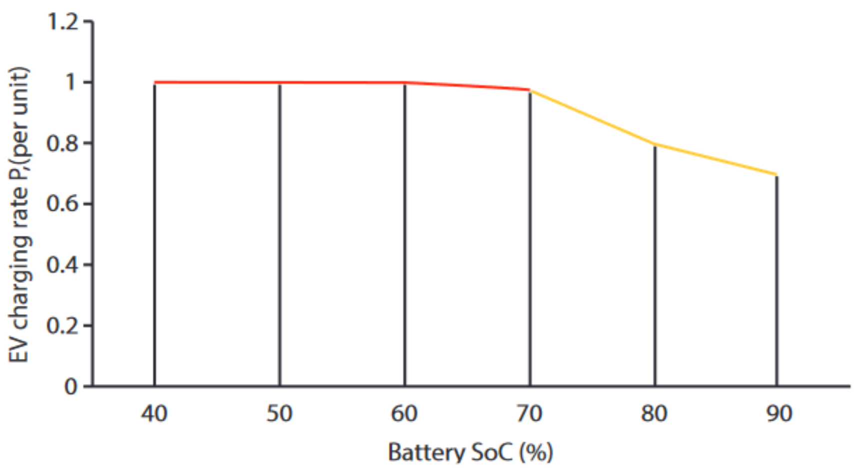


Figure 6.40: EV charging characteristic [179]

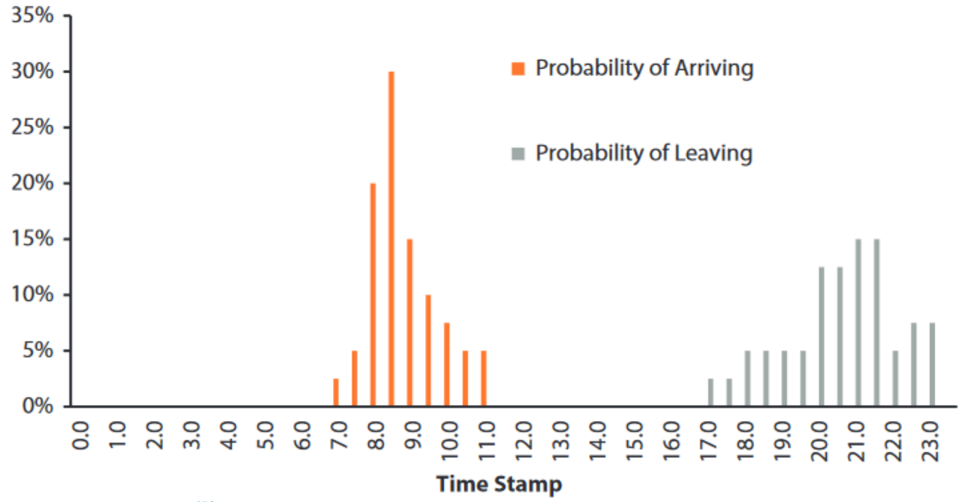


Figure 6.41: EV user travel behaviour[179]

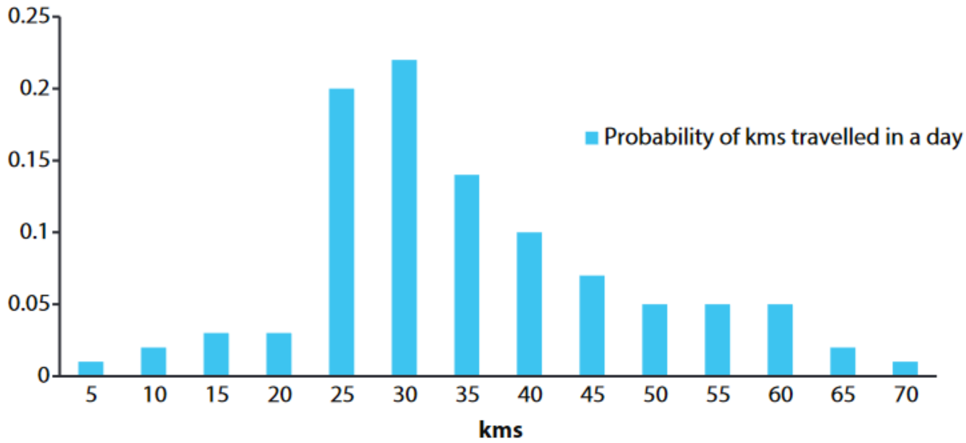


Figure 6.42: Probability of distance travelled per day[179]

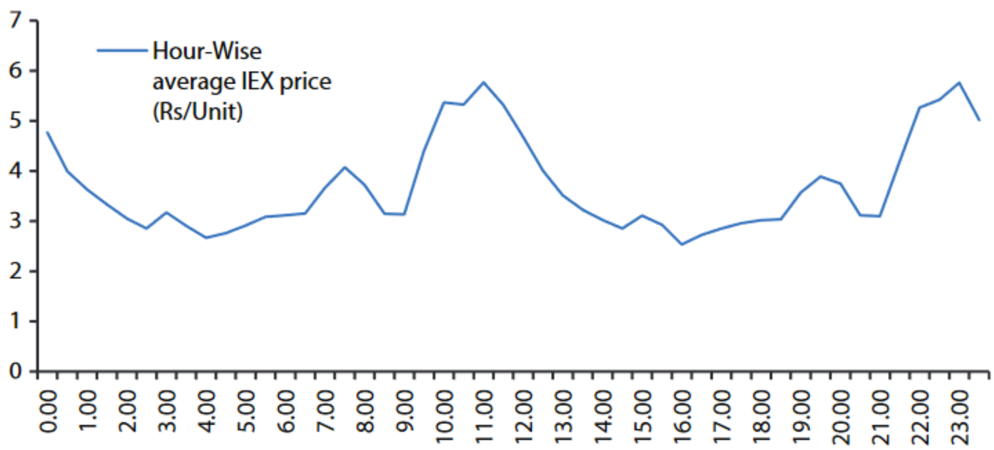


Figure 6.43: Hourly average price in IEX[179]

The hourly average of the electricity prices in IEX has been used as reference to control the charging. In the proposed controlled and coordinated (CC) scheme, the cost of EV charging has been defined as

- Power purchase rate as per dynamic market price (ToD)
- Shadow price associated to distribution component loading (CL(t)), if the EV is charged during overloaded conditions
- The total price = ToD(t) + CL(t)

In this scheme, the role of EV fleet operator (DISCOMs in this case) are

- Guarantee that the battery SOC at the end of the charging duration has enough charge to fulfil the EV users travel needs
- Implement a centralized control for reduction of peak power due to EV
- Optimize the charging to minimize the impact on distribution network assets.

Two scenarios have been considered for a comparative analysis.

Table 6.14: Scenarios considered for comparative analysis[179]

Scenario	Number of DTs with EVs	Number of EVs at each DT	Total number of EVs
1	30	15	450
2	50	7	350

Impact on Distribution Sub-Station

The effectiveness of the CC charging scheme has been summarized in Table 6.15, from which it can be seen that

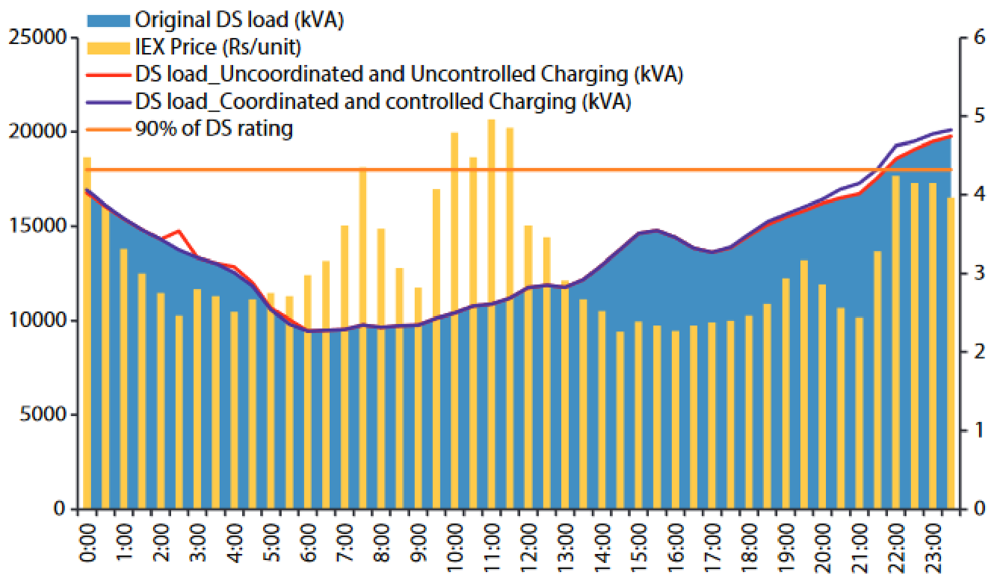


Figure 6.44: Loading on the distribution sub-station[179]

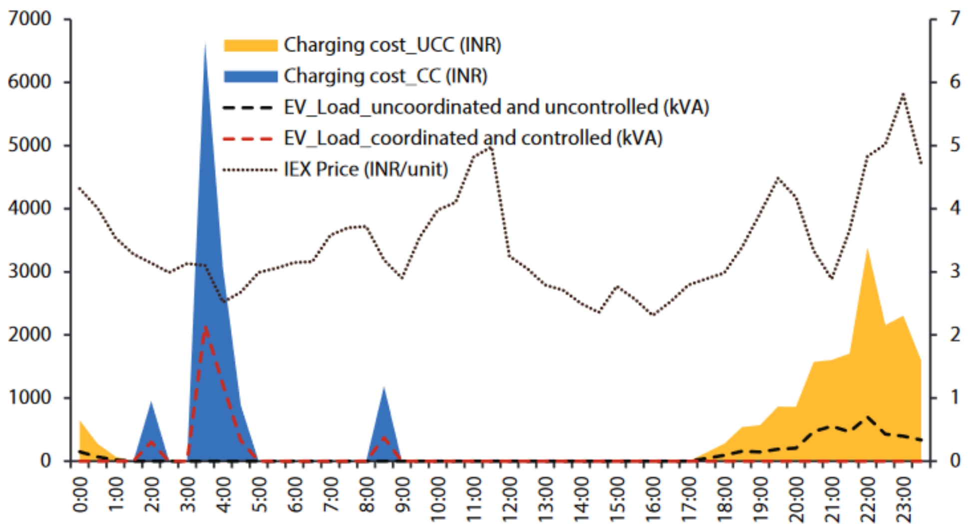


Figure 6.45: Total charging costs for both CC and UCC charging[179]

with the CC charging scheme, there were no instances of DT overload both for Scenario 1 and Scenario 2, as opposed to 5%-22% and 4%-14% DT overload instances using UCC charging in Scenario 1 and Scenario 2 respectively. The cost of EV charging has also reduced substantially, in addition to the 6% decrease in DS overload instances.

Table 6.15: Summary of results[179]

Parameters	Scenario 1		Scenario 2	
	UCC	CC	UCC	CC
% Increase in DT overload instances	5%-22%	None	4%-14%	None
% Increase in DS overload instances	6%	None	6%	None
Cost of EV charging (INR. /kWh)/ (EUR/ kWh)	4.3/ 0.05	2.7/ 0.03	4.2/ 0.05	2.5/ 0.03

6.8.4 CASE STUDY 4

Case Study: Impact of EV penetration on Delhi DISCOMs

The four DISOCOMs of Delhi, Tat Power Delhi Distribution Limited ((TPDDL), BSES Rajdhani Private Limited (BRPL), BSES Yamuna Private Limited (BYPL), and New Delhi Municipal Council (NDMC) – were selected for the case study, in which the impact of EV penetration on the DISCOM level has been explored. The study assumed that each DISCOM would have 10,000 EVs comprising of 2W, 3W and 4W and 100 e-buses. So, in the entire Delhi region there would be a cumulative of 40,400 EVs. The breakdown of the number of vehicles based on their category has been given in Table 6.16.

Table 6.16: Number of vehicles as per the different categories under each DISCOM[180]

2W	3W	4W	Bus
7100	1550	1350	100

The charging characteristics for the fleet of EVs is given in Table 6.17. Urban e-bus charging is expected to be mostly done at the bus depots. The charging frequency have been defined as the number of times each vehicle is charged per day. To determine the peak power demand different scenarios have been considered.

- Scenario I: All EVs start charging at the same time
- Scenario II: 50% of EVs start charging at the same time

Table 6.17: Charging Details[180]

Parameters			Unit	2W	3W	4W	Bus
Rated Charger Power	Home/Captive		kW	0.55	1.5	3	-
	Bus Charging	Slow Charger	kW	-	-	-	80
		Fast Charger	kW	-	-	-	100
	Public		kW	2	2	15	
Rated Battery Capacity			kWh	2	5	20	200
Charging Frequency			Ratio	1.1	1.5	2	1.5

The study has assumed that night-time charging starts at 10 pm for e-buses and 9 pm for the other EV categories. During daytime, the charging starts around noon.

The projected EV load for Scenario I under a single DISCOM area is given in Figure 6.46. The energy requirement of the 4W segment is higher, which is generally because of the larger battery in a 4W compared to 2W and 3W. Further, public charging is mainly observed during the daytime, as compared to home charging which has prevalence during the night periods. Comparison of Figure 6.47 and Figure 6.46 highlights the fact that for the scenario where EVs do not charge at the same time, the total demand on the network is significantly reduced, and more spread out through the day. Moreover, comparing the e-bus charging with slow charging, the total power drawn in lower than fast charging, but the time taken for charging is also higher, which may be a constraint considering the fact that the public transport buses have to maintain a strict schedule.

180 Shyamasis Das and Bhawna Tyagi, "EV- A New Entrant to India's Electricity Consumer-Basket," Alliance for an Energy Efficient Economy, 2020, https://shaktifoundation.in/wp-content/uploads/2020/08/Full-Report-A-New-Entrant-To-Indias-Electricity-Consumer-Basket.pdf.

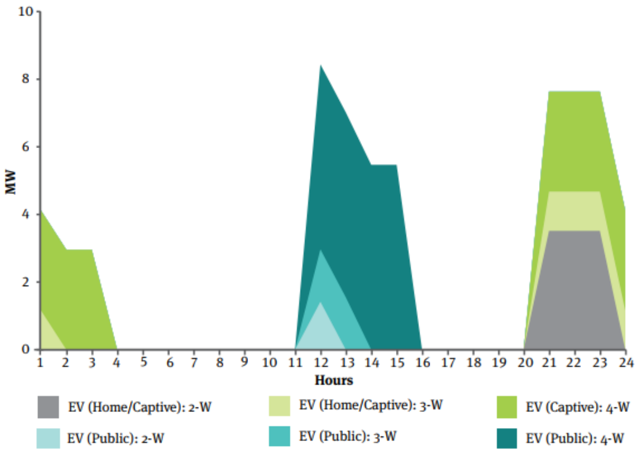


Figure 6.46: EV charging load of 10,000 EVs in Scenario I[181]

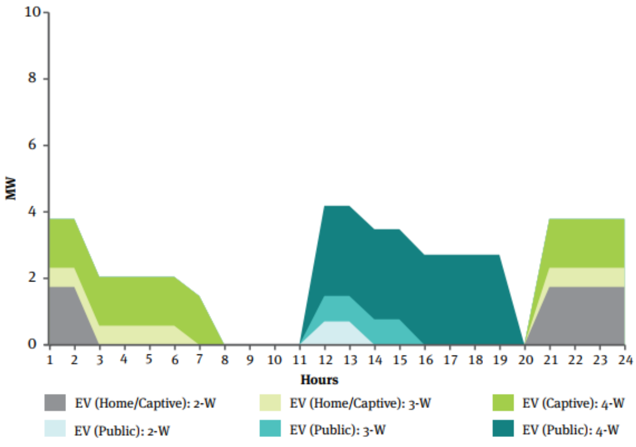


Figure 6.47: EV charging load of 10,000 EVs in Scenario II[182]

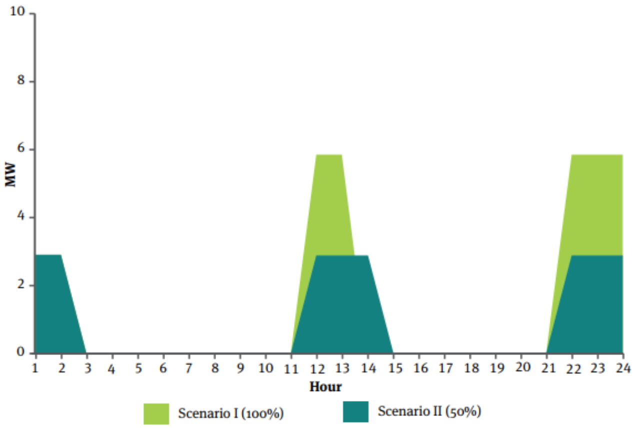


Figure 6.48: Project e-bus charging using slow chargers[183]

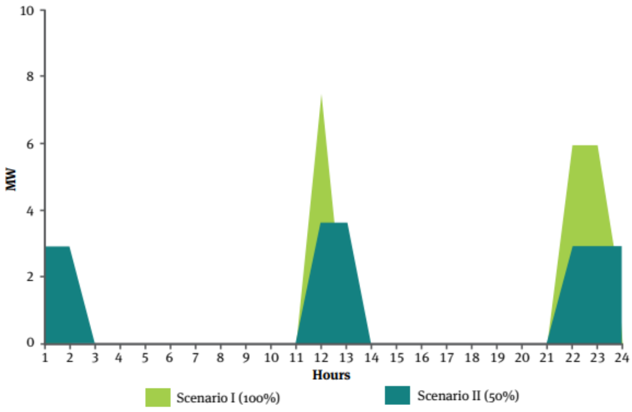


Figure 6.49: Projected e-bus charging using fast chargers[184]

181 Das and Tyagi.
182 Das and Tyagi.
183 Das and Tyagi.
184 Das and Tyagi.

Impact on DISCOMS:

The impact of EV charging on the DISCOMS is dependent on the relative load served by each DISCOM. So, as can be seen in Figure 6.50, the change in load curve in DISCOM-I is more prominent than the other 3 DISCOMs, primarily because its existing demand is less.

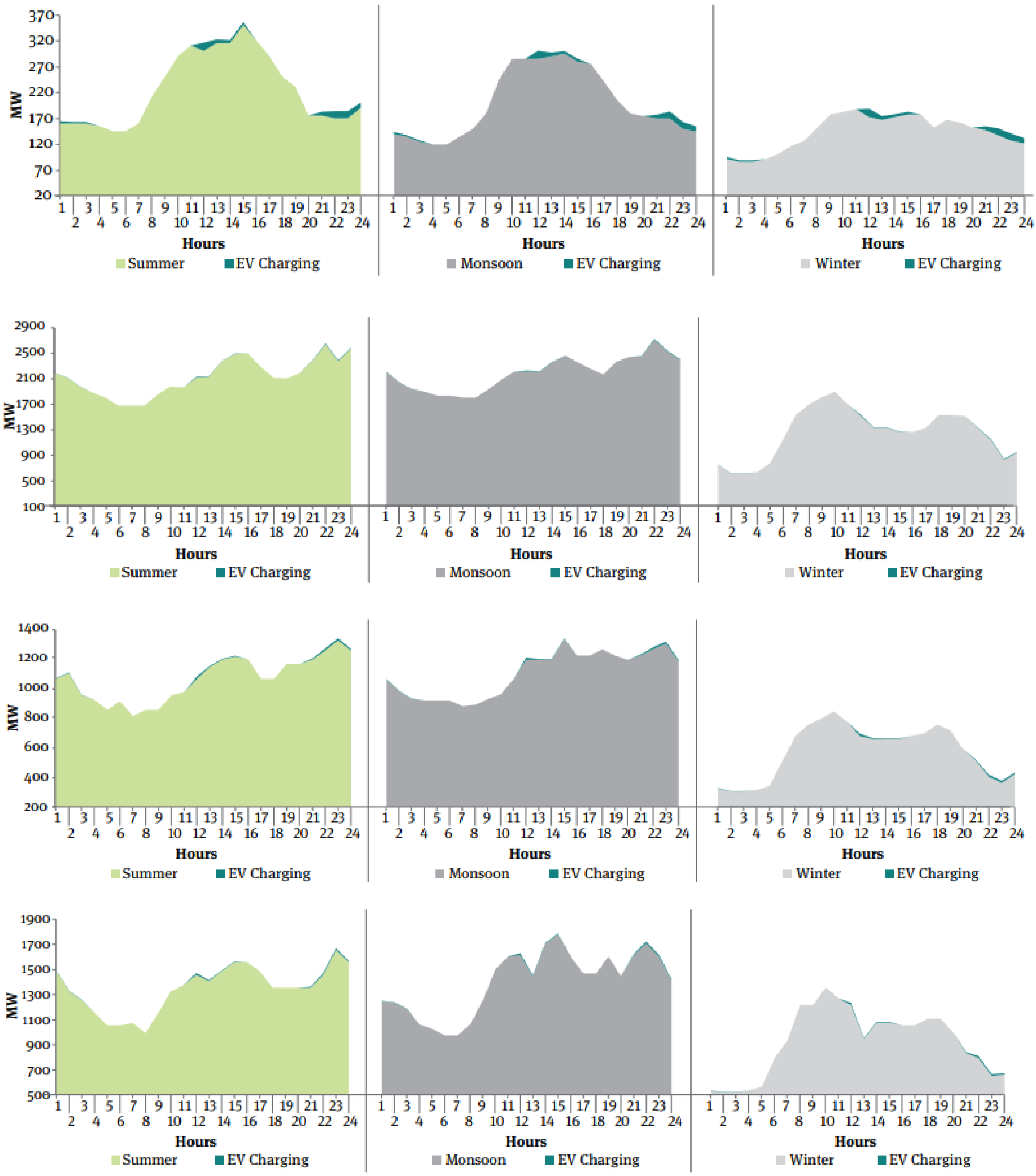


Figure 6.50: Modification of Load Curve due to EV Charging on DISCOM-I, DISCOM-II, DISCOM-III and DISCOM-IV respectively[185]

185 Das and Tyagi.

Impact on DISCOM Cost of Supply:

The impact on Cost of Supply due to EV adoption has been given in Table 6.18, considering a 15% year on year increase in energy sales for EV adoption. As per the analysis, in the 1st year for all the DISCOMs except DISCOM-III, the cost of supply is expected to reduce, which can be attributed to the availability of surplus contracted power, and increasing revenue made due to additional energy sold. Further, in certain periods of the day, the EV charging has helped to fill valleys in the load curves, thus improving the economics of electricity provision.

From Year 2 onwards, the cost of supply starts increasing, and although for DISCOM-I, the cost of supply is still in the negative, the margin decreases over the years.

Table 6.18: Impact of EV adoption on the Cost of Supply over 5 years[186]

DISCOM	Year 1	Year 2	Year 3	Year 4	Year 5
DISCOM I	-1.84%	-1.57%	-1.26%	-0.89%	-0.47%
DISCOM II	-0.52%	0.31%	1.26%	2.32%	3.48%
DISCOM III	0.19%	1.87%	3.74%	5.75%	7.84%
DISCOM IV	-0.18%	0.19%	0.60%	1.04%	1.51%

6.8.5 CASE STUDY 5

Case Study: Electrification of Surat Municipal Corporation Bus Fleet

This study conducted jointly by National Renewable Energy Laboratory (NREL) and Sardar Vallabhbhai National Institute of Technology (SVNIT) examines the potential for the Surat Municipal Corporation (SMC) to electrify its bus rapid transit system (BRTS) in Surat, India. The study focuses on the operational feasibility, and economic analysis of battery electric buses (BEBs) compared to diesel buses operated on the eight BRTS routes.

The model adopted uses actual vehicle operation to solve for the power requirements of the BEB, while considering aspects such as distance travelled, time taken, route conditions, driving behaviour, ambient temperature, space cooling, regenerative braking, weight of chassis and passengers, losses, traction as shown below:[187]

Battery ‹ Motor ‹ Transmission ‹ Differential ‹ Wheel ‹ Chassis ‹ Logged Data

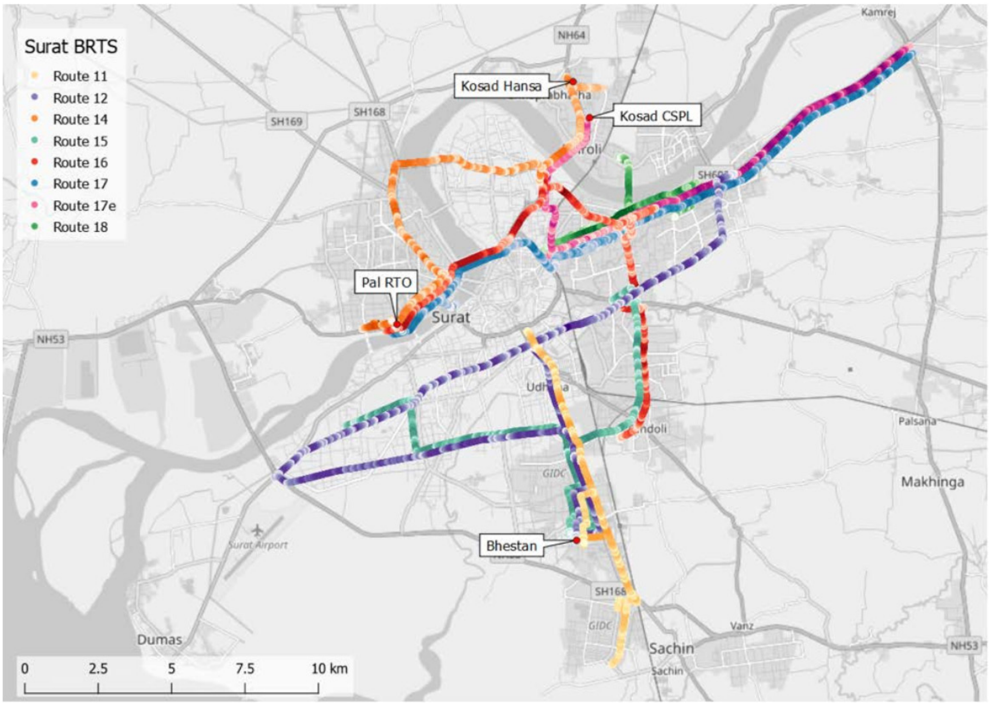


Figure 6.51: Map showing the bus routes studied in this project [187]

186 Das and Tyagi.
187 Cabell Hodge et al., "Surat Municipal Corporation Bus Electrification Assessment," National Renewable Energy Laboratory, 2019, https://www.nrel.gov/docs/fy19osti/73600.pdf.

Based on the considered parameters, the average calculated efficiency of the BEBs is given in Table 6.19.

Table 6.19: BEB consumption by temperature and Mass (kWh/km)

Temperature (0C)	25	28	30	35	40
Mass (kg)	Consumption (kWh/km)				
7000	0.56	0.61	0.64	0.72	0.80
8000	0.60	0.65	0.68	0.76	0.84
9000	0.64	0.69	0.72	0.80	0.89
10000	0.69	0.74	0.77	0.85	0.93
11000	0.74	0.79	0.82	0.90	0.98
12000	0.79	0.84	0.88	0.96	1.04
13000	0.85	0.90	0.94	1.02	1.10
14000	0.92	0.97	1.00	1.08	1.17
15000	0.99	1.04	1.07	1.15	1.24
16000	1.07	1.12	1.15	1.23	1.32
17000	1.15	1.20	1.23	1.31	1.40
18000	1.23	1.28	1.32	1.40	1.48

To perform the life-cycle cost analysis, it was assumed that BEBs would replace the diesel buses in a ratio of one is to one, and the cost of diesel was considered as INR 74.3/litre (EUR 0.84/litre) while the cost of electricity was provided by the Dakshin Gujarat Vij Company Limited (DGVCL) assuming overnight charging at the depots where time of use pricing was levied. Based on these assumptions, the life cycle cost analysis was performed considering ownership period of 7 years. From the analysis it was concluded that, by taking maintenance costs into consideration most of the BEBs were much more economical than their diesel counterparts as shown in Figure 6.52.

Life Cycle Costs:

The BEB has two capital expenditures, one for the purchase of the buses itself and the other for the cost of the EVSE and its related components.

The cost details of the buses and other relevant information is provided in Table 6.20.

Table 6.20: Details of buses

Manufacturer	Fuel Types	Length (m)	Passenger capacity	Battery Capacity (kWh)	Cost after FAME II Incentive (INR/ EUR)
Tata	Electric	9	31	125	49,90,000/ 56,653
Tata	Electric	12	40	125	63,00,000/ 71,525
BYD	Electric	9	31	162	90,57,600/ 102,833
BYD	Electric	12	40	324	1,10,39,400/ 125,333
Tata	Diesel	12	44	-	33,00,000/ 37,465
Volvo	Diesel	12	32	-	80,00,000/ 90,826

The other cost component includes the installation of the charging infrastructure. As per the FAME II program, grants up to 100% of the cost of one slow charger and one fast charger per 10 BEBs are provided. In this study, the chargers used for overnight charging of BEBs are considered to be slow chargers. The costs of installing a distribution transformer of 800 kVA and 1250 kVA and the associated installation costs are given in Table 6.21 and Table 6.22, respectively. The single line diagram for the installation is shown in Figure 6.53.

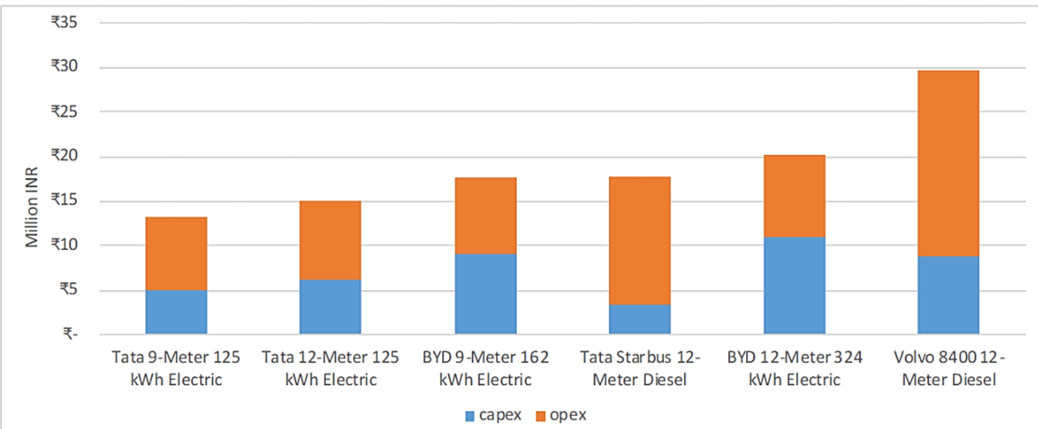


Figure 6.52: Total cost of ownership[188]

188 Hodge et al.

Table 6.21: Utility Setup Charges[189]

Setup Charges	600 kVA	1000 kVA
Registration Charges (INR/ EUR)	6,000/ 68.12	10,000/ 113.53
Service Connection Charges (INR/EUR)	10,400/ 118.07	16,000/ 181.65
Pro Rata Charges (INR/ EUR)	6,90,000/ 7833	11,50,000/ 13,056
Security Deposit (refundable) (INR/EUR)	32,94,000/ 37,397	55,53,000/ 63,044
Line Charges (approximate) (INR/EUR)	3,50,000/ 3,973	3,50,000/ 3,973
Total (INR/EUR)	43,50,400/ 49,391	70,79,000/ 80,370

Table 6.22: Distribution Transformer Costs[190,191]

Equipment Type	800 kVA	1250 kVA
BIS 1180 Level, 2(11/433), OLTE Tap, ONANA, Copper Wound (INR/EUR)	12,80,000/ 14,532	15,70,000/ 17,824
11 kVA Switchyard (INR/ EUR)	3,25,000/ 3,689	3,25,000/ 3,689
1250 A VCB and High-Tension Cable (INR/EUR)	3,25,000/ 3,689	3,25,000/ 3,689
LT Main PCC Panel with APFC Panel (approximate) (INR/EUR)	5,50,000/ 6,244	7,50,000/ 8,514
Cabling and Other Accessories (INR/EUR)	2,50,000/ 2,838	3,50,000/ 3,973
Total (INR/EUR)	27,30,000/ 30,994	33,20,000/ 37,693

As per the assumption of the analysis it has been considered that FAME II program would provide the grant for 100% of one slow charger per eBus and one fast charger EVSE per 10 eBuses. As it was unclear whether FAME II would also include subsidies for necessary electrical costs, the costs of the electrical infrastructure has been considered in the life-cycle cost analysis.

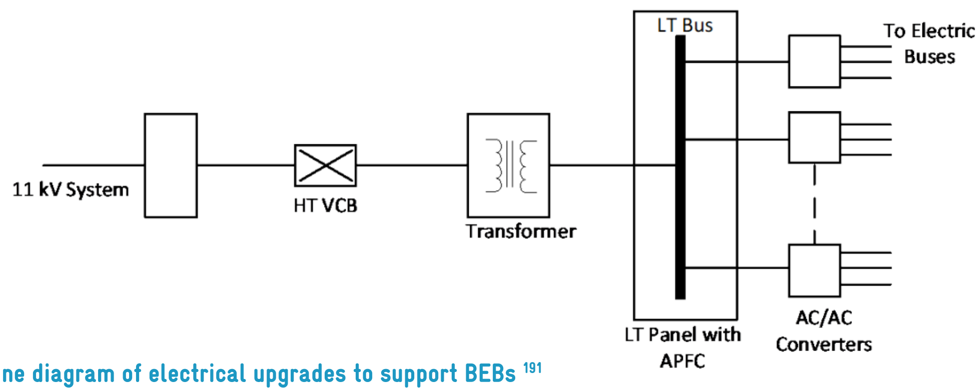


Figure 6.53: Single line diagram of electrical upgrades to support BEBs [191]

189 Hodge et al.
190 Hodge et al.
191 Hodge et al.

07

Mitigation of EV Integration Impacts

Although addition of EV charging load into the distribution system brings about different challenges, the controllable nature of EV loads, also provides solutions to help mitigate the different challenges. These solutions have been discussed in this section.

7.1 Smart Charging

The definition of smart charging is rather broad with different sources having different definitions of smart charging, as given below,

IRENA

"Smart charging means adapting the charging cycle of EVs to both the conditions of the power system and the needs of vehicle users. This facilitates the integration of EVs while meeting mobility needs."

ElaadNL

"Smart Charging is essentially a control signal that indicates when and at what speed an electric car is charged. Smart technology ensures that it is charged at the best time and at an optimum speed."

GOV.UK

"smart charging is defined as shifting the time of day when an EV charges, or modulating the rate of charge at different times, in response to signals (e.g., electricity tariff information)."

Generally, smart charging is a means of managing the EV loads to reduce the impact of EV integration on the distribution network and may also incorporate grid support services. It can be achieved by customers responding to price signals, EVSE responding to control signals from the DSO or central management service while at the same time retaining enough charge in the battery to fulfil the EV users travel requirements.

7.1.1 TYPES OF SMART CHARGING

The different types of smart charging have been listed in Table 7.1

Table 7.1: Different types of Smart charging

Type of Application	Control over charging power	Possible uses	Maturity
Uncontrolled but with ToU tariffs	None	Load levelling	High
Basic Control	On/off	Grid congestion management Voltage Support RE integration Load levelling	Partial market deployment
Unidirectional controlled (V1G)	The charging current/power is dynamically changed	Grid congestion management, RE integration, Voltage Support, Load levelling, Ancillary service	Partial market deployment
Bidirectional V2G and G2V	Bidirectional flow of power between EV and grid	Grid congestion management, RE integration, Voltage Support, Load levelling, Ancillary service	Partial market deployment
Bidirectional V2X	Integration of bidirectional charging and home/build-ing energy management systems	Behind-the-meter optimization Micro-grid optimization	Partial market deployment
Dynamic Pricing	Close to real time com-munication of dynamic electricity price between EVSE and grid	Grid congestion management Load levelling RE integration,	Partial market deployment

EOMini Smart

It is a smart EV charger available in India that includes an EO Mini charger and an EO Home Hub which is a smart home device, which integrates rooftop solar generation with EV charging. The energy usage can be monitored by an app on the phone. It has active load management and communicates via WiFi connectivity or through ethernet port. It has 3.6 kW and a 7.2 kW charging option .

7.1.2 SMART CHARGING ENABLERS

The primary enablers of smart charging have been described in this section.

7.1.2.1 Consumer behaviour

The success of Smart charging will be determined by the interest of EV consumers to participate in smart charging solutions. This may vary among the EV users, as some users can be technology enthusiasts willing to try and test new technologies, while a portion of the users may be sceptical of participating in smart charging either due to range anxiety, cybersecurity concerns, or for economic reasons. The active participation of users will be possible if there are incentives for the users to participate in smart charging. Public transport sector will remain a priority to participate in smart charging, as these services can be governed.

7.1.2.2 Smart Chargers

Smart chargers are the key enablers of smart charging, as these chargers have direct communication with the EV. A charger is called smart charger when it can communicate between different entities in the EV ecosystem, such as communication with CPO, DISCOM, etc., and based on the communication the charger is able to control the charging current.

7.1.2.3 Big data and artificial intelligence

Smart charging is a data-intensive service, where large amounts of data from the entire fleet of EVs and the measurements from the distribution network needs to be properly analysed so that the accurate state of the system may be painted in real-time. The service also needs to consider the complexity of electricity markets and participate in these markets based on the current state of the system. Big data analytics will thus play a significant role in the proper management of smart charging solutions. Along the same lines, artificial intelligence tools will become necessary for complex decision making considering a myriad of objective functions and constraints. Digitalization will play a key role in the optimization between transport services and grid services. Data analytics will enable matching the mobility demand with the power supply and load patterns and further help determine optimal charging point locations.

7.1.2.4 Blockchain technology

Blockchain is an open, distributed, digital ledger that can record transactions between two parties. As more and more EVs are entering the market, the transactions between the different stakeholders have seen a sharp rise, with increasing quantities of data being part of these transactions. Charging sessions generate a large amount of information such as the total amount of energy transferred, charging duration, location, etc. Different stakeholders may need to access this information for their own analytics. Blockchain provides a secure avenue for these players to immutably record and securely share their collected information. Since these blockchains are a part of the peer-to-peer network, the blockchain is a decentralized system, but highly secure technology. Blockchain can facilitate smart charging and V2G by connecting different parties and facilitating monetary transactions between aggregators and customers through open-source standards, replacing the propriety standards of today .

7.1.2.5 Smart Meters for EV

Smart meters in the context of EVs should have bidirectional communication capabilities. These meters should be able to interact with the grid, the customer, and the market, which will enable all participants to actively manage the power supply based on their priority. The information needed to be recorded and relayed to the different players include voltage per phase, current per phase, phase angle per phase, power factor, timestamp of the actual measurement and the meter ID in order to register these measurements against the user[192]. These measurements are required to analyse the health of the grid at the point of connection. The aggregate information from all smart meters in the vicinity provides the DSO a real-time picture of the actual grid status. A smart meter in EV context should not be viewed as a traditional energy meter, rather it should behave as a smart device capable of bidirectional communication along with provision of user app installation, with different functionalities as shown in Figure 7.1 . These apps provide added functionalities that can be installed based on user requirements such as analysing volatility in rooftop PV

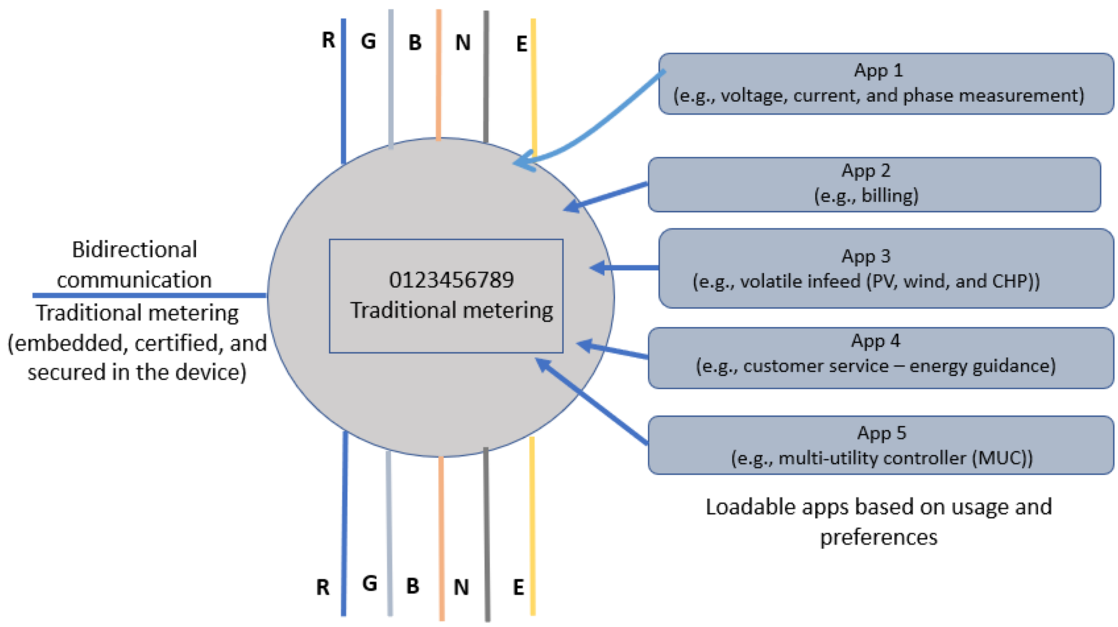


Figure 7.1: Smart Meter with added functionalities

192 Details about communication protocol and related standards used for smart charging has been summarized in https://www.mdpi.com/2076-3417/6/3/68/pdf

generation, creation of control signals for EV, etc., i.e., these meters need to have capability of basic data processing and provide insights.

7.1.3 ENABLING SMART CHARGING IN INDIA

7.1.3.1 Smart charging using time-based tariffs

As mentioned in Section 7.1.1, there are different ways to implement smart charging. One of the simplest ways is to provide a time based EV tariff, which can act as a passive smart charging. However, this would require a smart meter that would be able to log energy consumption with respect to the time of use. Here, the use cases will differ based on the type of users and the type of tariff structure.

Private EV user

Currently, ToD/ToU tariff has not yet been implemented for residential users in India. The customers pay a fixed energy price based on slabs as per their contracted demand. For a user with a private vehicle, a separate meter may be needed for the EV charger based on the tariff structure.

- If the tariff is structured such that ToU pricing is implemented for the household energy consumption, a separate meter would not be required as the smart energy meter of the household will record the total energy consumption. This can be further extended to include a smart energy management solution to optimize the household energy consumption based on the ToU prices.
- If the ToU tariff is specific for EVs, then installation of a separate smart meter would be required for the EV charger.

As discussed, enabling time-based tariffs such as ToU is bottlenecked by the smart meter proliferation in the country. Although the smart meter deployment has grown in the recent years, these smart meters have to be installed in private residential households in order to facilitate passive control over EV charging using time-based tariffs.

Commercial EV user

Different state electricity regulatory commissions have released tariffs in which they have included ToU/ToD pricing for commercial public chargers . For example,

- Andhra Pradesh Regulatory Commission has levied an addition charge of INR 1/kWh (1.1 cents/kWh) for usage during peak periods (6 am – 10 am and then 6 pm- 10 pm) and reduced the electricity price by INR 1/kWh (1.1 cents/kWh) for usage during off peak hours (10 pm – 6 am).
- Delhi Electricity Regulatory Commission has put a surcharge of 20% on the electricity price for usage during peak hours (2 pm – 5 pm and then 10 pm – 1 am) and a rebate of 20% on the electricity price for off peak periods (4 am – 10 am)

As the commercial players generally have larger budgets, so these players generally pay for their own smart meters recommended by the respective DISCOMs.

7.1.3.2 Control signal based Smart Charging

In order to have coordinated smart charging based on command signals, there needs to be a smart grid infrastructure along with a charging management system, which may be either centralized or decentralized, to control the EV charging based on some grid parameter. The smart grid infrastructure is needed to provide complete observability at the transmission level and, more importantly, at the distribution level. The MoP has initiated various Smart Grid Projects throughout the country. These projects can incorporate smart EV charging into their objectives as a demonstration of smart charging capability in the country. These projects can then be later studied and rolled out to the masses.

7.1.3.3 Regulations for smart charging

The development and installation of the required infrastructure alone is not sufficient to enable smart charging. The ministries and the grid operators would also need to frame regulations for smart charging. These regulations should be designed in such a way that they can solve various issues related to smart charging, such as,

- If multiple EVs respond to a command signal at exactly the same point, a sudden increase/decrease in load would occur in the network.
- How would the EVs respond if there is a sudden loss of communication with the central charge management system?
- Two different forms of data needs to be communicated between the EVSE and the CMS, the command signal and the actual EV response. What should be the frequency of transmission of these data?
- During extreme grid conditions, should DISCOMs have the authority to curtail EV charging?

The requirements for smart charging can be summarized in Table 7.2.

Table 7.2: Requirements to enable smart charging

Technical requirements	Hardware	Public and private smart charging points
		Smart meters
		Smart grid infrastructure for grid observability
	Software	Management software that runs the algorithm to implement smart charging by taking real time inputs from the EVs and the grid condition
	ICT	Interoperable communication protocols for communication across different charger types and entities
		Interoperable standards for communications including hardware requirements
Regulatory requirements	Electricity Market	EVs through aggregators should be allowed to participate in the electricity market
		Create revenue streams to incentivize smart charging
	Distribution System	Time based EV tariff needs to be created
Stakeholders Roles	State Institutions	Create sponsored projects to kickstart smart charging
		Help in financing the projects
	e-mobility market	Incentivize customers to participate in smart charging programs through different schemes
		Make smart chargers easily accessible to EV users

7.1.4 BENEFITS AND DISADVANTAGES OF SMART CHARGING, TOU CHARGING AND UNCONTROLLED CHARGING

The different smart charging approaches have their own advantages and disadvantages as highlighted in Table 7.3.

Table 7.3: Benefits and disadvantages of various smart charging methodologies

	Advantages	Disadvantages
Smart Charging using control signals	The congestion and voltage of the feeder is maintained within system thresholds	If the feeder is already overloaded or the voltage is poor without EV integration, the EV may never charge
	It helps the grid during contingency events	The EV may not have enough charge remaining to fulfil the users' travel requirements
	It may provide monetary incentives for the user by participating in grid support services	Complex to implement
	Defer the requirement of grid upgradation investments	
	Helps in integration of RE sources	
Time based tariffs	Reduces cost of charging by only charging when the electricity price is low	Integration of RE sources is limited
	Helps reduce congestion by only charging during off peak periods	Relaying of price signals needs proper communication infrastructure, which increases the cost of implementation.
	Helps in load levelling by shifting load from the peak periods to the off-peak periods	Cannot provide grid support services
	Defer the requirement of grid upgradation investments	
Uncontrolled Charging	Low cost of implementation	May incur high price for charging
	No anxiety for the customer that vehicle will not have enough charge after end of charging period	May cause congestion, voltage issues in the distribution network
		Cannot help in RE integration

7.2 Congestion Management

Congestion in the distribution grids occur mostly during peak load conditions. Uncontrolled EV charging will further aggravate the issue of congestion of the distribution lines. In order to mitigate the congestion issue due to EV load, following potential measures would be required.

Upgradation of the existing distribution network to accommodate the increase in demand.

Adopt smart charging approaches, which consider line congestion as one of the constraints while optimizing the EV charging.

Use dynamic pricing to incentivize the EV users to charge during off peak periods.

7.2.1 INFRASTRUCTURE UPGRADATION

The obvious choice for mitigation of congestion in the distribution network is to upgrade the existing infrastructure with higher capacity transformers, transmission lines and other related distribution system assets such as fuses, circuit breakers, measurement devices etc. The added infrastructure will be system specific and will depend on the expected increase in load. In this context, the concerned DISCOM may need to perform individual assessments of their own network to check if their existing infrastructure will be able to cater to the expected increase in EV demand. As shown in the case study reported in Section 6.8.1 under various scenarios, the infrastructure augmentation was different. Most DISCOMs in India are state-run and have a poor financial status, which may make it difficult for the DISCOMs to justify grid upgradation to cater to the EV load. In this respect, the DISCOMs can earn back the cost of grid upgradation in the following ways:

- Leveraging financial support from the government
- By levying higher demand charges to the specific set of customers with EVs and charge point operators under its jurisdiction. However, this would place a huge burden on the EV users and CPOs.
- Socializing the cost, i.e., by charging the entire customer base as per the net cost incurred. This can be reflected in the demand charge of the electricity bill.

The requirement of infrastructure can be reduced with the implementation of smart charging, as described in the section below.

7.2.2 SMART CHARGING FOR CONGESTION MANAGEMENT

In developing/designing an EV charging strategy, the maximum capacity of a feeder is taken as the constraint parameter for the EV charging. Considering feeder capability for charging optimization is crucial as feeder overloading can potentially result in feeder tripping, thereby leading to congestion in other lines. Because of this reason, EV charging is coordinated under consideration of the maximum feeder capacity. Feeder capacity constraint can be considered in two different ways while performing an optimization. The first option is by considering the thermal rating of the line. The second method of realizing the feeder constraint is by considering the amount of prespecified power flowing through the feeder, which can be calculated using load flow analysis or optimal load flow studies.

Applying feeder capacity constraint is simple in a centralized method as all decisions are taken centrally by performing load flow analysis, and EV owners are not involved in charging decisions. The centralized mechanism is not very popular amongst customers as it does not facilitate the direct plug-and-charge mechanism. This reduces the customer's degree of satisfaction, and people are less interested in such charging strategies.

Contrary to this, applying feeder constraint in decentralized strategy is difficult because the EV owner takes the EV charging decision based on electricity price without considering any network constraints. Dynamic price variation by an aggregator cannot guarantee the optimal solution to maintain the feeder's capacity constraint. The aggregator decides the variation in price signal by taking the information of load flow and power requests by the customers. However, this indirect control alone is not sufficient as a failure in maintaining capacity constraint from this approach may lead to system instability. So, another local control is also used in addition to decentralized control for arresting capacity constraints.

7.2.3 USING TARIFF

The third alternative to manage congestion in the grid is through utilization of Time of Use (ToU) tariffs in the form of dynamic pricing, Time of Day pricing etc. Using a variable electricity price, which reflects high electricity price during peak load periods and low electricity prices for off-peak periods incentivizes the EV users to shift their charging needs to off-peak periods which reduces the excess loads in the peak periods, thereby reducing congestion in the grid.

7.3 Power quality issues

Grid integration of EV can lead to power quality issues such as,

- Deterioration of voltage levels
- Phase imbalance issues
- Harmonic injection
- Voltage flickers

Power quality issues could be primarily addressed using the following :

- Optimal placement of fast EV chargers: As the power drawn by fast EV chargers is considerably high, so these chargers may significantly deteriorate the voltage profile if connected to a weaker section of the grid. In this aspect, the relevant distribution network operator must do a thorough analysis to determine the optimal placement of EV chargers.
- Smart Charging: Utilizing smart charging is also recommended to improve the power quality issues. Smart charging can be utilized to rectify both voltage profile deterioration and phase imbalance issues. By optimally controlling the charging power, the active power drawn from the grid may be reduced, thereby reducing the drop in the voltage. Also, in presence of phase imbalance issues, the smart chargers can alter the current drawn from the respective phases so that the phase imbalance issue is resolved .
- Equal share of single-phase chargers: Single phase chargers may introduce voltage imbalance, so the DISCOMs can take measures to ensure that single phase chargers are equally distributed among the three phases in the distribution network. Most 2W and 3W in India use single phase chargers. Even 4W chargers up to around 7 kW can be connected to a single-phase electrical connection . So, while approving connection for installation of EV chargers the DISCOM should analyze the loading of each phase of the distribution feeder.
- Automated and controllable tap changers on the distribution transformers: The taps on the DT would allow the system operator to maintain the secondary voltage at an acceptable level by just changing the taps.
- Capacitor Banks: The stored energy in the capacitor banks will help improve the power factor of the EV charging loads, thus reducing the apparent power drawn. However large-scale installation of capacitor banks is not preferred as they can cause resonance due to harmonics and switching transients.
- Static Compensators (STATCOM): These may also be used to rectify the degrading voltage profile in feeders with high EV charging.
- Regulating the permissible harmonic injection by an EV charger: Prior to allowing the sale of an EV charger in the market, it must be tested for meeting maximum harmonic injection limits.
- Decentralized Battery Storage System: Battery storage coupled with coordinated charging can serve as an intermediary, to shift the power required by EV charging from peak periods to off peak periods.

7.4 EVs as Virtual Power Plants

The Virtual Power Plant (VPP) is an aggregation concept whose aim is to address the challenges of integrating Distributed Energy Resources (DER) into the electricity market. As per this concept, different DER, which individually do not have the minimum required capacity to participate in the electricity market, can be aggregated as a single entity, enabling them to participate in the electricity market. It also reduces the financial risk of individual DERs and reduces the intermittency of generation up to a certain extent .

EVs have a high potential to be aggregated into a VPP. EVs individually have a power rating in order of tens of kilowatts, which is not sufficient to participate in energy markets. To introduce EVs as potential players into the markets, a collection of EV users needs to be aggregated into a VPP. Generally, many VPPs may operate in a region having contracts with EV users, residential users, charge point operators, customers with DERs, etc. The different actors/entities that interact with a supplier/aggregator using VPP has been shown in Figure 7.2. The VPP concept as a tool offers the opportunity to aggregate a variety of DERs, including EV clusters, thus creating a single portfolio that can act as a market player. The VPP can then participate in wholesale markets, spot markets, ancillary services, etc. The schematic of a VPP structure is given in Figure 7.3

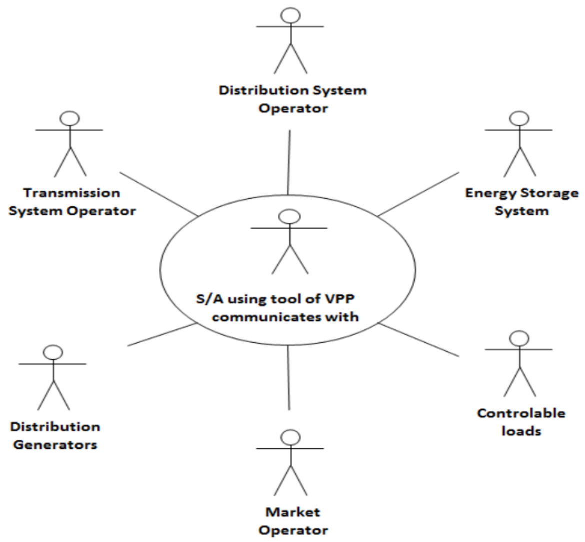


Figure 7.2: Actors interacting with the supplier/aggregator using VPP[193].

The flexibility provided by VPP is further augmented with the presence of a controllable resources and thus can also include microgrid concepts. The inclusion of EVs increases the flexibility of the VPP and provide an opportunity to reduce imbalances that may occur after market negotiations. The fast response time, no start-up or shut-down costs, low standby costs, and high availability actors are some of the enticing characteristics of EVs in terms of service to the VPP.

7.2.1.1 Need for VPP in India

VPP is one of the key technologies to unlock the RE potential of India. India has a goal of 175 GW of renewable energy generation with 100 GW from solar, 60 GW from wind, 10 GW from bioenergy, and another 5 GW from small scale hydro by 2022. Rooftop solar is also one the key interest areas of the government of India.

Residential rooftop has seen good growth in India in recent years, along with low voltage residential storage units. Bioenergy based distributed generation has also seen growth in rural areas. These distributed generation (DG) resources presents a unique set of challenges to the Indian grid. During high RE generation periods, power injection to the distribution system from the DGs is a significant challenge. Similarly, issues related impact of DGs on voltage control, protection, power quality, forecasting, scheduling, etc., have emerged with higher penetration of these DG resources.

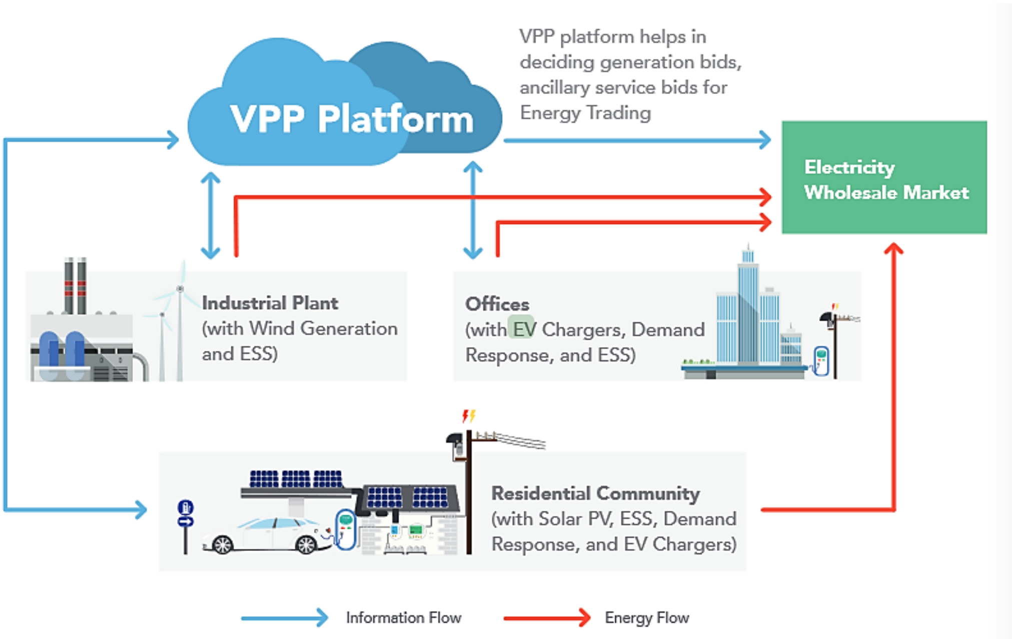


Figure 7.3: Schematic of VPP implementation

193 CIGRE, "Integration of Electric Vehicles in Electric Power Systems," CIGRE, 2015, https://e-cigre.org/publication/632-integration-of-electric-vehicles-in-electric-power-systems.

Using a VPP structure, these distributed generation sources can be pooled together to facilitate an efficient integration into the power system network. The range of services that could be provided using VPP in India include,

- Aggregation of resources for energy trading
- Aggregation of resources for local power consumption
- Provision of ancillary services
- Provision of demand response services

7.2.1.1.1 EVs as VPP resources in India

Now, with the focus on EV growth, these EVs can be utilized as resources in the VPP structure. It is expected that If FAME II and other related government interventions are successful, India could realize 70% of all commercial cars, 30% of private cars, 40% of buses and 80% of 2W and 3W annual sales to electric by 2030 . This increased number of EVs would result in increased charging demand which can significantly impact the distribution grid. Using VPP, this increased charging demand can be reduced by utilizing the local DGs to power the local EVs. On one hand it reduces the impact of power injection to the distribution system, while also reducing the strain on the distribution system to supply power to the charging stations, thereby helping to effectively manage the grid.

7.2.1.2 Concept of operation of VPP with EV and RE

Here, a concept of operation of VPP is explained with EV as participants with the goal to maximize the utilization of RE generation through energy time shift.

- Participants:
- RE Generation utilities
- VPP operator
- EV aggregator
- Sequence of activities

The VPP operator monitors the RE generation and predicts future generation either using its own forecasting tool or using information from the balancing market.

The EV aggregator collects data on the number of EVs in its fleet that is connected to the grid and charging. The aggregator also needs information on the approximate time by which the user would unplug the EV from the grid.

If the RE generation is expected to increase, the VPP operator would send a signal to the EV aggregator to increase the load, thereby utilizing the RE generation.

On receiving the signal, the EV aggregator would create a charging schedule so that there is higher amount of charging load connected to the grid during high RE generation periods.

Similarly, if the RE generation is expected to reduce, the VPP operator would send a signal to the EV aggregator, who would then redraw the charging schedule.

If the EVs are capable of bidirectional power flow, the EV aggregator would continue to utilize the EVs connected to the grid, to shift the energy.

7.5 Ancillary Services from EVs

7.5.1 BACKGROUND OF ANCILLARY SERVICES IN INDIA

In India, the power market has undergone significant development. On June 1, 2020, the Real-Time Market was implemented, which is a commendable attempt to address grid-balancing issues. To restrict deviations in active power generation in India, the Deviation Settlement Mechanism (DSM) has been in use since 2014 . The generic classification of frequency control in India, has

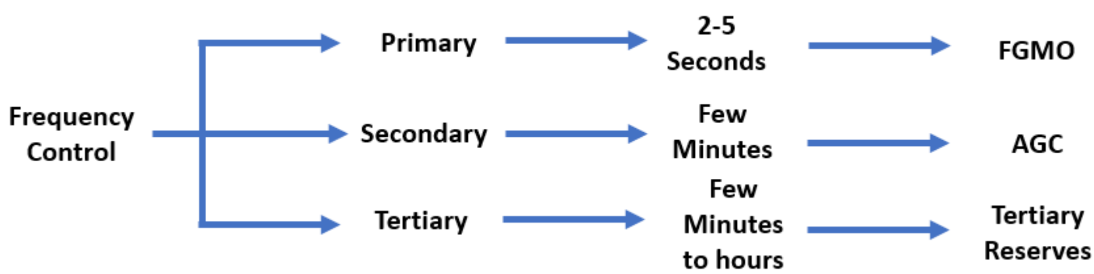


Figure 7.4: Classification of frequency control and response time in India

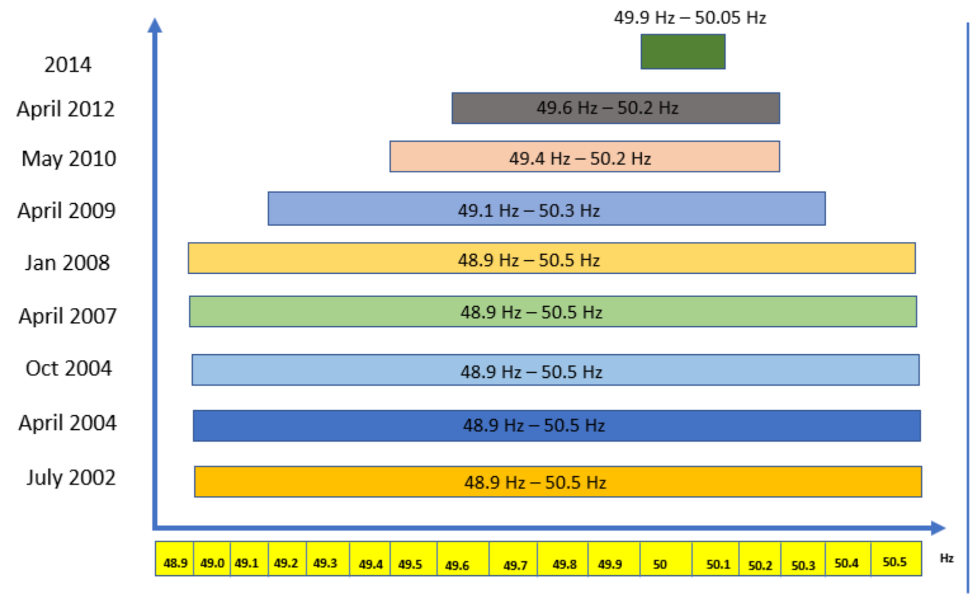


Figure 7.5: History of frequency band in India

been shown in Figure 7.4. The initial variation in frequency is contained by the Free Governor Mode of Operation (FGMO) of the generating units which has been later integrated with Automatic Generation Control (AGC). In India, the frequency should at all times lie within 49.9 – 50.05 Hz, during normal operation. The evolution of this frequency band is given in Figure 7.5.

The evolution of ancillary services in India has been given in Figure 7.6. In 2015, with initiative by CERC, a market product for balancing of frequency at the tertiary level, called Regulation Reserve Ancillary Service (RRAS) has been introduced . As currently regulated, Inter-state generating stations (ISGS) with un-dispatched surplus capacity are allowed to participate in RRAS. Besides market products, ancillary services such as inertial support and primary frequency support are mandated as per current regulations. The frequency control ancillary services in India have been summarized in Table 7.4.[194]

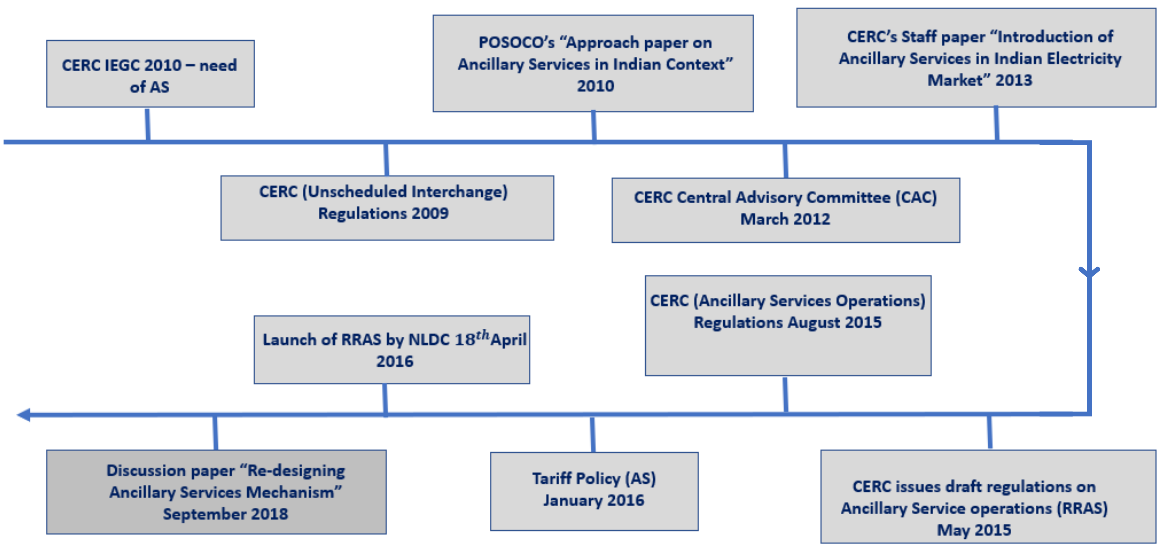


Figure 7.6: Evolution of Ancillary services market in India[194]

194 T. Bharath Kumar and Anoop Singh, "Ancillary Services in the Indian Power Sector – A Look at Recent Developments and Prospects," Energy Policy 149 (2021).

Table 7.4: Frequency control ancillary services in India[195]

Attribute	Inertia	Primary	Secondary	Tertiary	Generation Scheduling
Time	First few seconds post disturbance	Few seconds – 5 min	30s-15min	15-60 min	>60min
Quantum	10,000 MW/Hz	4000 MW	4000 MW	8000-9000 MW	Generation-load balance
Activation	Automatic	Automatic	Automatic	Manual	Manual
Obligation	Mandated	Mandated	Road Map for paid reserves	Paid reserve	Paid
Suitable for EV	Yes	Yes	Selective fleets	Selective fleets	Yes

7.5.2 UTILIZATION OF EVs FOR PROVIDING ANCILLARY SERVICES IN INDIA

By controlling the charging of EVs or by allowing bidirectional flow of power, EVs can potentially perform a range of grid support services. Ranging from the transmission operator to the distribution operator, EVs can be utilized as a mobile storage unit to benefit the different grid operators. The controllable nature of EV charging makes them ideal for providing ancillary services.

EVs are most suited for provision of high-power low energy services with fast response requirements such as inertial support, primary frequency support and frequency regulation. Utilization of EVs for provision of high energy services such as secondary frequency reserve and tertiary frequency reserve may deplete the energy of the battery and render them unavailable for the travel needs of the EV user. However, some EV segments such as e-bus and public fleets stationed overnight would have an aggregated high energy capacity. These segments of EV population can be used for provision of secondary and tertiary frequency reserve.

As currently being constructed, the only market procured ancillary service in India is the RRAS. In order for EVs to provide RRAS service, regulatory interventions are necessary to make EVs a viable candidate. The different requirements for EVs to be able to participate in ancillary market are listed in Table 7.5. Even without V2G provision, EVs can participate in both regulation up and regulation down services by controlling their charging power. With V2G, the available capacity for participation effectively doubles, as shown in Figure 7.7.

Table 7.5: Requirements for EV to participate in ancillary market

Technical requirements	Hardware	Public and private smart charging points
		Smart meters
		Minimum power capacity at aggregator level to participate in market
	Software	Management software that runs the algorithm to implement smart charging by taking real time inputs from the EVs and the grid condition
	ICT	Interoperable communication protocols for communication across different charger types and entities
		Interoperable standards for communications including hardware requirements
Regulatory requirements	Electricity Market	EVs through aggregators should be allowed to participate in the RRAS
	Financial incentive	Financial benefits to EV users for providing service
EV market structure	Aggregators	Aggregators would be necessary to pool together multiple EV users, thereby increasing the net maximum power capacity.
	VPP	A VPP can also be utilized with EV as a resource and the net VPP can then participate in the electricity market.

195 CERC, "Discussion Paper on Re-Designing Ancillary Services Mechanism in India" (Central Electricity Regulatory Commission, New Delhi, 2018), https://cercind.gov.in/2018/draft_reg/DP.pdf.

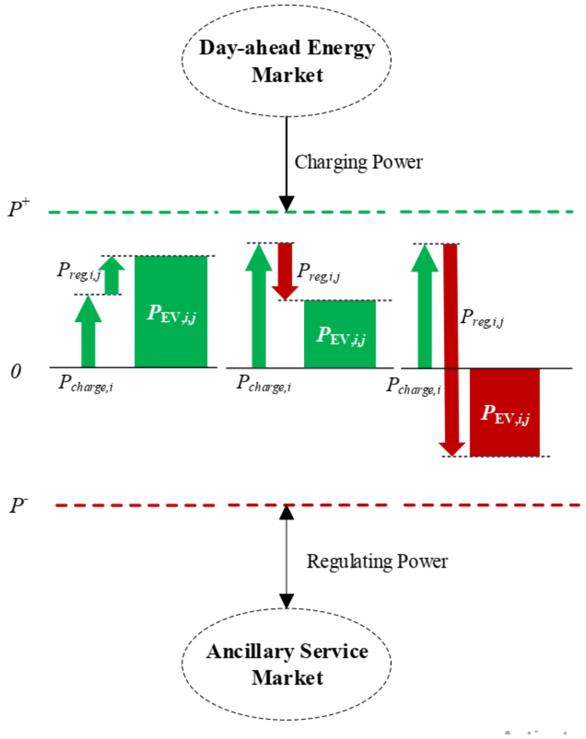


Figure 7.7: Margin availability in EV for provision of ancillary service

EVs can also provide fast response ancillary services such as inertial support and primary frequency reserves, but under current Indian electricity regulations, inertial support and primary frequency support are mandatory and are not traded in the energy market. In order for EVs to provide these services, regulations are required to make inertial and primary frequency support tradeable in the electricity markets. EVs are also excellent candidates to participate in other ancillary services such as secondary frequency reserve, reactive power support, black start supports etc, but adequate electricity market products are required prior to utilization of EVs into provision of these services.

7.5.2.1 Minimum EVs required for participation in electricity market

In order to participate in the electricity market, generally there is a minimum requirement for bid size, i.e., there is a requirement of minimum power capacity for the participating resources. A single EV alone does not have enough capacity to participate in the electricity market. The EV users willing to participate in electricity markets must be pooled together by an aggregator so that the minimum bid capacity is met. Here it needs to be mentioned that even though an aggregator may have a minimum number of EVs to surpass the minimum bid threshold, all the EVs may not be plugged at the same time which can lower their available power capacity. So, here the aggregator needs to devise mechanisms, so the minimum bid capacity is met at all time periods in which the aggregator wants to participate in the electricity market. Also, the power capacity is dependent on the charging power of the EVs, i.e., on the EVSE rating as well as the on-board charger rating.

Generally, the minimum bid capacity for an electricity market product, for example the primary frequency reserve in Denmark is set at 1 MW . So, the number of EVs that needs to simultaneously be connected to the grid and charging are given in Table 7.6.

Table 7.6: Minimum number of EVs needed for participating in primary frequency reserve in Denmark with 1 MW minimum bid requirement

Charging capacity	7 kW	22 kW	50 kW	100 kW	200 kW
Minimum EVs required to be plugged in simultaneously	143	46	20	10	5

7.6 Utilization of EVs for better RE Grid integration

The use case of utilisation of RE for EV charging have already been discussed in detail in Chapter-7 (Page 102) of Report 1 of this project.[196] In this section, some key studies and examples of RE use for EV charging in India have been presented.

7.6.1 CASE STUDY: INCORPORATION OF ROOFTOP PV AND BATTERY STORAGE IN THE CHARGING DEPOT LOCATED IN KASBA REGION OF WEST BENGAL

The depot at Kasba region under West Bengal Transport Corporation (WVTC) has 10 number of e-buses. This study analysed the monetary benefit for the installation of rooftop PV as well as an energy storage solution . A 145 kWp solar PV array has been considered based on the available size of the rooftop along with a 50-kWh battery

196 Zakir Rather, Rangan Banerjee, Angshu Nath, Payal Dahiwale, 'Integration of Electric Vehicles Charging Infrastructure with Distribution Grid: Global Review, India's Gap Analysis and Way Forward, Report 1: Fundamentals of Electric Vehicle Charging Technology and its Grid Integration', GIZ, NITI Aayog, 2021. https://changing-transport.org/publication/fundamentals-of-electric-vehicle-charging-technology-and-its-grid-integration/?nowprocket=1

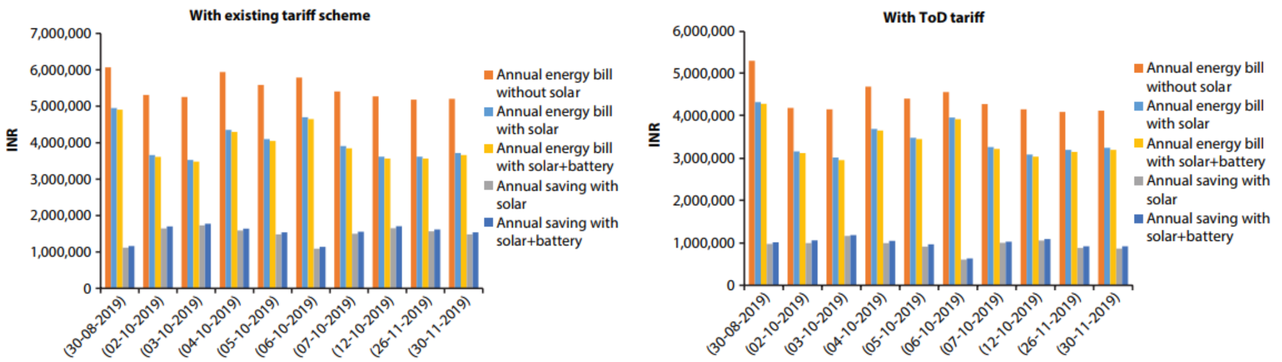


Figure 7.8: Annual electricity bill for different scenarios with existing tariff scheme as well as ToD tariff [198]

energy storage system (BESS). The BESS is charged during periods of excess PV generation and discharged during peak demand periods when the cost of power is highest. The loading of the distribution transformer, which only caters to the charging needs of the depot, has been taken over a period of 6 months to analyze the maximum energy bill. The monetary benefits to the consumer have also been estimated considering both Time of Day tariff as well as existing fixed tariff schemes (INR. 8.97/kWh (EUR 0.1/ kWh)).

The average annual benefit to the consumer with solar PV at existing tariff rate at 8.97 INR/ kWh is projected to be INR 14,86,661 (EUR 16,878) as indicated in Figure 7.8. Whereas in case consumer opted for optional tariff scheme (ToD), the benefit is estimated to be INR 9,43,395 [197](EUR 10,710). The average annual benefit with solar plus battery system at existing tariff rate is estimated to be INR 15,39,023 (EUR 17,473). Whereas the benefit is projected to be INR 9,84,465 (EUR 11,176) with optional tariff scheme (ToD).[198]

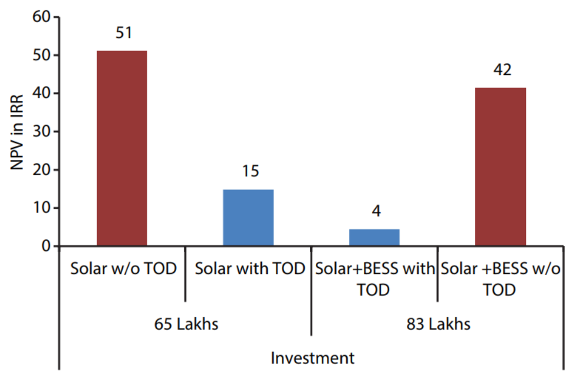


Figure 7.9: Net Present Value for different scenarios[199]

The Net Present Value (NPV) of the different combinations have been given in Figure 7.9. Although the initial capital of solar+BESS is higher, but due to the reduced operational cost, the NPV over a 10-year duration is very low.[199]

Following assumptions have been considered to evaluate the net present value of the project:

- Project Life: 10 Years
- Discount Factor: 10.72%
- Loan repayment period is 7 years with capital structure of 70:30.
- Depreciation is taken using SLM with 10% salvage value.
- O&M is 2% of total project value.

Fixed cost includes ROE, Interest on Loan, Depreciation, O&M, and Interest on working capital.

7.6.2 SOLAR PV INTEGRATION WITH EVSE AND ENERGY STORAGE WITH DYNAMIC CHARGING – A PILOT STUDY

Bangalore Electricity Supply Company Limited (BESCOM) is a government utility responsible for the distribution of power in eight districts of Karnataka (Bangalore Urban, Bangalore Rural, Chikkaballapura, Kolar, Davanagere, Tumkur, Chitradurga and Ramanagara), catering to the demands of 12 million consumers.

197 The margin of benefit due to solar+BESS is seen more for existing tariff scheme since the tariff in the existing scheme is higher than the ToD tariff.
198 TERI, "Electric Vehicles: Perspective of DISCOMs and Stakeholders," 2020.
199 TERI, "Electric Vehicles: Perspective of DISCOMs and Stakeholders," 2020

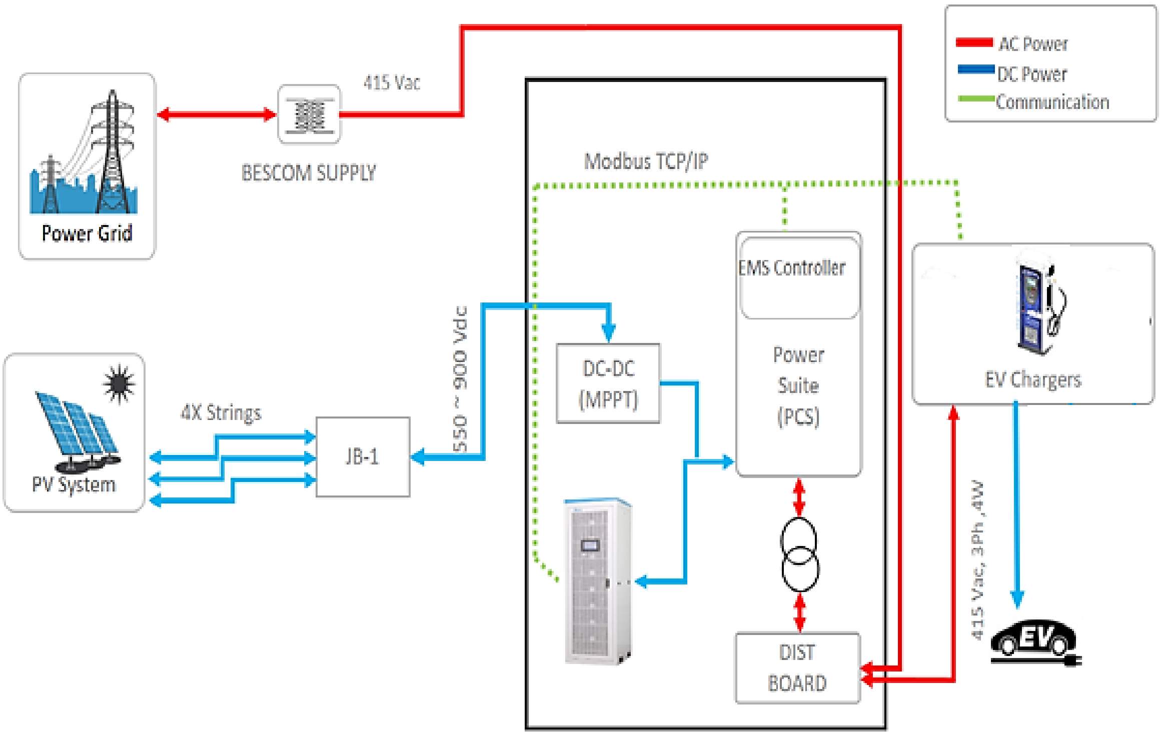


Figure 7.10: Block Diagram of the Charging Process[200]

BESCOM conducted a pilot project intending to demonstrate the idea of using a cleaner source of energy for electric transportation system using solar energy combined with a battery energy storage system (BESS) to charge the EVs directly . The financial support for the project came from Shakti Sustainable Energy Foundation, and technical support came from the Centre for Study of Science, Technology and Policy (CSTEP). Lastly, Delta Electronics India facilitated and engaged in building and conducting the prototype. The approach also enables zero-emission in the charging process, and the use of dynamic smart charging maximizes the local consumption of solar energy.

These features reduce peak demand, which may become a significant issue in the future with more and more charging stations getting connected to the power network. With the help of this kind of projects, it is possible to defer the investment in infrastructure costs. Plus, it is also scalable due to the key advantages that the system is modular in nature and solar power plant can be easily installed on the rooftop of the charging station premise.[200]

Figure 7.11 shows the establishment of the pilot project in the corporate office of BESCOM. The system design consists of a power conversion suite (PCS) connected to a 25-kW PV plant installed on the rooftop of the building. The charging station includes one 15-kW DC-001 Bharat EV charger. Additionally, 43-kWh energy storage is installed for storing the excess energy. An intelligent power suite is also incorporated for efficient energy management, which prioritizes the usage of solar power. On a positive note, the system can also work as a micro grid if there is a power outage in the locality.

Figure 7.11: The installed prototype[193]

The block diagram of the entire pilot project is depicted in Figure 7.10. The deployed rooftop (RT) PV system and the energy-based EV charging station can work in 2 different modes: normal charging mode and dynamic charging mode. In the normal charging mode, the source of power to the

200 C K Sreenath, "Solar PV Integration with EVSE and Energy Storage with Dynamic Charging" (Bengaluru, 2020).

charger is the RT PV, the battery and the grid. Under this mode, if the grid is not available, then PCS goes to off-grid mode, and the RT PV and battery will supply the power to the charger. In dynamic charging mode, the supply of power comes from the RT PV. This is the unique feature of the project where EV charging is made to follow the solar power generation. During normal and dynamic charging modes, the RT PV is set as the primary source of power for the connected charger. If the PV power falls short, then the battery supplies the deficient power ensuring its state-of-charge (SOC) is always above the prescribed limit of 15%. If the PV and battery cannot meet EV demand, then based on availability, the grid supplies required power. Similarly, if EV is unavailable, i.e., if no vehicle is plugged in, the battery is charged with solar power. Once the battery is fully charged, the excess power is fed to the grid. This set of priorities is set to ensure that the charger consumes the energy produced on site.

Some of the key innovations that the prototype showcases are:

- Intelligent bidirectional PCS that interfaces solar energy and the battery system with DC coupling to manage energy flow with the EV charger and the grid.
- Solar energy is prioritized for local consumption before feeding it to the grid.
- A novel smart, dynamic charging algorithm is being deployed wherein the EV charging load is made to follow the solar generation profile. Such a method will reduce the need for the high cost of energy storage.
- Also, a novel framework to estimate the levelized cost (derived for calculating the energy supplied to the grid) of charging at the particular EV charging station with grid-connected RT-PV and off-grid RT-PV, including energy storage, are presented.

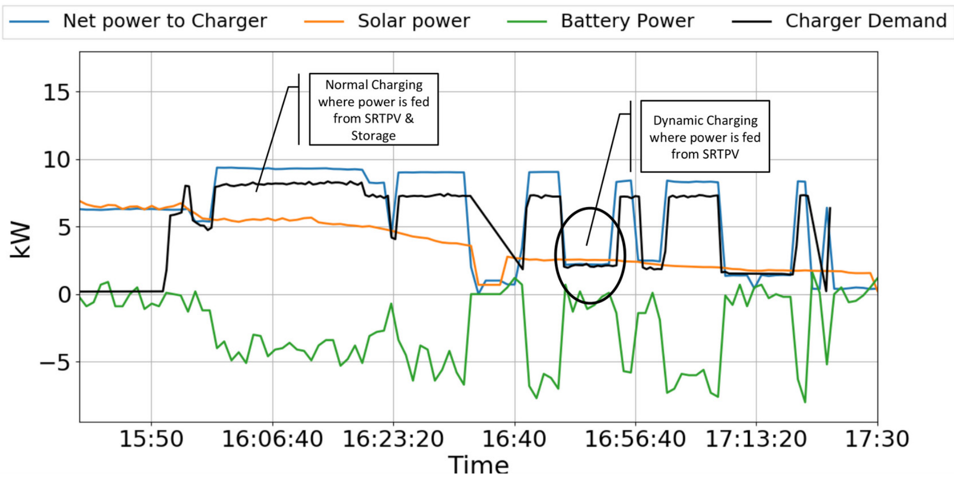


Figure 7.12 Characteristics during Normal Charging and Dynamic Charging[200]

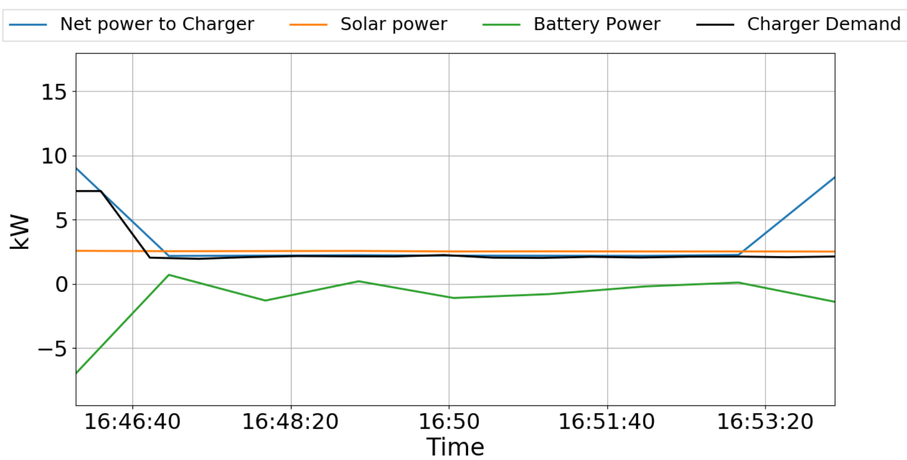


Figure 7.13: Characteristics during Dynamic Smart Charging[200]

The graphical representation of the two modes of charging is presented from the study in Figure 7.12 and Figure 7.13. During the normal charging mode shown in Figure 7.12, energy fed to the charger comes from the energy storage and RT PV grid. The green line indicates battery power, the orange line indicates the solar power, the blue line indicates net power top charger and the black lines indicates charger demand.

In dynamic charging given in Figure 7.13, the solar energy feeds the EV charger directly. A magnified look is shown in Figure 7.13 of dynamic charging where there is no discharge from the battery and the energy demand from the EV is made to follow the solar generation. This is the unique feature of the project, which is also the first of its kind in India.

In terms of the potential impact of the project prototype, it will promote a higher RT PV penetration in the grid and will help mitigate greenhouse gas emissions by replacing fossil fuel-based resources with cleaner RE sources. It will also potentially improve the business case for the charging station owner due to the lower levelized cost of solar energy. Scalability is not an issue with using this approach since the system is available in a modular manner, with no extra space requirement. The battery cabinet consumes minimal space, whereas the RT PV is located on the establishment's rooftop. An optimum sizing strategy of solar-plus-storage, including supportive policies such as net metering, can significantly enhance the business case for such a set-up.

The key learning from the economic rationale of the project is that the charging station with solar panels is primed for widespread production and is indeed economically viable. The problem of mismatch between solar energy generation and the consumption from charging units can be solved by deploying a net metering mechanism in charging stations. It was determined that the levelized cost of RT PV is around INR 3.5 – 4.5 (EUR 0.04 -0.05) per kWh, whereas that for RT PV and storage is around INR 8.9 (EUR 0.1) per kWh. On the other hand, the cost of grid electricity as set by the charging station tariff prescribed by the state policy is around INR 5 (EUR 0.06) per kWh. Hence, a cheaper rate for the RT PV energy supply boosts the business case for such a concept and affirms the prospect of return on investment. Among all the scenarios considered, the charging station connected with RT PV under the net metering policy represents the best-case scenario with the least levelized cost of sharing.

The Department of Heavy Industry under the Ministry of Heavy Industries & Public Enterprises has laid down the necessary guidelines for public EV stations across the country. However, similar guidelines for incorporating solar RT PV in the station is yet to come up, which could be cited as a drawback.

With the initial cost for setting up the prototype being around INR 35 lakhs (EUR 39,736), there are further plans for installing these units in places where it is difficult to extend the grid, such as highways. Since there are around 70 charging stations in Bengaluru, primarily in government offices, plans are in motion to install solar panels on these buildings wherever rooftop space is available and connect them to the charging station. The Government of Karnataka has further expressed the desire to provide 1000 charging stations throughout the state in the next three years. BESCOM has already drafted a technical plan for the same, focusing on the inclusion of this charging technology. Additionally, there are further plans and signed MOUs with NTPC Ltd. and Rajasthan Electronics & Instruments Limited (REL) to add 140 more charging stations (103 and 37 respectively) in Bengaluru, and the adoption of this technology has been made an integral part of the project.

7.6.3 SOLAR CARPORTS

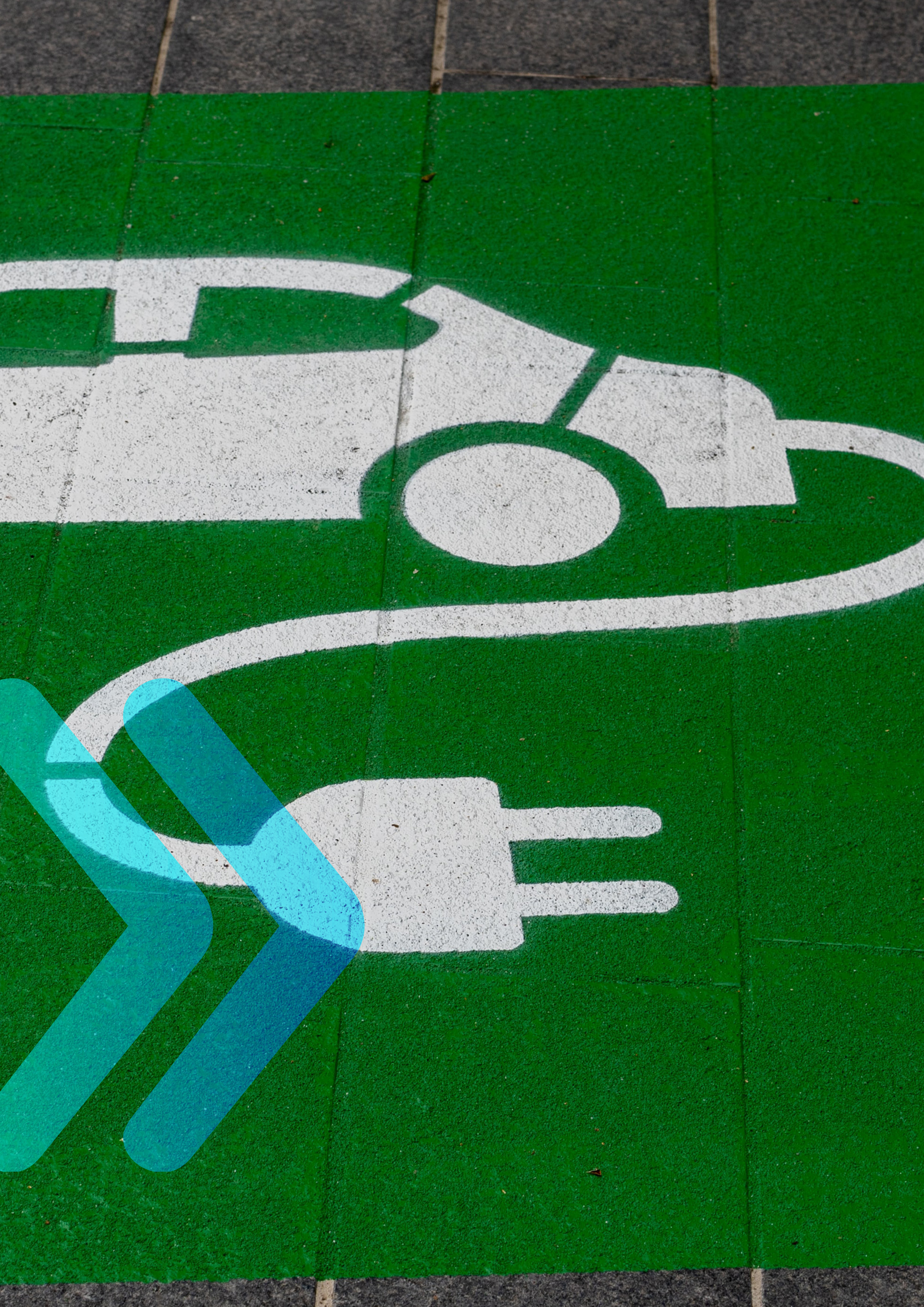
Solar carports are increasingly becoming one of the most popular commercial installations in the electric vehicle charging infrastructure segment. These are a system of overhead canopies made of steel frames with solar panels mounted directly on top and covers the parking spots of different residential, commercial, and industrial establishments. Using solar carports, the owners can enjoy the advantage of renewable power generation in an easily accessible, locally owned area, often enough to satisfy their power demand. If generated in excess, the electricity can also be sold to the local grid . In addition to generating clean and sustainable energy, solar carports provide covered parking facilities, making them lucrative business ventures. Solar carports share many resemblances with ground-mounted PV plants in terms of the presence of angled solar panels and installation of the panels on ground-based structures. However, contrary to the ground-mounted PV plants, a solar carport uses an existing area and does not entail the need for a separate, dedicated plot of land and hence enhances the value of the land immensely.

Presently, solar carports are being built with myriad options during installation, such as electric vehicle charging stations, lighting systems, waterproof installations to name a few. They can also be made in different configurations, such as single row and double row format. The double row configuration can further comprise three different layouts, namely, through slope, long span, and mono slope. With EV charging stations, the carports, in a way, offer the triple benefit of parking, power supply, and charging and thereby the scope of earning substantial revenue.

In India, the technology of solar carport is still in a nascent stage but holds immense potential that needs to be eventually tapped into. Gradually, as more and more corporate establishments and residential communities begin adopting EVs, integrating EV charging stations with these carports could prove to be a great choice. Not only will it provide substantial cost benefits to the owner, but it also will help create a reputation as an environmentally conscious entity embracing sustainability and can further help achieve green building certifications.

In this context, Magenta Power Private Limited is an EV charger manufacturing start-up in India who began their journey in 2018 and presently provide affordable EV charging solutions supporting all forms of vehicles . This is one such company specializing in building solar carports integrated with EV charging stations and can already boast of having several installations under their portfolio, the first of which came up in Navi Mumbai in 2018.

In terms of projects in scale, Tata Power Solar Systems Limited has constructed a 2.67 MW solar carport for the Cochin International Airport in Cochin, Kerala, spread over 20,000 square meters, consisting of 8,500 PV modules. It has also recently commissioned a 6.2 MW grid-synchronized, behind-the-meter solar carport at the Tata Motors car plant in Chikhali, Pune . Hence, there is immense potential in the installation of carports over large industrial and commercial spaces and integration of the same with EV charging stations for catering to the future needs of the EV consumers on a mega-scale.



08

Economic Analysis of EV charging infrastructure integration

Integration of EV load into the distribution system can potentially result into a significant stress on the grid if EV charging is not coordinated either through smart charging, or the capacity of the distribution network is increased to accommodate the EV load. Smart EV charging can be either the use of variable tariffs or through advanced control of EV charging. A typical connection diagram of an EV charging station with the grid has been shown in Figure 8.1.

8.1 Grid upgradation

In India, the residential consumers are provided power at 415/230 V, for which the distribution company (DISCOM) lays 11 kV lines generally from a 33/11 kV substation to a 11/0.415 kV distribution transformer (DT) near the load zones. Depending on the increase in peak load due to EV charging, different components may need upgradation to accommodate the increase in load. Typical costs associated with different components of the distribution grid are given in Table 8.1.

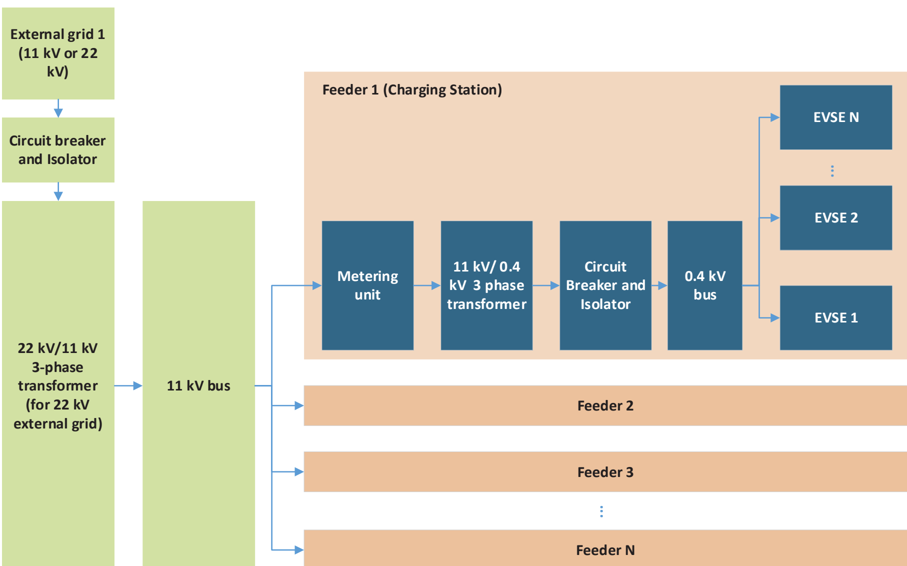


Figure 8.1: Typical layout of electrical connection from grid to EV charging station

Table 8.1: Cost of components[201]

Component	Cost (INR/EUR)
11 kV overhead (OH) line with bare conductor (per km) (3-phase, 4-wire)	4.5 lakh / 5,108
0.415 kV OH line with bare conductor (per km) (3-phase, 4-wire)	3.5 lakh / 3,973
0.415 kV OH line with aerial bundled cable (ABC) conductor (per km) (3-phase, 4-wire)	8 lakh/ 9,082
12.5 kVA, 11/0.415 kV DT	1.35 lakh/ 1,532
25 kVA, 11/0.415 kV DT	1.57 lakh/ 1,782
50 kVA, 11/0.415 kV DT	2.15 lakh/ 2,440
63 kVA, 11/0.415 kV DT	2.50 lakh/ 2,838
100 kVA, 11/0.415 kV DT	3.00 lakh/ 3,405
250 kVA, 11/0.415 kV DT	6.50 lakh/ 7,379

Based on the costs mentioned above, two different distribution network topologies have been compared to understand the advantages and disadvantages of both the topologies.

8.1.1 LOW VOLTAGE DISTRIBUTION SYSTEM (LVDS)

In this topology, 11 kV lines are drawn from the 33/11 kV substation to the 11/0.415 kV DT from which 0.415 kV OH lines are extended to the customers (shown in Figure 8.2). This topology reduces the number of DTs and so the cost of the overall system is reduced, however, it has some limitations as listed below,

- Poor voltage at the tail end of the feeder
- Higher losses due to power being transferred at lower voltage
- Fault in the DT would cut-off the entire downstream network, so the reliability of power is decreased

8.1.2 HIGH VOLTAGE DISTRIBUTION SYSTEM (HVDS)

The HVDS topology can be used as an alternative to the LVDS to improve the quality of power as well as increase reliability of power. In this topology the 11 kV lines from the substation are passed into the distribution network and each 11/0.415 kV DT only serves a small section of the load as shown in Figure 8.3. The advantages of this topology are listed below:

- Lower losses as the power is transmitted at higher voltages
- Improved voltage regulation at consumer end
- Fault at any single DT would only cut-off a few of the customers, so reliability of power is improved.

To compare the costs of both the systems, two scenarios are considered. In Scenario I, aggregate distribution transformer capacity of 100 kVA is added, and in Scenario II, aggregate distribution transformer capacity of 250 kVA is added. The number of EV chargers that can be accommodated by addition of 100 kVA and 250 kVA distribution system has been given in Table 8.2. Considering the costs as per Table 8.1, the two scenarios have been compared in

Table 8.3 and Table 8.4 respectively. Although LVDS is more cost effective than the HVDS topology, as mentioned above the power quality and reliability may be a concern if LVDS topology is used.

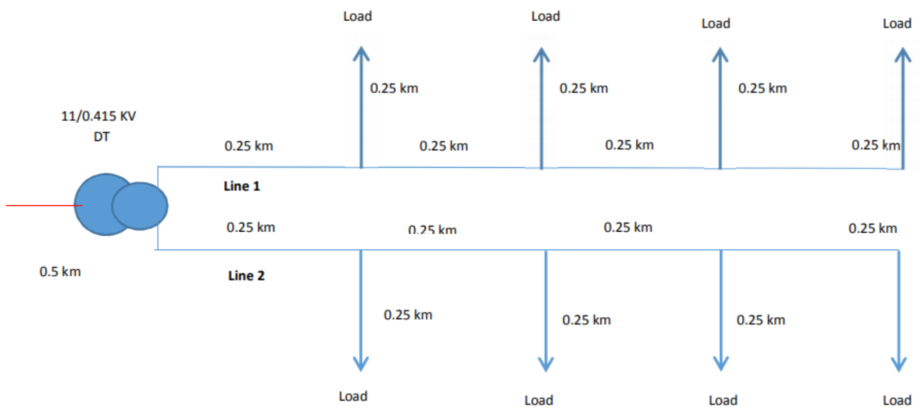


Figure 8.2: Illustrative LVDS topology [201]

201 CEA, "Cost Benefit Analysis of High Voltage Distribution System(HVDS)," 2020, https://cea.nic.in/wp-content/uploads/2020/04/d.pdf.

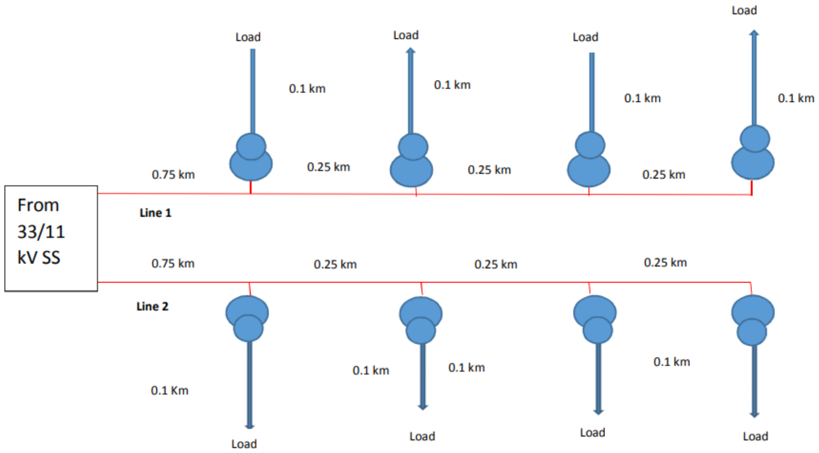


Figure 8.3: Illustrative HVDS topology[201]

Table 8.2: Number of chargers of different rating that can be added with no remaining spare capacity in the DT

DT rating	Number of chargers that can be added				
	3.3 kW	7 kW	15 kW	22 kW	50 kW
100 kVA	30	14	6	4	2
250 kVA	75	35	16	11	5

Table 8.3: Summary of Scenario I, (100kVA capacity)[201]

Item	LVDS	HVDS
No. of DTs	1	8
Capacity of each DT (kVA)	100	12.5
Aggregate DT capacity (kVA)	100	100
Length of 11kV line (kms)	0.5 (single line)	3 (two lines)
Length of 0.415kV line (kms)	3.5 (two lines)	0.8 (eight lines)
Cost of total system (INR/ EUR)	17.5 lakh/ 19,868	27.1 lakh/ 30,767

Table 8.4: Summary of Scenario II, (250kVA capacity) [201]

Item	LVDS	HVDS
No. of DTs	1	8
Capacity of DT (kVA)	250	50 (2 nos.), 25 (6 nos.)
Aggregate DT capacity (kVA)	250	250
Length of 11kV line (kms)	0.5 (single line)	3 (two lines)
Length of 0.415kV line (kms)	3.5 (two lines)	0.8 (eight lines)
Cost of total system (INR/ EUR)	21 lakh/ 23,841	30.02 lakh/ 34,082

The above scenarios have not considered the costs of other auxiliary grid equipment such as circuit breakers, isolators, measurement devices, protection devices etc. The cost of the system would further increase if the costs of these equipment are taken into consideration along with the operational and maintenance costs.

8.2 Smart Charging

As seen in Section 8.1, a significant investment would be necessary for grid upgradation if the charging of EV load is not controlled. To minimise/potential avoid or defer the investment of grid upgradation, the EV charging could be coordinated so that the grid is not stressed at any point in time. There are different business models for implementation of smart charging and they are as given below:

- The utility owns the smart EVSE

  In this model, the utility pays for and owns each smart EVSE, and is responsible for all maintenance charges as well as regulating the EV charging as part of its smart grid. Customers may give certain charging preferences, but they defer the controllability rights of charging during peak periods to the grid operators in return for lower EV specific electricity rates.

- The customer owns the smart EVSE but with subsidy from the utility

  In this model the customer owns the smart EVSE and pays for its operation and maintenance, however the grid operator subsidizes the prices to make it favourable for the customer. The utility would also have the ability to control charging a certain number of times per year.

- The customer owns the smart EVSE with subsidy from the utility and a separate meter for EVSE

  This model is same as model 2, but instead of billing the customer based on their overall household energy consumption, the EV charging is billed separately using the separate meter.

For implementation of smart charging, different components and infrastructure developments needs to be considered as mentioned below,

- **Smart charging capable EVSE:** This is the most crucial component of the smart charging methodology as the EVSE should be able to regulate the EV charging load based on the signals from the management software.

Figure 8.4: EO Genius

EO Genius & Hub

It is a modular and scalable smart charging solution for fleets, apartments, and destinations. The EO Hub is the central controller that can connect up to 30 EO Genius Chargers and monitor and control each of the chargers individually. It has static, dynamic, and scheduled load management functionality and power ratings of 3.6 kW, 7 kW, 11 kW and 22 kW .

Cost of single phase up to 7.2 kW – INR 1,12,995/ EUR 1,282

Cost of 3 phase up to 22 kW – INR 1,26,695/ EUR 1,438

- **Smart Meter:** The next important component to facilitate smart charging is a smart meter. The smart meter enables logging energy usage based on time of use so that variable tariffs may be employed. The smart meter also communicates between the utility and the user and hence increases the transparency of the energy consumption pattern and helps in moulding the behaviour of the EV user. The cost of smart meters generally ranges between INR 6,000- INR 7,000 (EUR 68.12 - 79.47) .

- **Energy Management Software:** The energy management software (EMS) is a cloud/server-based management system that houses the algorithms to coordinate the charging based on the system status. The cost of the EMS is vendor specific and depends on the included functionalities. Smart charging maybe achieved even without utilizing an EMS by using variable tariffs.

- **Software:** The EV user and the utility need a platform in which they can change the preferences of their charging needs as well as monitor the EV charging, for satisfactory performance. For this purpose, a web portal may be designed, where all the parameters may be monitored and changed according to the needs of the customer or the utility, based on the business model of the smart charging implementation. There can also be a mobile app, so that the information is available to the user at any point in time and at any location. The costs associated with software include the costs incurred for designing the platform as well as server costs for hosting the website or the app, along with the cyber security costs to protect the user's privacy.

- **Communication infrastructure:** The next smart charging enabler is a robust communication infrastructure so that information and signals may flow seamlessly between the EVSE, the grid operator and the EMS. Th costs of the communication infrastructure would also vary based on the type of communication used. For example, if internet protocol-based communication is used (which is the most common), the communication infrastructure cost would include the cost of the modem, the Wi-Fi router, the internet usage charge etc.

- **Data management and storage:** By collecting the system data continuously at high sampling rate, a huge amount of data would be generated. This amount of data would need to be stored in a data centre so that the data may be later analysed to improve the smart charging algorithm or for any other analytics.

Operation and maintenance: This includes the different operation and maintenance cost such as repair of components, running a call centre to provide customer care service etc.

8.2.1 COST ANALYSIS OF SMART CHARGING STATIONS

The cost of smart charging mainly consists of procurement cost along with some additional costs. Procurement cost includes hardware and software procurement cost whereas additional cost covers adaptability cost, future-readiness cost, and permit costs. Major contributors in procurement costs are the purchasing of hardware, computing power, and suitable software. In addition, it also consists of network access charges and contract charges. Major contributor in additional costs covers maintenance cost, interconnection and adaptivity cost, manpower hiring cost whereas investments towards future-readiness and permits are also contributors in additional costs.

The case studies available in the literature have analysed the cost comparison of different numbers of chargers installed at a site. The result from such studies shows that except manpower cost, all other costs per charger are reduced whereas manpower charge increases due to more charger's installation work[202]. The study further reported that Time-of-use scheme for smart charging is the basic and less expensive way of implementing smart charging whereas other methods work on modulation of the rate of charging. It mentions that the transition cost from level 2 charger to smart charger is usually less than INR 3,710 (EUR 42.12) but in some smart chargers with higher number of features, the cost could be more than INR 37,110 (EUR 421.32) in comparison with the equivalent dumb charger.

A study on the similar objective of cost analysis for various EV charging conditions and schemes are carried on 100 populous metropolitan areas from 2019 to 2025 in the United States for the public, home, and workplace charging infrastructure. The study shows that the cost per charger in the cluster of chargers in the networked and non-networked conditions[203] is comparatively cheaper than individual charging station installation. Table 8.5, shows the data of the cost per charger reduction in case of clustered chargers. The study mentions that networking enables chargers to communicate, and it can be considered smart or controlled charging. The cost comparison of chargers for dumb charging and smart charging is shown in Table 8.5.

Study at Hamburg's distribution grid found that the establishment cost of control unit to monitor the EV charging load is 90% less than the reinforcement cost of cables in conventional charging technique's conditions[207]. Green eMotion project at European Union and Sacramento Municipal Utility at the United States on unidirectional controlled charging found that smart charging reduces the grid reinforcement cost by 50% and 70% respectively [207]. Another study however, also mentions that the V2G and V2X at current condition takes interface cost 3-5 times higher than unidirectional smart charging [207].

Table 8.5: Cost per charger for networked and non-networked connection[204]

Level	Type	Charger per pedestal	Per charger cost (USD)	Per charger cost in INR[205] (EUR)[206]
Level 1	Non-networked	1	813	60,340.86 (691.05)
Level 1	Non-networked	2	596	44,235.12 (506.6)
Level 2	Non-networked	1	1,182	87,728.04 (1004.7)
Level 2	Non-networked	2	938	69,618.36 (797.3)
Level 2	Networked	1	3,127	2,32,085.9 (2,657.95)
Level 2	Networked	2	2,793	2,07,296.5 (2,374.05)
DC fast	Networked 50 kW	1	28,401	21,07,922 (24,140.85)
DC fast	Networked 150 kW	1	75,000	55,66,500 (63,750)
DC fast	Networked 350 kW	1	140,000	1,03,90,800 (119,000)

202 Chris Nelder and Emily Rogers, "Reducing EV Charging Infrastructure Costs", RMI, 2019
203 Networked chargers have the ability to communicate over WiFi or other cellular signal, while non-networked chargers do not have such communication ability.
204 Michael Nicholas, "Estimating Electric Vehicle Charging Infrastructure Costs across Major U.S. Metropolitan Areas" (ICCT, August 2019).
205 USD 1 = EUR 0.85
206 USD 1 = INR 74.22
207 IRENA, "Innovation outlook: Smart charging for electric vehicles", 2019

Considering the installation of 2 million smart EV chargers over 20-year EVSE system lifetime, the cost benefit analysis of the 3 smart charging scenarios as well as the dumb charging with grid investment has been given in Figure 8.5 . The costs considered for the smart charging infrastructure included

- EVSE costs, including hardware and firmware
- Software, including the EV management software on the utility side and the customer EV portal
- Installation costs
- Operational costs such as expenses for call centres, IT, asset, and inventory management etc.

The benefits component of the model included the different benefits that the smart EVSE can provide to the grid. The different benefits have been summarized in Table 8.6.

Table 8.6: Benefits for the different business models[208]

Driver	Benefit	Utility owned smart EVSE	Customer owned smart EVSE	Customer owned smart EVSE with separate meter
Peak Control	Reduction in cost of peak generation	Yes	Yes	Yes
	Reduction in cost of transmission and distribution expansion	Yes	Yes	Yes
	Lower energy cost due to shifting EV charging to non-peak times	Yes	Yes	Yes
Time of use tariffs	Lowers energy cost by shifting loads to non-peak times	Yes	Depends on customer engagement	Depends on customer engagement
Load scheduling	Maintains local distribution grid reliability	Yes	No	No
	Supports integration of more renewable energy	Yes	No	No

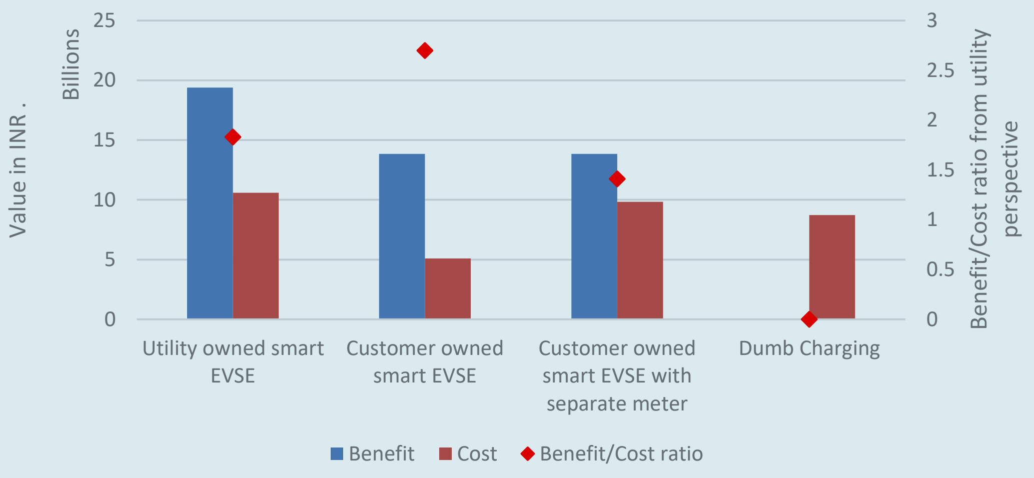


Figure 8.5: Benefit and cost of the different smart charging business models 208

As seen in Figure 8.5, utility owned smart EVSE provides the highest benefit to the utility as the total control of the EV charging lies with the grid operator and they can schedule the EV charging based on grid conditions. But in this business model as the cost of installation of the charging infrastructure is completely paid for by the utility, so the capital expenditure by the utility is higher in this scenario. As a result, the benefit to cost ratio is slightly lower. The customer owned smart EVSE business model may appear to have the highest benefit to cost ratio. Although the benefit in this model is reduced compared to the earlier model as the utility does not have total control over the EV charging, the deferment of the EVSE cost to the customer greatly reduced the cost incurred by the utility. However, if the cost of a separate meter is added so that the EV can be billed separately, then the benefit to cost ratio of this business model goes lower than the utility owned business model.

208 Networks, S. "The Dollars-and Sense-of EV Smart Charging Thinking Through the Options for Utility Integration of Electric Vehicles". SilverSpring Networks

8.3 Comparative cost analysis: EV charging infrastructure connected to Grid only and supported by Grid and PV

The use of renewable energy in addition to providing benefits to emissions, can also potentially impact the economics of the PCS.

A 210 kVA EV charging station with two 50 kW CCS chargers and five 22 kW Type 2 AC charger have been considered for the analysis. The average CAPEX and OPEX cost for installation of the charging station has been detailed in Table 8.7.[209]

Assumptions made for this analysis

- The PCS purchases electricity at INR 6.09/kWh (EUR-¢ 6.91/kWh)
- Four different prices for provision EV charging service have been considered INR 7/kWh (EUR-¢ 7.95/kWh), INR 9/kWh (EUR-¢ 10.22/kWh), INR 15/kWh (EUR-¢ 17.03/kWh) and INR 20/kWh (EUR-¢ 22.71/kWh).
- The utilization of the chargers is expected to increase by 10% annually.
- It has been assumed that the chargers have an operational life of 10 years, while the PV has a lifetime of 20 years.

For analysis of the impact of RE integration, different PV penetration levels have been considered. The penetration level is defined based on the annual energy consumption of the PCS. The NPV of the PCS considering 10 years of operation has been given in Table 8.8. From the table it can be observed that, with higher penetration of RE, although there is a larger initial investment, the NPV of the business over a period of 10 years is higher compared to without RE. The same trend is seen irrespective of the charge levied by the PCS for EV charging.

The impact of RE penetration is also dependent on the EV tariff placed on the PCS by the respective DISCOMs. So,

Table 8.7: Charging station specification[209]

Type of Charger	Number of Chargers	Power Output (kW)	Approx. Cost in INR Including GST @18% (INR/EUR)	Number of EVs that can be charged Simultaneously	Maximum Energy sold to EVs per day (8 hrs/day) (kWh)
CCS	2	50	14,50,000/ 16,462	2	800
Type 2 AC	5	22	6,25,000/ 7,095	5	880
New Electricity connection (250 kVA) Transformer, Cables, breaker, Energy Meter			7,50,000/ 8,515		
Civil Works			2,50,000/ 2,838		
EVSE Management Software			40,000/ 454		
CCTV Camera Setup			30,000/ 340		
Total (excluding RE CAPEX cost)			31,45,000/ 35,706		1,680
OPEX					
Technicians (1 @ INR 25,000/month for 6 months)			1,50,000/ 1,703		
Site Maintenance (1 @ INR 15,000/month for a year)			1,80,000/ 2,043		
Network service provider fee			6000/68.12		
Land Lease Rental @ INR 50,000/month			6,00,000/ 6,811		
EVSE Management Software Fee (10% of net margin on electricity charges			10% of revenue margin		
Advertising @ INR 3,000/month			36,000/ 408.72		

209 Framework adopted from Nimesh Shah, "Cost Estimates and Revenue Model for a Public Charging Station (PCS)," PluginIndia, 2019, https://www.pluginindia.com/blogs/cost-estimates-and-revenue-model-for-a-public-charging-station-pcs.

Table 8.8: NPV of the PCS business for the different scenarios considering 10 years of operation

	Scenario A (85% RE)	Scenario B (60% RE)	Scenario C (50% RE)	Scenario D (45% RE)	Scenario E (40% RE)	Scenario F (15% RE)	Scenario G (0% RE)
Size of PV installation (kW)	293	207	173	155	138	52	0
Total CAPEX (including PV) (INR/ EUR)	1,92,60,000/ 218,664	1,45,30,000/ 164,963	1,26,60,000/ 143,733	1,16,70,000/ 132,493	□ 1,07,35,000/ 121,877	60,05,000/ 68,176	31,45,000/ 35,706
NPV (EV charging @ INR 7/kWh)	1,63,292.87/ 1,853	-9,28,324.92/ -10,540	- 13,83,579.26/ -15,708	-15,64,688.38/ -17,764	-17,92,315.55/ -20,349	-28,83,933.35/ -32,742	-35,20,296.81/ -39,967
NPV (EV charging @ INR 9/kWh)	1,00,60,020.15/ 114,215	89,68,402.35/ 101,821	85,13,148.01/ 96,652	83,32,038.89/ 94,596	81,04,411.72/ 92,012	70,12,793.93/ 79,618	63,76,430.47/ 72,394
NPV (EV charging @ INR 15/ kWh)	3,97,50,201.96/ 451,297	3,86,58,584.17/ 438,903	3,82,03,329.83/ 433,734	3,80,22,220.71/ 431,678	3,77,94,593.54/ 429,094	3,67,02,975.74/ 416,700	3,60,66,612.29/ 409,476
NPV (EV charging @ INR 20/ kWh)	6,44,92,020.15/ 732,198	6,34,00,402.35/ 719,805	6,29,45,148.01/ 714,636	6,27,64,038.89/ 712,580	6,25,36,411.72/ 709,996	6,14,44,793.93/ 697,602	6,08,08,430.47/ 690,377

the analysis has been extended to get the NPV of the PCS businesses considering 10 years of operation for different EV tariffs placed on the PCS and the charges levied by the PCS from the EV users.

Besides the potential economic savings of the PCS, usage of renewable energy for charging of EVs also has huge implications on the greenhouse gas emissions. However, financial quantification of the externalities of electric power generation is needed to analyse the impact of RE integration. These external costs include the impact of greenhouse gas emissions from electricity generating facilities, the associated climate change and other related effects. Extensive work has already been carried out in determining the financial implication of greenhouse gas emissions from different generating units. A study by the European Commission have determined that the external costs for electricity production in the European Union (EU) as given in Table 8.9. These costs were determined for most EU member states and is within the EU range as mentioned in Table 8.9. In this analysis, the median value of the external costs has been utilized.[210]

Figure 8.6 shows the sensitivity of the NPV of the PCS business to the energy buying price for the PCS and the selling price considering different PV penetration levels. In this analysis, the total capital expenditure, all the operational and maintenance cost, the annual revenue and the additional cost of emissions (shown in Figure 8.7) have all been taken into consideration. Figure 8.6 indicates that under the assumptions considered for this analysis, increasing RE penetration leads to increased profitability for the PCS, for example,, at a buying price of INR 8/kWh (EUR-¢ 9.08/kWh) and selling price of INR 19/kWh

Table 8.9: External costs for electricity production in the EU (INR/kWh (EUR-¢/kWh))[210]

	Coal & Lignite	Peat	Oil	Gas	Nuclear	Biomass	Hydro	PV	Wind
EU range	1.76-13.21 (2-15)	1.76-4.04 (2-5)	2.64-9.69 (3-11)	0.89-3.52 (1-4)	0.17-0.62 (0.2-0.7)	0-4.4 (0-5)	0-0.88 (0-1)	0.53 (0.6)	0-0.22 (0-0.25)
Median	3.52 (4)	2.20 (2.5)	2.64 (3)	0.88 (1)	0.26 (0.3)	0.88 (1)	0.18 (0.2)	0.53 (0.6)	0.11 (0.125)

210 Owen, Anthony D. "Renewable energy: Externality costs as market barriers." Energy policy 34, no. 5 (2006): 632-642.

(EUR-¢ 21.57/kWh), the net benefits can be increased from INR 25 million (EUR 0.28 million) to INR 43.5 million (EUR 0.49 million) over a 10-year period by increasing the RE penetration to 85% from 0%. The return on investment is further increased if the PCS sells its charging services at lower price points (but the overall profit margin of the business is reduced). For example, for a selling price of INR 13/kWh, the net benefits can be increased from INR 0.25 million (EUR 2,800) to INR 18.82 million (EUR 0.21 million) by increasing the RE penetration from 0% to 85%.

The discounted annual emission costs have been shown in Figure 8.7, which have been calculated based on the amount of energy purchased from the utility for the year and considering that all utility power is produced in coal based thermal power plants. It can be observed that the annual emission costs are highest for the scenario with 0% RE penetration, and the lowest with 85% RE penetration, which is to be expected as higher amount of energy is being produced by coal based thermal generating stations. Another trend seen is that the cost of emission increases with time. This is because the usage of the PCS has been considered to have an annual increment of 10%, while the installed PV capacity remains constant. So, in the later years, a share of the total energy would be purchased from the utility. This cost can be potentially reduced if PV capacity addition accounts for future increase in energy usage.

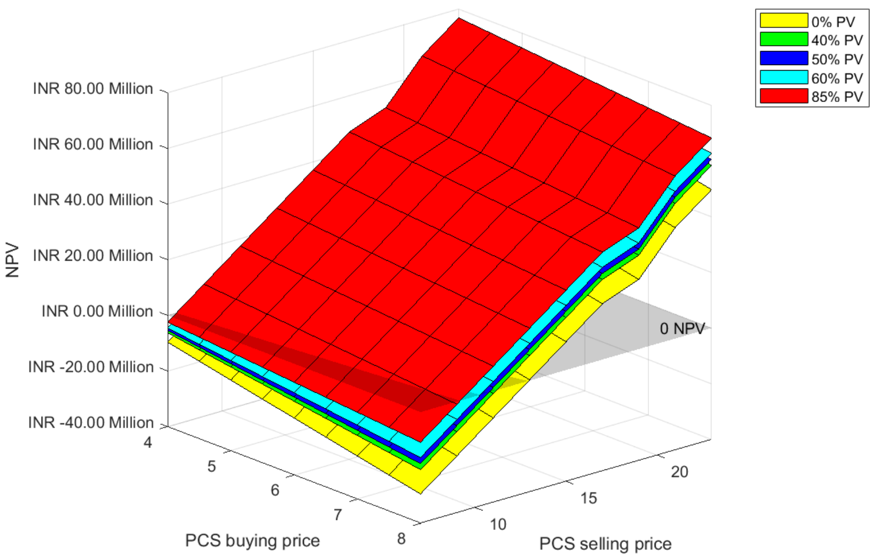


Figure 8.6: Sensitivity of NPV for the PCS with its buying and selling price

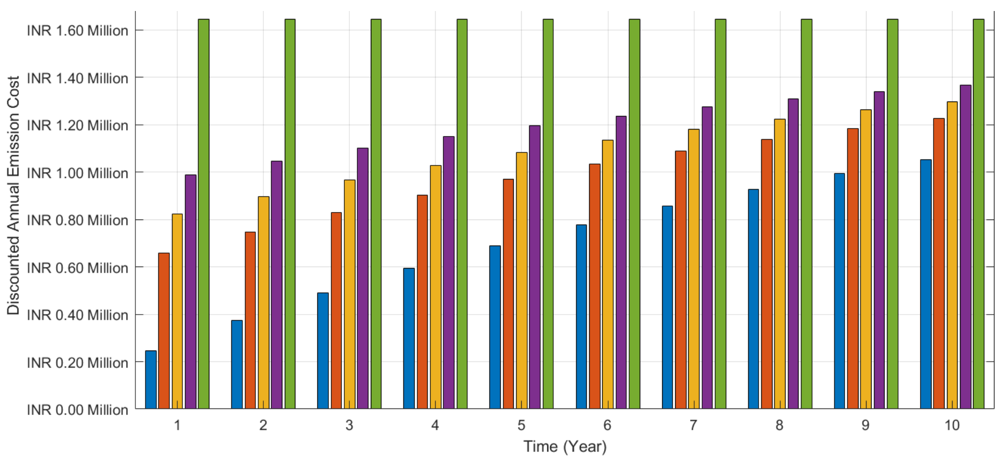


Figure 8.7: Discounted annual emission costs for the different RE penetration levels

09

Gap Analysis in EV charging infrastructure and its grid integration in India

Though NEMMP 2020 laid down the vision and roadmap for EV penetration in India, the scheme could not achieve the envisaged penetration targets. However, the various actions taken as per NEMMP guidelines has provided the kick start for uptake of e-mobility and increased the awareness level among the consumers and industry players. However, these provisions were not effectively implemented under NEMMP scheme. After NEMMP, the Central Government launched FAME scheme in 2015 to enhance hybrid and electric vehicle technologies in India. The overall scheme is proposed till FY22 to support market development of EVs. The FAME Scheme was extended four times between 2017 and 2019 and Figure 9.1 below represents the journey of FAME I scheme.

Although the FAME I scheme could not fully utilize the sanctioned funds, it has provided the steppingstone for uptake of electric mobility in the Indian market. The scheme was successful in creating awareness and momentum for electric mobility in the Indian market.

FAME phase II was issued in March 2019, with increased layout of 10,000 crores with two-year duration from FY 2019-20 to FY 21-22. This scheme is majorly aimed to leverage the buzz created by its first phase to create a platform for the e-mobility sector to take off in the country. Some of the key gaps in FAME II are listed below:

Figure 9.1: Journey of FAME phase I

1. **No incentive for vehicle scrappages/ Retro fitment allowance:** FAME II provided incentives for new EV purchase only, and does not provide for any scrappage incentive, to encourage existing ICE vehicle owners to exchange their vehicle for buying EVs. Also, it does not mention any retrofit allowance for converting existing ICE vehicle to EV.

2. **No mandate for EV adoption:** There is no EV mandate provided under FAME II scheme, which resulted in the following issues: (i) insufficient development of charging facilities, (ii) investment dilemma among vehicle manufacturers.

3. **Absence of fee-bate concept:** Conventional ICE based automobiles are more comfortable for users since they have been in use from a longer time, and this inertia developed among the consumers restricts the transition to EVs. Absence of fee-bate concept in the policy which allows to put huge fees/ penalty / cess/surcharge in using ICE vehicle may restrict the EV adoption due to the reluctance of users to convert from ICE to EV.

4. **Absence of subsidy for private 4W:** FAME II provides subsidy only for public 4W and not for private 4W, which will restrict the transition of ICE based cars to EVs.

5. **Requirement of re-certification:** In order to be eligible for getting demand incentives, OEMs have to undergo re-certification process for conformity check to obtain certificate of 'FAME II India Phase II eligibility fulfilment' from approved testing agencies in India. The requirement of this certificate in each year to claim the subsidy creates unnecessary administrative issues for OEMs.

6. **Requirement of Indigenous component:** As per FAME II guidelines, to avail subsidy, OEMs have to use certain percentage of indigenous components. To have a large number of EVs on road, there is a need for well-developed supply chain of auto components, the absence of which causes requirement of indigenous components to act as a barrier. This will cause issues in getting incentives as well as increase price of EVs if OEMs try to import such components to fulfil the requirement.

This chapter identifies the key gaps in EV charging infrastructure and its grid integration that needs to be addressed for seamless adoption of charging infrastructure which indirectly will enable faster EV adoption in India.

9.1 Gaps in policies for EV charging infrastructure development

EV and EV charging infrastructure adoption is relatively at a nascent stage, however, due to various policies and EV schemes at central and state government level, Indian EV ecosystem is experiencing rapid development. While the efforts by the central and state level governments have certainly helped the EV ecosystem to gather a good momentum, there is a need to address various challenges and further develop EV charging infrastructure and improve its grid integration.

9.1.1 LACK OF SUPPORT TO PRIVATE SECTOR COMPANIES FOR DEVELOPING CHARGING INFRASTRUCTURE

The DHI through the FAME II scheme have sanctioned 2,877 charging stations till June 2021 throughout the nation. Subsidies were provided to agencies for installing these 2,877 charging stations. However, the establishment of these charging stations were primarily awarded to Public Sector Undertakings (PSU) or other government agencies. While PSUs and the government agencies were able to submit the proposals directly to DHI, private companies were required to submit their proposals through Urban Local Bodies (ULB), which added an extra barrier for private companies. To encourage the growth of private sector however, the public tenders need to provide a fair and level playing field.

9.1.2 NON-OPTIMAL ALLOCATION OF PCS UNDER FAME II

The 2,877 PCS allocated under FAME II scheme have been used to set up charging stations in 62 cities across India. The allocation of charging infrastructure to such a wide range of cities has led to reduced and non-optimal distribution of chargers among different states. For a comparatively EV-rich city like Delhi with around 3,000 4W EVs (till Q2 2021), only 72 PCS have been allocated in FAME II (173 under entire FAME scheme), while for Chandigarh with a 4W EV count of only 100 (till Q2 2021), 70 PCS have been allocated in FAME II (120 under FAME). Thus, there is a mismatch between demand and allocation of PCS.

9.1.3 MISALIGNMENT BETWEEN SUBSIDY IN CHARGING INFRASTRUCTURE AND VEHICLE SUBSIDY

Under FAME II scheme, a major portion of the subsidies are offered for purchase of 2W and 3W vehicles. Of the total FAME II budget, 20% has been allocated for 2W EV segment subsidy, 25% for subsidizing the 3W segment, while only 5.5% has been allocated for the 4W segment. In the 4W segment, subsidies are only provided for commercial vehicles and not to the vehicles for private use. The 2W and 3W EV models currently available in the country generally are equipped with only slow charging capability. These vehicles are mostly charged using the standard 15A sockets. However, of the total funds allocated for charging infrastructure development, 80% of the funds are allocated for high powered chargers used for charging of 4W vehicles. Therefore, there is a mismatch between the subsidies provided for the segment-wise EV demand and the corresponding subsidies for the EV charging infrastructure, which needs to be addressed.

9.1.4 IMPLEMENTATION OF BUILDING BYELAWS FOR EV CHARGING

Residential charging is one of the key pillars of successful transition to e-mobility. EV users residing in private houses can install their own EV charging units, but for people residing in RWAs and apartments, installation of charging units in the common areas may be opposed by the building management. While the building bye-law amendment guidelines have been in place since 2019, they are yet to be adopted/implemented by the State Governments. Lack of adoption of the guidelines can be attributed to various factors including i) low EV penetration of EVs, more so in suburban and rural areas, and ii) potential increase in real state process due to additional infrastructure cost. Currently public charging infrastructure establishment is promoted through various subsidies to public charging stations. However, promoting EV charging infrastructure in building premises can potentially play a critical role in EV adoption.

9.1.5 LACK OF ALIGNMENT BETWEEN CHARGING DEMAND AND ALLOCATION OF CHARGING INFRASTRUCTURE

EV traffic flow will be primarily dominant in the main city rather than in the outskirts of the city. Moreover, as EV charging would take a fair amount of time, the EV user would be more inclined to charge at locations which have added amenities like market areas, playgrounds, movie theatres etc. As mentioned in Section 5.2, 2,877 PCS have been awarded to PSUs and other government entities, and it has been observed that in most of the cases, such PCSs would be installed in the space/land available with such agencies, which includes government office buildings, PSU office buildings, PSU industrial locations etc. Although the expression of interest listed out few categories of EV charging stations (based on location types), there was no mandate on the number of charging station in each category. So, the installed charging stations may not be easily accessible to the commercial and private EV users due to location disadvantage. Therefore, location of PCS needs to be aligned with the demand of public charging to cater to the charging requirement effectively and efficiently, thereby resulting in better utilisation of the charging infrastructure.

9.1.6 LACK OF FINANCIAL SUPPORT FOR BATTERY SWAPPING

MoP has already published guidelines for battery swapping stations, however the FAME II scheme does not have any provision for subsidy for battery swapping infrastructure. In order to encourage battery swapping, Government of India has also allowed sale of 2W and 3W EVs without battery. However, as the FAME II subsidies are linked with the battery size, so the calculation of subsidies for vehicles without batteries also needs to be looked into. Moreover, an EV with battery is eligible for 5% GST, however, purchase of battery from a third party has 18% GST which can be a bottleneck for battery swapping stations as the EV user is likely to prefer an EV with inbuilt battery rather than buying the battery separately.

9.2 Gaps in EV Regulations

Adequate grid code regulations for grid connection of EVs are still not in place. These include adequate technical regulations for integrating EV load to the LV/ MV and HV grids. There is a need for specifying the operating limits (voltage and frequency) and response characteristics for normal grid operation and during grid disturbances. Additionally, the regulations need to cover the maximum allowable harmonic injection by each charger, types of mandatory protection schemes, the acceptable power factor ranges during operation etc.

9.2.1 LACK OF ADEQUATE GRID CODE REGULATIONS

Experience on RE integration has proven beyond doubt that adequate grid code regulations introduced at right time played an instrumental role in successful integration of RE in majority of RE rich countries. Therefore, taking an inspiration from the journey of RE integration so far, it is important to plan adequate grid code regulations for EVs for seamless adoption in Indian electricity grid. Therefore, design of adequate grid codes for utilization of EVs for grid support services should also be looked into. The regulations should regulate the minimum capabilities required for V2G application while specifying the active/reactive power requirement from a charging station during a frequency/ voltage event in the grid. To have efficient EV integration, there is also a need for appropriate protection schemes as well as minimum communication requirements that can be addressed through relevant regulations.

9.2.2 GAPS IN EV INTEGRATION WITH DISTRIBUTION SYSTEM

In near future, considerable number of EV chargers are expected to be connected to the low voltage distribution network, therefore the quality of the network is of paramount importance. Here, quality of power supply refers to resiliency, margin availability, reliability of supply, grid stability and all other power quality related indices. The distribution network needs to be robust enough to cater to the increased charging load particularly during peak periods. Distribution feeders have been traditionally designed to supply power to domestic loads, but EV charging significantly increases the power drawn at a household level. Therefore, for secure and stable EV integration, determining the hosting capacity of the distribution feeders should consider all the critical constraints, such as thermal limit of the distribution lines, transformers etc., voltage profile and power quality issues, distribution losses, and protection aspects. However, it is also important to consider potential countermeasures such as congestion management, demand response, smart charging and grid upgradation that would alleviate the aforementioned issues. Therefore, the distribution network operator needs to play an important role in controlling the number of chargers that can be allocated to each feeder.

In almost all the countries reviewed under Report-2: International review of Electric Vehicle Charging Infrastructure and its Grid Integration of this study, the distribution system operator directly manages the number of EV chargers that are installed in their feeders. Even an

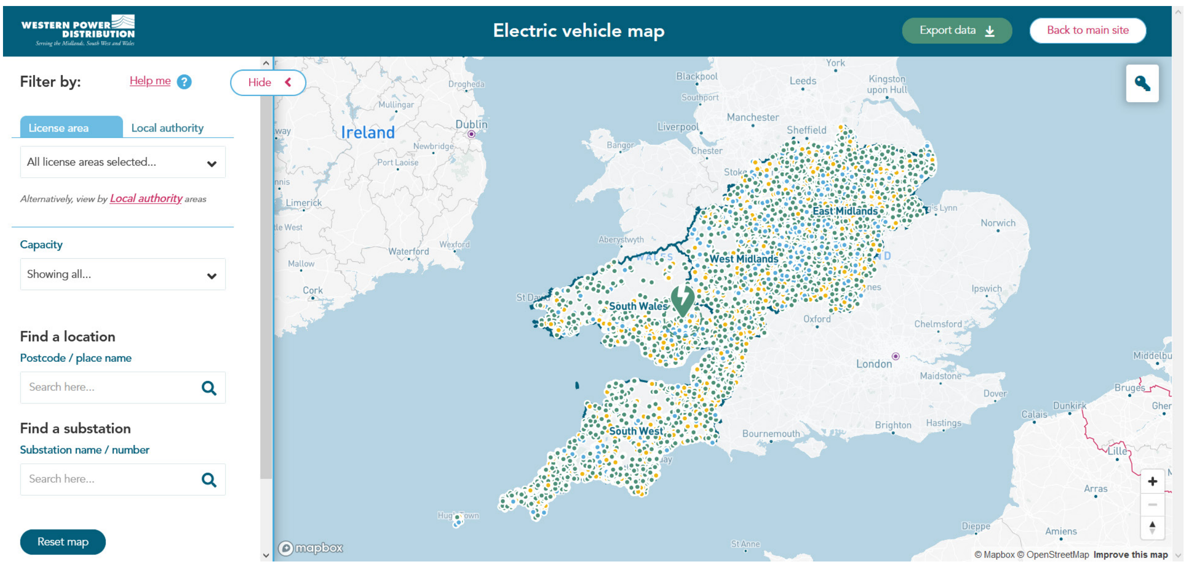


Figure 9.2: Interactive map released by WPD showing the capacity available in each distribution substation for placement of EV chargers

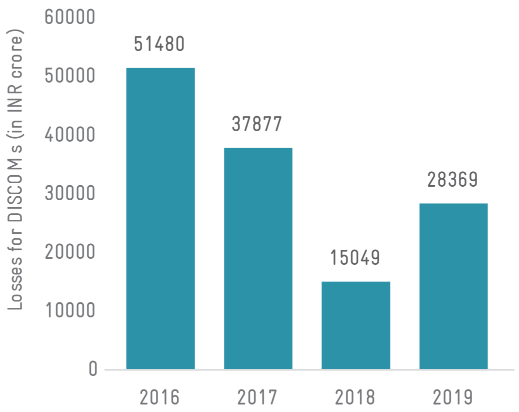


Figure 9.3: Total losses for DISCOMs

EV user that desires to install a private charger for his/her private use needs to get necessary approval from the respective DNO prior to installation of the charger. In UK, the Western Power Distribution has also released a publicly accessible map showing the available margin at each distribution substation under its jurisdiction as shown in Figure 9.2 . In a similar vein, Indian distribution feeders should also be monitored closely, and the headroom available during peak load period must be taken into consideration prior to allocation of EV chargers.

From a technical viewpoint, in the Indian distribution networks, the primary distribution is at 66 kV or 33 kV, the secondary distribution is at 11 kV and the last mile delivery is at 0.415 kV. However, Indian distribution grids are generally lacking adequate voltage control , with only a section of the transformers having the provision of automatic voltage control using on-load tap changers . Moreover, the distribution networks are generally highly loaded with aging equipment which reduces the reliability of power supply. Depending on the characteristics of each distribution grid, necessary upgradation may be required to cater to increased EV charging load. However, apart from the metro cities in India, most of the distribution system operators are state owned, with poor financial status shown in Figure 9.3, which makes it difficult for such DISCOMs to pay for the necessary grid upgradation costs. An additional challenge for Indian DISCOMs is their inability to buy cheaper power due to long term power purchase agreements (PPA). Thermal generating stations are still the primary generating source in the country, and these thermal stations have a significant portion of their contracted power sold through long term PPAs. Such PPAs are generally constructed as a two part structure, i.e. energy charge and capacity charge. Now, with increasing penetration of RE sources in the Indian grid, and with these sources being given a 'must run' status, the plant load factors of the thermal generating stations have gone down to approximately 60%. This puts an added burden on the DISCOMs as they continue to pay for capacity charges for the thermal units, which accounts for roughly 45-50% of the total tariff for the contracted power, even if the actual power delivery is not scheduled, and cheaper options for power procurement are available in the sport market .

Further, most distribution transformers at the tail end of the feeder are rated at less than or equal to 100 kVA. So, installation of even one fast 50 kW fast charger or 7 kW moderate chargers would not be possible without augmenting the grid with a second transformer. There is also a lack of uniformity among the distribution companies when it comes to the maximum load that can be connected to the LT and HT side. For example, while Maharashtra and Delhi have a limit of 480 kW and 100 KW for LT side connection, corresponding limit for most of the other states is relatively low, for example, 50 kW for Rajasthan and Karnataka. There is a need for increasing the minimum allowed capacity for LT connection and bringing uniformity among the States that can help EV integration and EV adoption in Indian EV ecosystem.

A PCS such as Tesla's 72 charger station in Shanghai with each charger having rated capacity of 120 kW would add to total power of 8.64 MW. Similarly, Tesla's 56 charging stalls in Firebaugh, California are equipped with 250 kW V3 Superchargers, thus having a maximum power draw of 14 MW . Like industrial loads, such high power charging stations would need to be connected to the MV network. So, the DISCOMs should also make the necessary infrastructure development so that the MV network is ready for integration of large PCS. Even for installation of moderately sized PCS or for e-bus charging depots for which the LV network may be sufficient, a separate feeder may be installed specifically for the charging station.

9.2.3 LACK OF ADEQUATE IT INFRASTRUCTURE IN DISCOM

EVs can play the role of an active load i.e. the charging load of the EV can be varied based on control signals, which can be utilized by distribution utilities to optimally manage the grid. However, to enable smart charging of EVs, adequate IT infrastructure needs to be in place for data communication between the distribution system, the charging management system and the EV chargers. However, most of the DISCOMs in India lack the necessary IT infrastructure required.

9.2.4 LACK OF ADEQUATE SUPPORT TO CPOS BY THE DISCOMS

LT infrastructure up to the point of connection to the customer is supposed to be provided and necessary upgrades made by the DISCOMs as per the Indian Electricity Act and prevailing grid codes. Public EV charging stations may require a separate LT connection or may need upgradation to the existing infrastructure. However, due to the poor financial status of Indian DISCOMs as highlighted in Section 9.2.2, the DISCOMs are hesitant to incur expenditure on grid upgradation or may defer the upgradation by several months or may ask the CPOs to bear the cost of grid upgradation. It is important to note that while there is a provision for subsidy on EVSE under FAME-II scheme, there is no incentive allocation for grid upgradation cost for connecting high power chargers. Therefore, in the current scenario, grid upgradation cost for connecting high power chargers is to be borne by the CPO/developer which significantly hurts the profitability of the CPOs and demotivates private sector companies from investing in EV charging infrastructure business .

9.2.5 LACK OF ADEQUATE STUDIES ON INDIAN DISTRIBUTION SYSTEM WITH DIFFERENT SCENARIOS OF EV CHARGING INTEGRATION

As described in Chapter 6 (Page 87) of Report-1: Fundamentals of Electric Vehicle Charging Technology and its Grid Integration, EV charging has substantial impact on the local distribution network. Due to very low EV penetration in India at present, the impact of EV charging on the distribution networks is not significant, however, for better planning purposes, dedicated studies to investigate various technical impacts of EV integration will be very useful. Studies like the pilot case study 'Electric Nation' of UK which has been described in detail in Section 2.6.3 (Page 62) of Report-2: International review of Electric Vehicle Charging Infrastructure and its Grid Integration, can be useful in understanding of the challenges associated with grid integration of EV charging. In Indian context, GIZ has undertaken the Grid Impact Assessment study with BYPL which has been described in Section 6.8.1 of this report.

9.2.6 LACK OF ADEQUATE ACCOUNTABILITY OF DISCOMS

Since the DISCOMs are the appointed State Nodal Agency (SNA) for most states, so there is a need to address institutional accountability in part of DISCOMs for timely approval of providing electrical connection to CPOs. Efforts to streamline the approval mechanism, such as single window clearance model (adopted in Delhi) need to be taken to address the concerns of the players in EV charging infrastructure in India.

9.3 Challenges in developing Charging Infrastructure

Majority of the urban population of India, particularly metro cities, reside in multi-unit dwellings with lack of private parking space for every dweller. Even for the limited number of parking spaces in apartments, it will be difficult for the EV users to install an EV charger while supplying electricity from his/her the contracted home electrical connection. For the EV users residing in private residences, installation of a 7-22 kW EV charger would likely require the upgradation of the electrical infrastructure to the property.

It is important to note that for an EV charging station, planning is based on four key metrics as described below.

a. Location of Chargers

Location planning is one of the key design criteria for installation of charging infrastructure. PG&E conducted a study on optimal placement of DC fast chargers as discussed in Section 4.6.2 (Page 118) of Report-2: International review of Electric Vehicle Charging Infrastructure and its Grid Integration. Similar study needs to be conducted by each DISCOM for installation of public chargers in areas within its jurisdiction. The identification for optimal location may depend on several factors such as

- Locations with high EV growth forecast
- Existing charging landscape
- Capability of distribution network at the location to accommodate the charging station.

b. Charger Technology

From the international review as documented in Report-2: International review of Electric Vehicle Charging Infrastructure and its Grid Integration, all the EV rich countries in the world are transitioning towards fast (7-22 kW) and rapid (> 50 kW) chargers for public charging stations. Share of slow charger is shrinking steadily from the public EV charging space. There are two main components that drive this shift towards faster chargers as mentioned below:

- Increase in energy capacity and power density of batteries used in EVs.
- Limited time availability for an EV user to plug in their EVs to a public charging point.

However, as per the latest developments in India, the initial push towards public charging is seen to be primarily towards AC001 and DC001. The utilization of these chargers however needs to be analysed as neither 2Ws nor 3Ws (without an adapter) nor the popular Indian 4W EVs in the market use these connectors. Therefore, a proper market study may be necessary to determine the ideal technology to be utilized for EV chargers in India. Moreover, AC001 are slow chargers with power output of less than 3.3 kW which will need longer time to charge up 4W EVs which can be discouraging factor for EV user to use slow chargers in public charging spaces. A study of behaviour of EV customers would help in giving insights on the amount of time spent by Indians in public spaces. The insights from such a study would be useful in selecting an EV charger of appropriate power rating.

c. EV category

In India, the market share of EVs is currently dominated by the 2W and 3W segment. Therefore, consideration of requirements of different EV segments is important while planning for the charging infrastructure. Indian 2W and 3W are mostly equipped with proprietary connector types which makes them unsuitable for charging with standard EV charger connectors like, AC001, DC001, Type 2 etc. These vehicles can be charged by plugging their proprietary charging cables to a standard 15 A socket. Unlike e-2W and e-3W, the e-4W uses standard connector types. However, the popularity and compatibility of each connector type needs to be considered, including the number of vehicle models that are equipped with each connector type along with the market share of each model.

Beyond 2W, 3W and 4W EV segments, the charging infrastructure requirement for the buses and heavy duty vehicles (trucks etc.) also needs to be taken into consideration. Government of India has already allocated electric buses for public transportation requirements in the different states. These buses generally have a much larger battery capacity compared to 4W, so the time required for charging would also increase accordingly. Also, since private home charging is not applicable for these buses, a public charging infrastructure would be necessary with higher charger output ratings from 120 kW to 300 kW . The locations of the e-bus charging stations would be dictated by the already established depots and parking lots. As the power requirements for the e-bus charging stations would be quite large, DISCOMS may need to provide separate power infrastructure just to cater to the e-bus charging load.

9.3.1 NEED FOR STANDARD CONNECTOR TYPES IN 2W AND 3W SEGMENT

The current lot of 2W and 3W models available in Indian market are generally equipped with proprietary connectors and are supplied with an unique charging cable for the charging needs. These cables can be plugged into a standard 15 A socket to charge the vehicle. However, such EVs cannot be charged using the standard EV charger types like Type 2 AC connector, Bharat DC001 etc. This presents a conundrum as the charging infrastructure that is being developed throughout the nation mainly consists of the standard connector types. So, there is a need to standardize the connector types used in 2W and 3W segment so that charging infrastructure for the 2W and 3W segment can also be rolled out[211].

9.3.2 GAPS IN THE LEV CHARGING STANDARD IS 17017 (PART 22/SEC 1): 2021

The recently released charging standard by BIS for LEV AC chargers, is a step in the right direction for the required harmonization in 2W/3W charging, however, certain gaps and challenges have been identified in the proposed standard.

1. The socket/outlet that have been recommended as per this standard is the industrial IEC 60309. However, most electric 2W/3W models currently available in India are provided with charging cable that have the proprietary charging ports on one side of the cable, and a standard 3 pin plug to connect to any domestic socket. To plug it into an IEC 60309 socket, an extra adapter would be needed for the EV user.
2. The charger has a rated power capacity of around 3 kW, and the intended target user of this charger is typically the local shops. But for such establishments which typically have a lower contracted demand, installing a 3 kW charger may require additional investment in upgrading the contracted demand of the establishment.
3. As the chargers would be installed in these commercial shop, which are supplied electricity at the commercial tariff, this would entail that the EV user charging at these chargers installed in the commercial locations,

211 Individually metered low cost AC outlets are being developed to cater to the charging 2W and 3W vehicle segment.

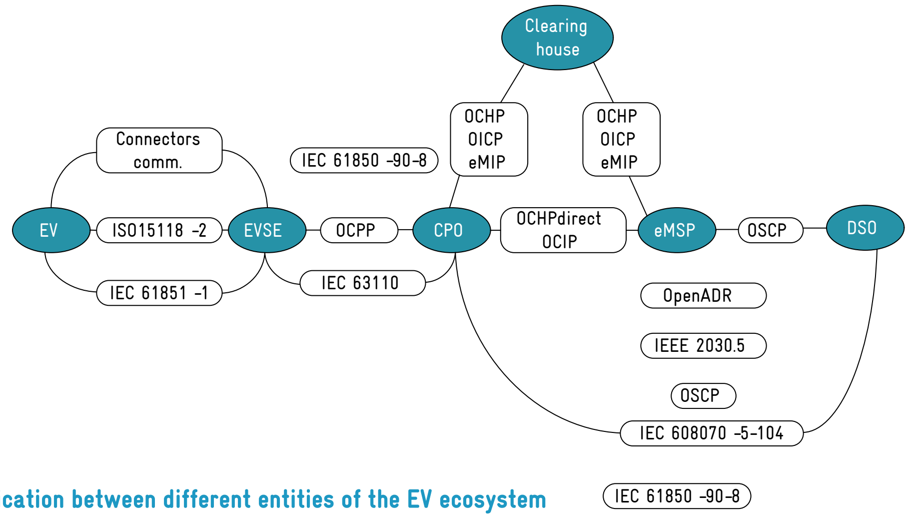


Figure 9.4: Communication between different entities of the EV ecosystem

would also be billed at commercial tariff. Thus the cost of charging would be higher than the cost incurred if the EV is charged at their own residences.

4. As the communication would be via Bluetooth between the LEV AC charger and the EV user mobile, if the EV user does not possess a mobile with Bluetooth facility, they would not be able to charge their vehicle.

5. The Indian streets which already have issues with unorganized parking, may get further cluttered, with the placement of these LEV AC chargers at these local retail locations, thereby hindering the movement in the street, activity of other nearby shops, residences etc. So, proper parking locations would be required along with the placement of these chargers.

9.4 EV charging load should not be treated as a conventional load

The EV charging load in India is largely being considered as any other conventional load, except for special EV tariff. However, EV charging load while being power intensive is a special type of load having unique characteristics, particularly the controlled charging, with V0G load being the exception. V1G technology chargers can be dynamically controlled to limit the power drawn by the chargers, thereby allowing technical flexibility to control the load drawn from the grid. V2G on the other hand is technically much more advanced technology that not only allow controlled charging but also has a provision to inject controlled power to the grid. Therefore, EV charging load, particularly V1G and V2G technology based charging stations have entirely different and controlled characteristics compared to any other conventional load. Hence, unlike conventional load where connected load is generally determined by considering maximum load that the facility can draw from the grid by simultaneously operating all the connection points at rated load, the EV chargers can draw from the grid or even inject back to the grid (in V2G) a pre-set power irrespective of the maximum rating of the charging points. In an EV charging station, even though the simultaneous power rating of all the charging points in the station can be higher, a total load drawn by the charging facility from the grid can be limited to any lower value agreed between the CPO and the utility. Moreover, even for the scenarios where all the charging points are simultaneously connected to EVs, depending on SOC level of EVs and charging characteristics (constant current/constant voltage mode), the EVs will draw lower than rated power. Therefore, under such scenarios, cumulative load of all the charging points in a charging station will be lower than the aggregate rated power of all the charging points even during their simultaneous operation.

Grid upgradation cost required for connection of a charging station to HT side of the distribution system is currently being borne by CPOs, thereby increasing the capital cost of charging station significantly, and at times leading to unviable business in the public charging infrastructure. Therefore, contracted demand determined based on simple algebraic summation of the rated power of charging points in a station leads to increased capital cost and higher demand charges.

Moreover, under current regulations, including the 2019 amendment to the MBBL for EV charging infrastructure, it has been recommended that the contracted demand be increased considering the simultaneous operation of all EV chargers to be installed. This may significantly increase the contracted demand of the property which would lead to increased electricity bill for the user. At the same time increasing the contracted demand at the property level may also warrant an upgradation in the upstream grid infrastructure. A similar argument can be made for ride hailing companies or other fleet operators that have electrified their fleet. These companies/fleet operators generally deploy a large number of chargers to charge their fleet, and so under current regulations the contracted demand of these properties is generally on the higher side.

Moreover, a charging station may be collocated with renewable energy generation source, battery swapping station, fuel cell etc. which can be treated as a mini/microgrid system, thereby warranting EV charging load be considered as a special controllable load enabled through adequate regulatory provision in order to facilitate smooth EV charging adoption

9.5 Challenges in communication infrastructure

The EV ecosystem comprises of different stakeholders including EV and EVSE, the CPO, eMSP, DSO and the clearing house. Communication between all the different entities are required for smooth integration of EVs with all functionalities like roaming, smart charging etc as given in Figure 9.4.

However, as per the recommendation by CEA as well as Ministry of Heavy Industries and Public Enterprises, communication standards have only been mentioned for communication between EVSE and the CPO. OCPP 1.5 and above (compatible with OCPP 1.5) standard of communication has been mandated for this purpose which allows communication of information like battery SOC, allowable current limits for charging, type of connector etc. There is no mention regarding the requirement of communication between the other entities, such as CPO and DSO etc. Due to the lack of requirement of communication standards, there is no provision of roaming facilities or the ability of DISCOMs to control the EV load. The disregard of roaming facilities may be a cause of concern for the EV users owing to the limited choice for charging while travelling.

Communication between DISCOM and CPO/eMSP is required for smart charging as well as for demand response services. These communication channels are used by the DISCOM to send signals to the CPO/eMSP to control the charging powers. For the participation of EVs in any grid support services like, Demand Response, Ancillary services etc. the communication between the CPO/eMSP and DISCOM needs to be mandated.

Beyond the communication standards, there is also the need to specify the details of data that needs to be exchanged between different entities in the EV stakeholder chain. For example, which parameters (voltage, power factor, current etc.) a CPO needs to communicate to the DISCOM and what should be the time resolution of the data (rms value, instantaneous value, real time etc.).

For the provision of instantaneous values of voltage and current, the CPO as well as the DISCOM would need to invest significantly in measurement and communication devices to handle such large volumes of data. The potential insights that these instantaneous values would provide the DISCOM should then be considered. It needs to be deliberated if the insights provided by instantaneous measurements justifies the added costs. It is important to highlight that a balanced view on data requirement from the charging stations needs to be adopted. Handling a huge data, and whether such high sampled data would be worth to receive, store and analyse are important questions to be considered while setting up data requirement from the CPOs/chargers.

9.6 Challenges in Interoperability and eRoaming

Increasing the availability of charging opportunities for the EV users is one of the key requirement for EV adoption. However, access to charging facilities and increased utilization of the charging infrastructure is hampered by lack of interoperability between the different charging standards and protocols. Lack of interoperability between chargers is quite prevalent in the Indian EV 2W and 3W segment, where most of the manufacturers have their own unique charging protocol. This creates difficulties for the CPOs in designing the optimum share of charger types that needs to be installed in their charging stations. Having interoperable chargers ensures that, the EV models can be charged by any available charger which increases the availability of chargers for the EV users while at the same time increasing the potential number of customers for the CPO.

Besides hardware interoperability, there is also potentially a need for 'eRoaming' to maximize the availability of chargers to all EV users. eRoaming ensures that EV users can have access to a greater number of charging stations owned and operated by CPOs where the EV users is not a subscribed to. This includes sharing of numerous details including book keeping between the CPOs. This mandates the use of standard communication protocols between the CPOs.

9.7 Challenges for Smart Charging

Under high EV penetration, simultaneous charging of large fleet of electrical vehicles will undeniably put stress on the electrical grid. Smart charging is an innovative technology to reduce the overloading of DTs and defer the network augmentation, and this technology is already in place in many EV rich countries. Different DSOs in Germany have mandated the requirement of smart charging functionality for EV chargers and the corresponding DSO has control over the charging of the EVs. Similarly, UK has draft regulations in place with a goal to mandate all private EV chargers to have smart charging functionality[212].

One of the simple approach for implementation of smart charging is the utilization of a Time of Use/Time of Day tariff. Most of the EV rich countries, such as USA, UK, Netherlands have some form of ToU tariffs specific to EV charging in place, as discussed in Section 2.5 (Page 36) and Section 4.5.1 (Page 112) of Report-2: International review of Electric Vehicle Charging Infrastructure and its Grid Integration. In India, although ToU tariffs have been in place for the industrial customers; barring a few states such as Delhi, Uttar Pradesh, Maharashtra, Kerala, Telangana, Chattisgarh, and Andhra Pradesh, ToU tariffs have not been implemented for EV charging. To enable ToU tariff, the electricity meters need to have the functionality to record the energy usage along with the time of usage. So, smart meters become one of the key enablers to facilitate smart charging.

The Nordic countries have smart meters installed in almost 100% of their residences . In comparison, in India, smart meters are being steadily rolled out under the National Smart Meter Program by Energy Efficiency Services Limited. Under this scheme 15,79,052 meters of the total 25 crore conventional meters in India have been replaced by smart energy meters till 2021 . Smart meter is one of the key enablers of smart charging, so mass deployment of smart meters catering to EV load will influence the capability of implementation of smart charging.

Other active forms of smart charging, such as, charging control due to operating conditions of the distribution grids require more hardware and communication infrastructure. There needs to be smart grid infrastructure, which in some specific applications may need monitoring of the operating conditions, such as voltage levels, loading on transformers and cables, stability limits of voltage and frequency etc. Based on these operating conditions, a centralized/decentralized controller can be used to manage the charging of EVs. Different state electricity regulatory commissions in India have already laid regulations in place for development of smart grid infrastructures and projects. For example, the Karnataka Electricity Regulatory Commission (KERC) released the Karnataka Electricity Regulatory Commission (Smart Grid) Regulations in 2015. The main objective of this regulation is to enable integration of smart grid technologies for efficient use of the generation, transmission and distribution grid resources. One of the components identified in these regulation is the realization of smart grid projects for EV integration including Grid to Vehicle (G2V) and Vehicle to Grid (V2G) interactions.

9.7.1 CHALLENGES IN EV SCHEDULING

As discussed in Section 9.2.2, EV charging at system level is a high power load, therefore, to minimize the impact of multiple EV charging, there is need for optimal scheduling of EV charging based on grid condition. However, in order to design the framework for EV charging schedule, the following requirements are mandatory

- Observability of distribution grid
- Robust communication infrastructure
- Accurate forecasting of general load, EV charging load and RE generation
- EV charger with capability of modulating charging power
- Acceptability of EV user to allow for scheduling of EV charging
- A central charge management system that pools the data gathered from the distribution grid and then uses this data along with the EV user needs to schedule an EV charging schedule

Currently in the Indian scenario, there is a lack of adequate infrastructure for adequate observability of the distribution grid. Further, regulations of communication protocols and standards have not yet evolved in Indian EV ecosystem. Forecasting of distributed RE generation is another area where maturity is lacking in an Indian context. Development of all the above-mentioned fields would be necessary for optimal scheduling of EV charging.

212 HM Government, "Electric Vehicle Smart Charging," HM Government Department for Transport (London, UK: Department for Transport & Office for Low Emission Vehicles, HM Government, July 2019), https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/817107/electric-vehicle-smart-charging.pdf."plainCitation":"HM Government, "Electric Vehicle Smart Charging," HM Government Department for Transport (London, UK: Department for Transport & Office for Low Emission Vehicles, HM Government, July 2019

9.7.2 SMART GRID INFRASTRUCTURE

MoP has rolled out 12 Smart Grid pilot projects throughout the country as well as 3 full Smart Grid Projects. The list of projects along with their primary functionalities have been given in Table 9.1.

Some of the key functionalities of the smart grid pilots in India are described below .

9.7.2.1 Advanced Metering Infrastructure

It facilitates monitoring and measurement of energy usage information as well as controls smart meters installed at the consumers premises. It supports bidirectional information flow using communication channels like GPRS/PLC/RF. Use of ToU tariffs/ Critical Peak Pricing (CPP)/ Real Time Pricing will also be facilitated by the use of Smart Meters.

9.7.2.2 Peak Load Management

This refers to the controlling of demand resources as per the available supply during peak periods. Using inputs from SCADA/EMS regarding the power margin available, the peak management algorithm considers various constraints and priorities predefined based on the customer profile and suggests recommended options. The preferred options include the management of peak load either by load curtailment through AMI or by price incentives/ disincentives in the form of ToU pricing.

9.7.2.3 Power Quality Management

Events like voltage fluctuations, voltage phase imbalances, harmonic distorted supply etc. would be addressed by this functionality, which will lead to an efficient power system with reduced losses as well as customer satisfaction and minimize equipment failure rates. The management of

Table 9.1: Functionalities added to each Smart Grid Project[213]

Functionalities	AMI-R	AMI-I	PLM	OMS	PQ	DG	MG	DR	SCADA	Other
APDCL, Assam	✓	✓	✓	✓	✓	✓				
CESC, Karnataka	✓	✓	✓	✓		✓	✓			
HPSEB, Himachal Pradesh		✓	✓	✓						
IIT Kanpur Smart City	✓					✓				
PED, Puducherry	✓	✓							✓	✓
PSPCL, Punjab	✓	✓	✓							
Smart Grid Knowledge Centre, Haryana	✓			✓		✓				✓
TSECL, Tripura	✓	✓	✓				✓			
TSSPDCL, Telangana	✓	✓	✓	✓	✓					
UGVCL, Gujarat	✓	✓	✓	✓	✓					
UHBVN, Haryana	✓	✓	✓	✓					✓	
WBSEDCL, West Bengal	✓	✓	✓							
CED, Chandigarh	✓	✓								✓
MSEDCL, Amravati	✓	✓		✓				✓		
MSEDCL, Congress Nagar	✓	✓		✓				✓	✓	
KESCo, Kanpur	✓	✓	✓			✓				✓

213 AMI-R: Advanced Metering Infrastructure – Residential, AMI-I: Advance Metering Infrastructure – Industrial, PLM: Peak Load Management, OMS: Outage Management System, PQ: Power Quality, DG: Distributed Generation, MG: Microgrid, DR: Demand Response, SCADA: Supervisory control and data acquisition

power quality will be done using voltage/VAR control, load balancing, harmonic control etc.

9.7.2.4 Outage Management

This system manages unscheduled outage of distribution infrastructure. It coordinates the information about outages and reports to the operator to take necessary corrective actions.

9.7.2.5 Microgrids

A microgrid is an integrated energy and communication system with loads as well as distributed energy resources (DER), which can operate in stand-alone mode or in parallel with the larger power grid.

One of the objectives of the Smart Grid Projects in India is the creation of Electrical Vehicle charging infrastructure with smart control functionalities, including demand response and V2G. However, so far tangible results of the Smart Grid projects have not been observed with regard to EV charging space. Smart charging of EVs can potentially participate in peak shaving, in demand response initiatives as well as provide ancillary services. However, adequate smart grid infrastructure would be required to facilitate those services. Therefore, incorporation of smart EV charging into the Smart Grid pilots needs to be addressed.

9.8 Lack of an advanced energy market

The transition to electrification of transportation sector has been envisaged with the goal of carbon emission reduction. To realize this, the energy used for EV charging should be delivered from clean, renewable energy sources, as the transition would be debatable if the emission is just shifted from the demand side (vehicles) to the generation side (fossil fuel based thermal generating stations). To integrate RE into EV charging, efficient electricity markets can play a key role. Further, the stochasticity in time of energy requirements for EV charging can also be managed using electricity markets.

In this respect, EV aggregators would be needed to bid into the energy market and control the charging of its participant EVs as per the bid, as shown in Figure 9.5.

In the Netherlands, different energy companies are synergising the EV charging with RE generation. To facilitate this, the energy companies utilize the balancing markets to determine the real time generation from the renewable sources. During periods of low RE generation, they cap the EV charging power to a lower value, which is then released when the generation from RE sources increases. This helps shift the energy required for EV charging from thermal stations to greener RE sources. Netherlands is able to achieve this, mainly due to its robust energy market.

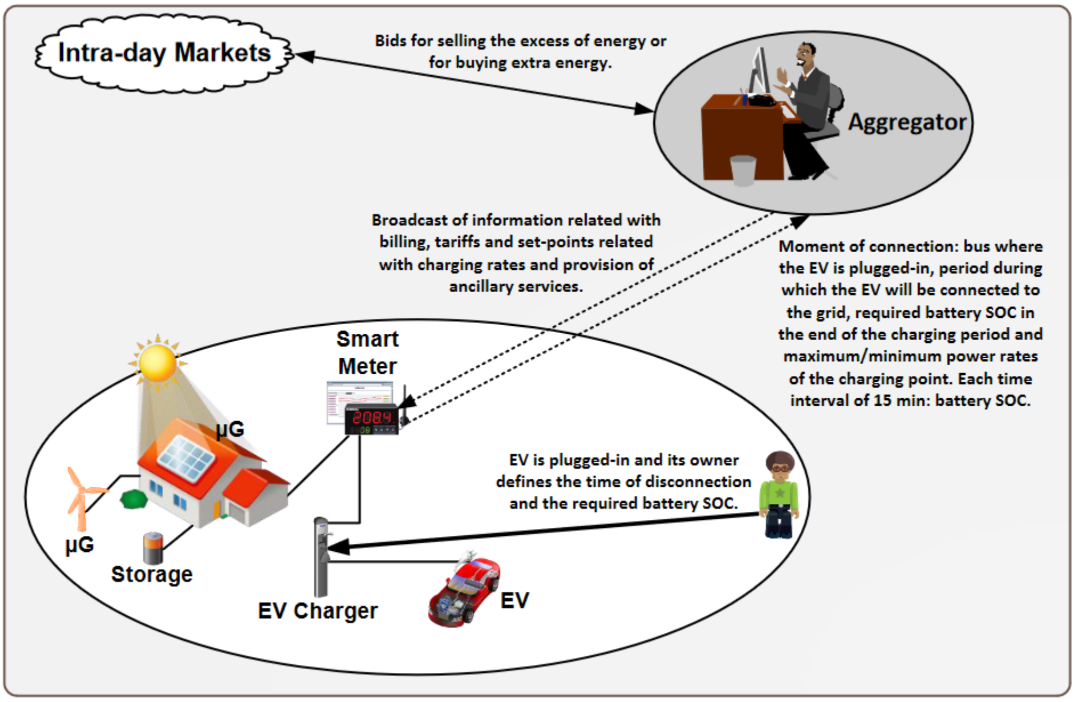


Figure 9.5: Participation of EV in energy market

Comparatively, in India, energy is still largely traded through long term bilateral Power Purchase Agreements (PPA)s. Only around 6% of total electricity in India is traded in the power exchanges .

9.9 Business models for EV charging infrastructure

An EV business model has four different dimensions based on which different business models can be differentiated as highlighted below,

1. **Who** – This referred to the intended customer of the business model. The consumer segment may either be 'Public' i.e. the EV infrastructure can be used by multiple users or it can be 'Private' i.e. the access to the charging station is limited to only a certain group of predetermined users (e.g., fleets, workplace etc).
2. **What** – This refers to the bundle of services that are offered by each business model. These services may include:
   - The charger and additional hardware requirements. This is a business-to-business service where hardware components are provided.
   - The sale of energy required to charge the EVs
   - Additional services which may include software applications for aspects like location, payments, billing, grid services, data analytics etc.
3. **How** - This consists of the partnerships that can be formed between the different key actors of the EV charging ecosystem. The three different sets of actors are:
   - Public Authority, which includes ministries, local municipal bodies, public sector undertakings, transport authorities etc, who are tasked with EV charging infrastructure development.
   - Power Utilities, which include distribution network operators and retail companies that supply the electricity needed for the charging needs.
   - Enterprise, which may include automobile manufacturers, charging hardware manufacturers, fleet operators, parking facilities, software application companies, etc who participate in enabling EV charging infrastructure.
4. **The Value** – This refers to the pricing strategy of the business model, which can be either 'Pay-as-you-go' i.e., pay per use, or 'Subscription' i.e. billings arrangements which are time frame bound.

The following international business model case studies can be of great benefit in customising the EV charging specific business models in Indian EV ecosystem.

9.9.1 CASE STUDIES OF INTERNATIONAL EV CHARGING BUSINESS MODELS

9.9.1.1 Ubitricity

Ubitricity business model revolves around offering lean charging points, with minimal space requirement which can be easily integrated into the public or private spaces. They also offer various pricing subscription options and the access to a wider network of charging station via e-roaming 'PlugSurfing' network. Some of the features of their business model have been summarized in Table 9.2.

Table 9.2: Key features of Ubitricity Business Model

Country of Operation		Germany, UK
Business Model	Who	It provides business-to-business (B2B) and business-to-customer (B2C) and public B2B and B2C charging solutions
	What	The customer is provided with a smart cable with built-in meter and the required connector type to connect the EV and a charging point. The company also provides space saving charger options along with software solutions.
	How	Ubitricity has partnerships with the power retailers as well as other EV charging providers for e-roaming via PlugSurfing.
	The Value	The Ubitricity business model is subscription-based where the price depends on the contract of the users with their energy provider and the energy consumption is logged by the smart cable. It also provides 'pay-as-you-go' billing for users without the smart cable.

9.9.1.2 Nuvve

Nuvve primarily offers bi-directional charging capability to its customers. It provides V2G as well as fleet management solutions to fleet operators, Electric buses and charging stations. It also provides charging hardware with V2G capability. Some of the features of their business model have been summarized in Table 9.3.

Table 9.3: Key features of Nuvve Business Model

Country of Operation		USA, UK, Denmark, France
Business Model	Who	The company mainly provides to B2B market.
	What	The primary service provided by Nuvve is the provision of V2G capability to its users. It achieves this though its GIVeTM platform and its Powerport chargers.
	How	It has formed partnerships with different fleet operators, including electric bus users.
	The Value	The pricing is predominantly subscription based.

9.9.1.3 Tesla

Tesla is primarily an EV manufacturer, but its provides charging solutions as a service to its customers. Its extensive charging network is one of the biggest drivers for Tesla being in lead in the EV sales category. The company provides free use of SuperChargers (which is proprietary fast charger technology) for models purchased before January 2017 as a way to entice customers into buying a Tesla . Some of the features of their business model have been summarized in Table 9.4.

Table 9.4: Key features of Tesla Business Model

Country of Operation		Global
Business Model	Who	The company mainly provides to B2C market.
	What	The primary product of Tesla is its range of EV models. It has created the extensive charging network to cater to the charging needs of its EV users. Tesla also provides private charging solutions to its customers.
	How	It has formed partnerships with different businesses such as retail outlets, hotels, restaurants etc, to install chargers at their premises.
	The Value	The company provides 'Pay-as-you-go' billing based on the energy/time used for charging. However, the company also provides free charging as and when applicable.

9.9.1.4 Share & Charge

Share&Charge offers peer-to-peer platform to connect EV users with different EV charging service providers using blockchain. The key features of their business model are given in Table 9.5.

Table 9.5: Key features of Share&Charge Business Model

Country of Operation		USA, UK, Denmark, France
Business Model	Who	The company mainly provides public B2B and B2C charging solutions.
	What	It uses blockchain technology to provide peer-to-peer matchmaking between charging service provider and EV users.
	How	It has formed partnerships with charging service providers and mobility service providers.
	The Value	The pricing is determined by the charging service provider selected by the user.

The section above discusses just four of the multiple different business models that have been operational globally. It is evident that, EV charging is not a one-dimensional business, where the only goal of the entity is to establish charging infrastructure and the only revenue stream is the sale of electricity. It is a multi-sectoral ecosystem where business models can be developed to cater to different services including services like:

- Charging infrastructure rollout
- Battery swapping
- EV fleet management,
- Bidirectional charging provision,
- ICT services,
- e-roaming facilities,
- OEM
- e-mobility services

EV Charging infrastructure in India is in its nascent stage, and the public utilities have taken the lead to expand this network. Though a few private players have entered the market, their current penetration into the EV charging network is still quite limited. Most of the charging ecosystem has been seen to be predominantly in the urban locations. However, with 2W and 3W EV segment being currently the major driver of EVs in India, business models centred around rural locations may need to be developed.

One of the issues of private EV charging players in the market is the long breakeven period. Considering the high upfront cost of establishing a charging infrastructure, it restricts the number of able participants competing in the EV charging market. In this regard the government may need to introduce financial instruments to arm the participants with enough financial strength to create a vibrant and competitive EV charging market.

9.10 Lack of single window system

Installation of a public charging station is cumbersome process for the CPO due to the need for multiple approvals. For example, the CPO has to get a 'No Objection Certificate' from the land-owner for installation of EVSE in case of rented land, get the equipment type tested and certified from the necessary authorities, apply for electrical connection from the DISCOM, necessary approval from the municipality etc. As the CPO has to get approval from multiple different authorities, it significantly delays the installation process. This is a time consuming process making it challenging for a private CPOs to make progress.

9.11 Unavailability of land in suitable locations

In Indian urban localities, there is generally a lack of publicly available land. Most of the available land is under the ownership of state run offices, municipalities and other public authorities. Currently, there is not any specific scheme or procedure through which the private EV charger installers can purchase/lease these spaces.

9.12 Battery Swapping

In order to increase the uptake of e-2W and e-3W, the Government of India has promoted the sale of EVs without battery, as a battery alone accounts for 30%-40% of the cost of the vehicle. This would also increase the use of battery swapping in the nation.[214] However, there are different issues with this policy as given below.

1. Accountability issues, as the safety of the EV would come into question if subpar batteries are used by the EV user.
2. Purchasing a battery separately may also increase the cost, as the GST applicable for battery is higher at 18% compared to the EV's at 5% .
3. The FAME II subsidies are based on battery size, so claiming subsidies for EVs without batteries would warrant clarification.
4. In order to increase compatibility, the batteries would be needed to be standardized which would slow down innovation.
5. There needs to be understanding among the different EV OEMs to have the same battery specifications for easy swapping.
6. Ownership issues would also need to be regulated, on who owns the EV battery after being swapped at a swapping station.
7. Honouring warranty claims would be challenging.

9.13 Challenges to implement V2X

V2X application of EVs has a lot of potential to benefit to the entire EV ecosystem and the energy sector at large. However, in India there are a myriad of challenges for the widespread proliferation of V2X implementation.

9.13.1 LACK OF EV MODELS WITH BIDIRECTIONAL CHARGING CAPABILITY

Currently in Indian market, there are no EV models that have bidirectional charging capability. Although vehicles with V2X capability have been rolled out in the international market, these models have not yet been launched in India. Until V2X capable EV models are available in India, the implementation of V2X would still be a prospect of the distant future. Better planning to leverage the benefit of V2X technology would be significantly beneficial for Indian EV ecosystem.

9.13.2 ABSENCE OF REGULATIONS FOR AGGREGATION OF EVS WITH DERS

A standalone EV does not have enough capacity to provide grid support services, so for EVs to provide grid support services, aggregation of a fleet of EVs is necessary. These aggregations can even include DERs in the form of a VPP. But for such aggregation to happen, there must be regulatory provisions in place. The existing electricity distribution and transmission operational framework is highly centralized, with a lack of necessary regulations for third party aggregators to participate in grid support services. On 29 May 2021, CERC issued a draft regulation for ancillary services in India. The draft regulation allowed the participation of demand resources for provision of ancillary services. This regulation could open the door for EVs to provide grid support ancillary services.

214 A draft policy on battery swapping has been released by the Govt. of India on April 2022, which may potentially address a few of the gaps mentioned here.

9.13.3 LACK OF COMMUNICATION INFRASTRUCTURE FOR ENABLING V2X

Enabling V2X would require a robust communication infrastructure with regulated and open communication protocols among the different stakeholders in the EV ecosystem. In case of V2G application of providing critical ancillary services, the system stability would be highly sensitive to the time delay between the transmission of the command signal from the grid operator, the EV receiving the command signal and then acting on it. The gaps in communication infrastructure have been explained in detail in Section 9.4.

9.13.4 METERING ISSUES

The next challenge in the utilization of V2X is addressing the issues for accurate metering. A V2X enabled unit would optimize the EV charging based on the variable energy price or based on grid conditions as per the requirements of the distribution utility. The bidirectional flow of power needs to be accurately metered along with the time of use. Such meters also need to have communication capabilities to relay information between EVSE and the distribution utility. However, the availability of such smart meters is still limited in India.

9.13.5 CUSTOMER BEHAVIOUR AND PREFERENCE

One of the critical challenges of V2X implementation at a large scale is the acceptance of V2X by the EV users. Even if the infrastructure is in place to enable V2X, the EV user needs to be willing to participate in V2X services. The EV user needs to get convinced/motivated that utilization of V2X services would not impact charging process, if adequate guiding procedures are followed while participating in V2X applications. Further, there are also issues regarding the impact of V2X on the battery health which can demotivate the EV user to allow for bidirectional charging, and such concerns need to be countered rationally with scientific evidence.

9.13.6 FORMATION OF COMPLEX VALUE CHAINS

V2X services involve different players including, EV user, aggregator, OEMs, distribution utility, IT stakeholder, electricity regulator and charging management system. All these stakeholders should be able to benefit from the V2X service, for the business model to be viable. Therefore, a complex value chain needs to be designed for the smooth uptake of V2X, so that each individual stakeholder can benefit from the V2X implementation.

9.14 Challenges of RE integration for EV

The transition to electrification of the transportation sector has been undertaken with the prime motive of the reduction of greenhouse gas emissions. It would be possible if this transition is coupled with the use of renewable energy for the charging of the EVs. Renewable energy has already experienced a rapid growth in the past decade with 105.85 GW of RE capacity installed in India by January 2022[215], which has introduced its own set of challenges. EVs due to their controllable nature have the potential to mitigate a few of the issues introduced by RE integration. As an example, California was one of the first regions to aggressively push for rooftop solar PV installations, which resulted in the famous duck curve issue as shown in Figure 9.6. To address the duck curve, one of the solutions was that the Californian utilities adopted a lower tariff for EV charging for periods when the PV generation is maximum as described in Section 4.5.1 (Page 112) of Report-2: International review of Electric Vehicle Charging Infrastructure and its Grid Integration. This incentivizes the EV users to charge their EVs during high PV generation periods which increases the system demand. Such an increase in the system demand accommodates the increased generation thereby helping mitigate the duck curve to a certain extent.

Similarly, to avoid curtailment of excessive generation of renewable energy, some charge point operators in the Netherlands have designed a charging solution in which the EV charging power is directly controlled based on the RE generation. During periods of low RE generation, the charging power is limited. When the RE generation increases the EV charging speeds are also increased accordingly.

215 Source: Ministry of New and Renewable Energy, Government of India (link)

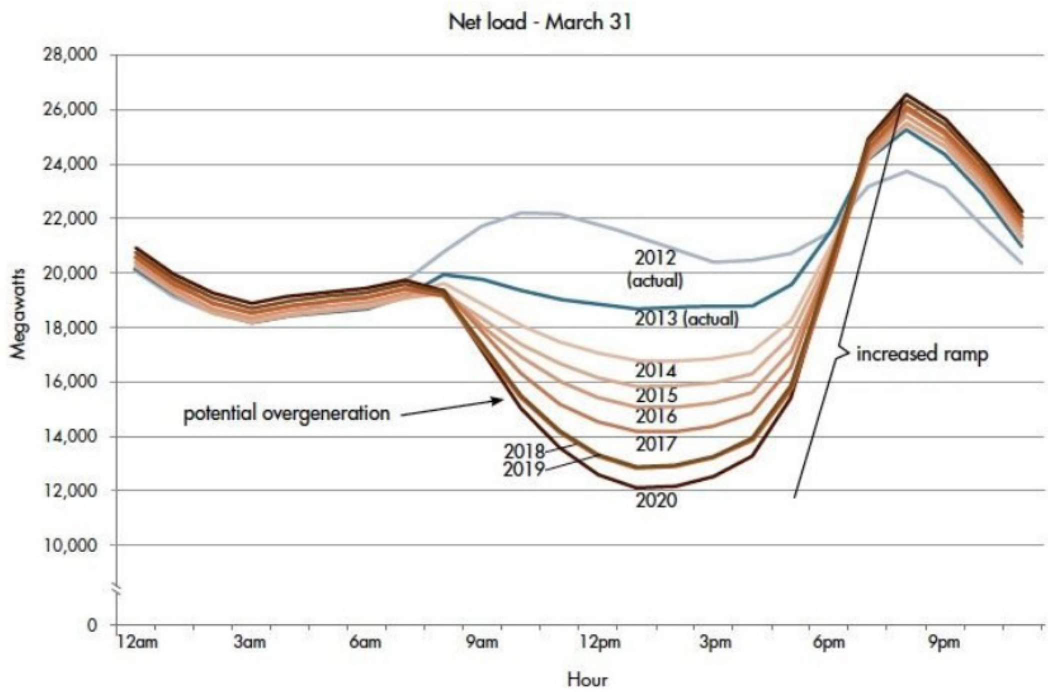


Figure 9.6: Duck Curve in California ISO

Further, charging solutions have also been designed to make use of rooftop solar PV installations. Here, an energy management system is utilized at the household level, to maximize the utilization of the local PV production and minimization of power drawn from the grid. With advanced V2G functionality, the EV may also serve as a battery storage unit, that may release the energy into the grid during peak evening periods when the cost of energy is high to increase the revenue generation. This idea has been explored as pilot a project by California PG&E as discussed in Section 4.6.3 (Page 121) of [Report-2: International review of Electric Vehicle Charging Infrastructure and its Grid Integration](). However, for implementation of such a system the core requirement is the use of a smart energy management system which can control the operation of the different controllable loads and can manage the direction of power flow to and from the grid, along with a meter which can log bidirectional power flow and bill the customer accordingly.

Virtual net metering: Another concept which has been gaining increased popularity in respect to RE generation is virtual net metering. Virtual net metering is a bill crediting system for solar installations that are made off-site at a community level instead of individual households. These community PV installations are then shared among the subscribers who get a deduction on their monthly electricity bill based on the generation from their share of the community installation. Here, community installations refer to PV systems that are collectively paid for by the community and provides power to multiple households. In India, most of the residents reside in multi-storeyed apartments without access to private rooftops. So, a community PV system utilizing virtual net metering has a huge potential. Further, this concept can then be evolved to utilize the community PV system to deliver power to a community EV charging station.

The use of rooftop solar PV for EV charging also applies to EV charging stations. In such stations the charge point operator has the benefit of choosing the energy source based on the energy prices. During periods of high electricity prices, the operator can shift to solar power to charge up the EVs. If a storage unit is also included, then the utilization of cheap solar energy can be increased further. Electrify America, which is one of the leading EV charger installers in USA, has already installed 30 solar powered EV charging stations in California. The novelty of these chargers is that such chargers are completely off-grid and are meant to serve rural parts of California with a goal of increasing EV adoption in all parts of the country . These kind of business models can be viable for a country like India which has a large section of population located in rural areas with poor connection to the electrical grid.

Increased penetration of stochastic RE sources in the grid has also increased the requirement of ancillary services in the grid such as regulating reserve, frequency containment reserve etc. In this respect, the regulators of countries

Figure 9.7: Off grid solar EV charging station in California

like USA, Denmark, Netherlands have recognized the potential of bulk EV fleet to participate in such ancillary market and provide grid support services. This would on one hand help utilities maintain stable operation of grid during high share of RE generation while at the same time provide the EV users with financial benefits, and thus make a win-win situation for both parties. These countries have already come up with regulations / draft regulations that utilize grid support services from the EVs discussed in Report-2: International review of Electric Vehicle Charging Infrastructure and its Grid Integration. It is important to note that provision of bidirectional capability of EV chargers is not mandatory for providing grid support service, as unidirectional charging can also provide grid support services by regulating their charging power based on the signals received from the utilities.

Though RE has seen a rapid growth in India in recent years, the integration of RE into the grid has its own challenges. Currently, in India there is a lack of robust transmission network to adequately evacuate the energy generated from RE sources, and there is not sufficient storage to store the surplus generation, which at times leads to forced RE curtailments. India, which is in its initial stages of development of regulations for EVs has a good opportunity to exploit the potential of grid support from EVs, hence enable EVs as a tool to help grid operators for grid management and enable greater use of renewable energy.

9.14.1 METERING AND BILLING ISSUES FOR OPEN ACCESS

One of the ways of increasing utilization of RE sources in EV charging is by permitting charging stations above a certain power rating to have open access to the transmission and distribution network so that they can purchase power from any renewable energy generating plant in the country. However, the issue with open access is inaccurate metering and billing at the distribution level. The energy transferred using access and the energy purchased from the local distribution company needs to be metered and billed separately. The CPOs may need to install special energy meters generally used in bulk power transfer locations such as substations. Moreover, transmission charges if levied for open access by CPOs can also be a discouraging factor to increase RE for EV charging.

9.15 Limited EV Market

One of the major barriers to the growth of the EV charging infrastructure is the limited EV market. EV charging station owners have a low margin of profitability as they are generally only paid for the energy use which is a low gain revenue stream. To maximize the profitability of EV charging stations, the usage of the EV chargers in the charging stations need to be high, which would only be possible under high EV penetration level. Without a considerable EV proportion, the private sector companies are reluctant to invest in an EV charging station. There are different reasons for the slow growth of the EV market, and in turn for EV charging infrastructure as highlighted below.

9.15.1 HIGH UPFRONT COST OF EV

The high upfront cost of an EV is one of the prohibitive factors leading to lower adoption rate of EVs. Electric variants of comparable ICE models are priced a bit higher than their ICE counterparts. Moreover, without subsidy to private ownership of e-4W under FAME-II scheme, the adoption rate of 4W EVs would remain slow until a cost parity can be achieved either through incentives, tax exemptions etc.

9.15.2 LACK OF PREMIUM EV MODELS AVAILABLE

The other factor that plays into the lower adoption rates of EVs is the lack of premium EV models available in the market. As of 2021, the total EV models available in India have been listed in Table 5.4. From the table it can be seen that only three EV models, the Hyundai KONA, Tata Nexon EV and MG ZS EV have a big enough battery capacity to satiate both the intra and the inter-city travel needs of a potential EV customer. This lack of options in the EV market is another of the reason on why the EV market has not picked up, especially for private users.

9.15.3 FINANCIAL BARRIERS

In India around 40 lakh vehicles are sold annually. Of these only a quarter i.e. 25% are bought outright, the rest 75% are financed by banks and other financial institutions[216]. As per RBI, a total of Rs. 4.7 lakh crore (EUR 53.3 billion) was offered by different banks as financial offers for purchase of vehicles. The majority of these were disbursed for the purchase of internal combustion engine vehicles as the sale of electric vehicles is very limited.

9.15.1.1 High Interest Rates

High interest rates is one of the factors for the low sale of EVs in the country. As already mentioned above, majority of the vehicles in the country are purchased with aids from financial institutions in the form of loans. The interest rates for EV loans are generally higher as compared to loans for ICE vehicles. As an example for the purchase of a private vehicle in Delhi, banks charge a marginally higher rate of interest as compared to ICE vehicles for 4W. A commercial e-4W can be charged an interest rate up to 14 -15% compared to 12 % for a diesel car. For e-2W, loans are generally not issued. Even if they are issued, only 75% of the total cost is covered, the loan repayment is also very short (less than a year) and interest rates can go up to 14% .

9.15.1.2 Limited Financing Options

Banks and other financial institutions in India do not offer specialized products for EVs, with the exception being SBI Green Car Loan Scheme. Due to lack of specialized schemes, Indian customers are forced to choose loans with high interest rates with short repayment periods. These financial institutions also need collateral in addition to the vehicle for cases where the credit history of the customer is unreliable, which further increases the challenge for EV procurement. In comparison, in Norway, China, Australia and other major EV markets, most leading financial institutions have specialized products for EVs, which is one of the factors for high EV adoption in these countries.

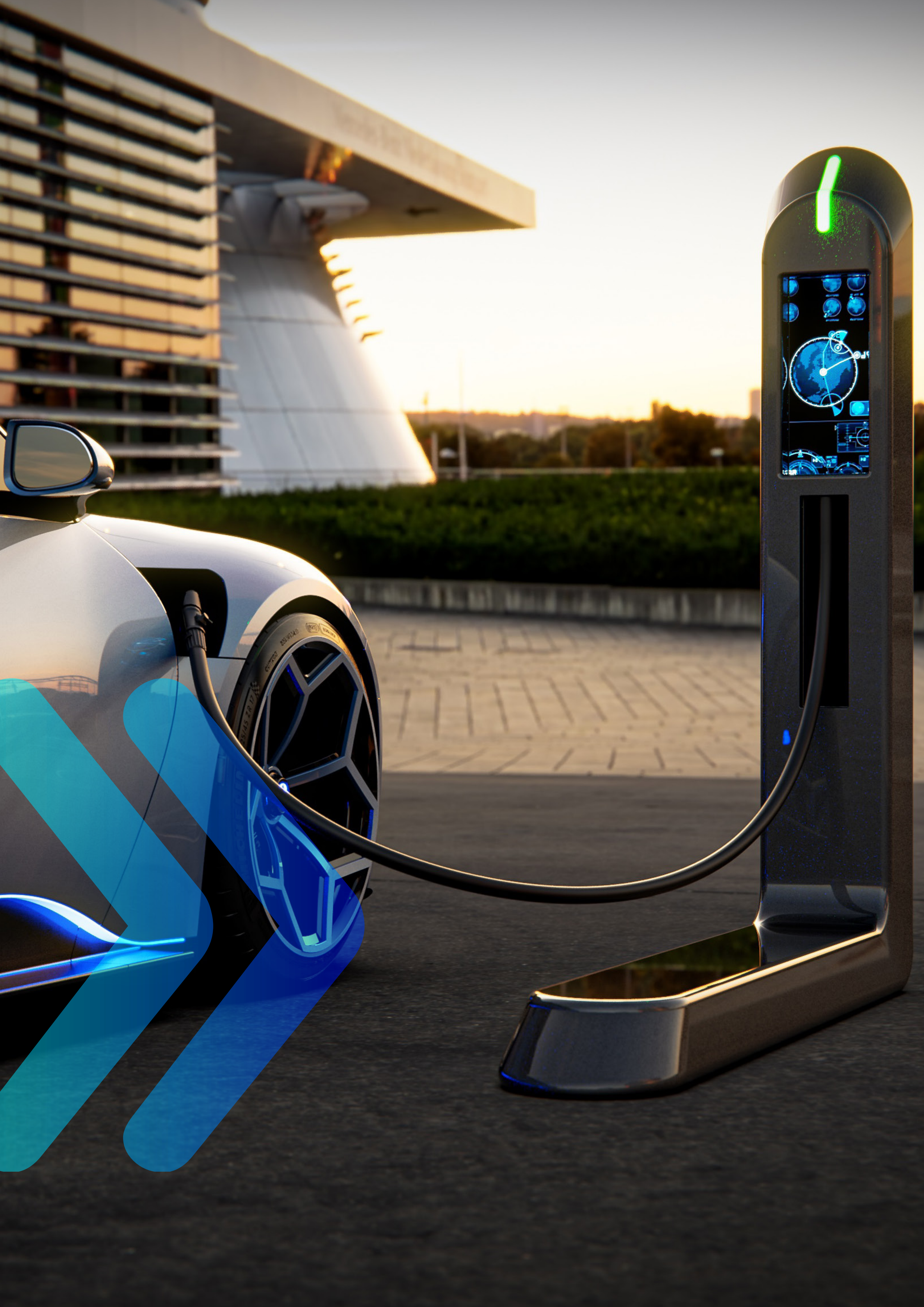
9.15.1.3 High Insurance Cost

Insurance cost is based on the capital cost of the insured entity. So as the capital cost of EVs are generally higher than that of a comparable ICE vehicle, the insurance premiums are also higher. The insurance companies also perceive a higher risk in a newer technology and may as a result put higher rates due to lack of historical performance data of EV products and associated business model.

9.16 Lack of Training and Capacity Development for EV Workforce

The number of technical institutions that offer dedicated courses on EVs is still limited in the country. Such courses and programmes are necessary for the required skill development to fill out various roles such as EV component designers, technicians, mechanics etc. Adequate skilled manpower is necessary to bring parity between EV and ICE vehicles in terms of satisfactory service provision, which is one of the concerns for potential EV users.

216 Amit Bhatt and Garima Agarwal, 'Electric vehicles could help fight India's pollution crisis – but the lack of bank loans is a hurdle', Scroll.in, 2021 (link)

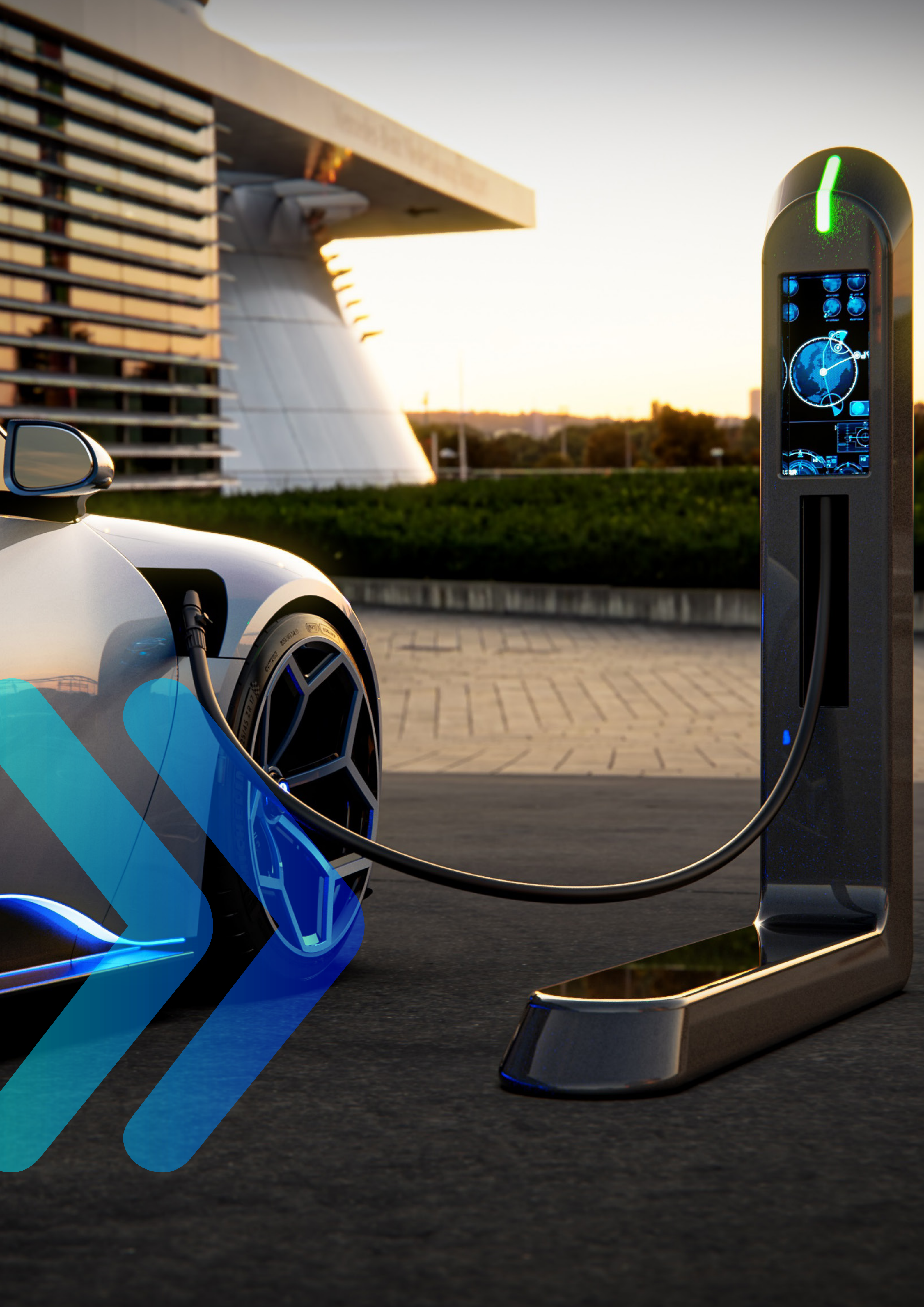


10

Way Forward

India has set ambitious targets to electrify Indian transportation sector. The Central and State governments have already launched different schemes and policies with an aim to increase the adoption of electric vehicle by the masses. However, there are various challenges that need to be tackled for seamless adoption of EVs in India, as described in Chapter 9 of this report. Such challenges mostly include planning issues, technical issues, regulatory issues, financial and administrative challenges among others.

However, mitigation of the identified challenges would need a systematic and scientific approach, with coordinated action by different key stakeholders. Therefore, the critical question is what are the key interventions required to address the identified challenges, and with what priority should the recommended key interventions be implemented to maximise the impact with minimum resources. In this backdrop, a detailed scientific approach based analysis to identify key interventions required for seamless adoption of EV charging infrastructure and its grid integration, ranking of the key interventions, and detailed analysis of top key recommended interventions in Indian EV ecosystem will be presented in Report-4, the last in the series of four reports of this study.



Appendices

A.1 Stakeholders consultation

Name of Organization	Nature of Organization
Fortum	CPO
Kerala State Electricity Board	DISCOM
Bangalore Electricity Supply Company Limited	DISCOM
CharIn	Charging Standard Issuing Authority
Central Electrical Regulatory Commission	Electricity Regulatory Authority
Central Electrical Authority	Electricity Regulatory Authority
Tripura Electricity Regulatory Commission	Electricity Regulatory Authority
TATA Power-DDL	DISCOM
BSES Yamuna Power Ltd.	DISCOM
BSES Rajdhani Power Ltd.	DISCOM
Department of Science & Technology	Government Agency
Technology Information Forecasting and Assessment Council	Government Agency
National Smart Grid Mission Project Management Unit	Government Agency
Ashok Leyland	OEM
Ola	OEM
Indian Smart Grid Forum	Public Private Partnership Consultancy
Amara Raja	OEM
World Resources Institute	Think-tank

A.2 Analytical Framework

The development of EV charging policies considers two fundamental perspectives: the supply (developers of EV charging infrastructure and charging service providers) and the demand side (EV users). This report applies the analytical policy framework developed by the Florence School of Regulation . The various elements to be considered within these perspectives are shown in the table given below.

Table A.1: Analytical framework for EV charging infrastructure policy

Dimensions	Elements
Enabling EV charging on supply-side	Definition of a fundamental market design framework to limit distortions and entry barriers
	Incentives for promoting the EV charging infrastructure
	Prioritization in terms of EV characteristics and social geography
	Easing out administrative barriers for establishing charging stations
	Mandate on user data sharing and privacy
	Mandate on the utilization of V2X capabilities
	Focus on RE integration and EV charging
Enabling EV charging on demand-side	Technical standardization of chargers for inter-operability
	The mandate for the development of digital platforms and database management systems
	Specification of the use of a wide range of payment methods
	Specification of minimum facilities to be provided at the charging stations
	Harmonization of Intra/interstate user registration for accessing charging infrastructure
	Establishment of a mechanism to address consumer complaints
Additional measures for promotion of EV sector	EV Market Support services to promote EV adoption
	Institutional framework for roll out of policies
	Enhancement of EV value chain peripheral ecosystem
	Promotion of Battery Recycling/ scrapping facilities
	Miscellaneous

The supply-side constitutes the entities mainly responsible for setting up the charging infrastructure and providing the charging services. Therefore, the first six elements are targeted at qualitatively assessing the presence and extent of these elements enabling the supply side to deploy public charging infrastructure in a particular EV policy. The demand side involves the EV user that would ultimately utilize the charging infrastructure and the services it provides. Therefore, the remaining six elements are applied to qualitatively assess whether and to what extent a particular EV policy enables the "demand-side" in terms of ease of use. EV charging policy can play a critical role in accelerating the adoption of EVs and providing value and convenience to the EV user.

A.2.1 Enabling EV charging on supply-side

The supply side refers to the entities that would eventually set up the charging infrastructure and provide the charging services. The first six elements are therefore aimed at qualitatively assessing whether and to what extent a particular EV policy includes these elements that enable the supply side in the deployment of public charging infrastructure.

A. DEFINITION OF A FUNDAMENTAL MARKET DESIGN FRAMEWORK TO LIMIT DISTORTIONS AND ENTRY BARRIERS

For the efficient functioning of a market, it is essential to develop clear and precise policy decisions and market design frameworks from the start, minimizing market distortion and entry barriers. With regards to EV charging, this could potentially include the level of competition allowed and the price-setting approach.

A rudimentary choice is the introduction of competition which can be broadly introduced using two techniques. The first technique is the in-market competition, which allows establishing infrastructure and its commercial provision by any entity. The second technique is competition for the market. A competitive bidding process is used to award the winner a time-limited concession to set up charging infrastructure and provide services within a particular area. The policymakers also have the choice to mandate the state-owned utility to set up and operate charging stations. A combination of various techniques can also be considered if needed.

Another critical element is the principle for price setting for EV charging. The policymakers can choose between a fully regulated price, a fully market-based price-setting or a price cap. After the elementary design choices are made, the policy is also required to mandate changes to incumbent regulation (such as open access, deregulation of electricity retail, etc.) to minimize entry barriers.

B. INCENTIVES FOR PROMOTING EV CHARGING INFRASTRUCTURE

The causality dilemma of whether the EV or the charging infrastructure needs to come first has long been a much-debated topic . However, global experiences make it clear that the thrust has to arrive from either side. Therefore, initially, incentives for installing charging stations and necessary innovation are required to launch the market.

The level and kind of incentive would depend upon a given state or country's social, economic, and political priorities. However, the EV policy needs to clarify whether or not an incentive for launching the EV charging market is to be provided to enable the rollout of charging infrastructure. If provided, then its boundary conditions (limits) must be specified as the minimum criteria.

C. PRIORITIZATION CONCERNING EV CHARACTERISTICS AND SOCIAL GEOGRAPHY

The implementation of charging infrastructure can follow two methods: a coverage-based method to charging infrastructure spanning an entire region and a demand-based method for the charging infrastructure deployment to follow demand. Hence, a choice needs to be made concerning social geography.

Another component that might influence EV charging is the EV attribute (chassis and engine). For instance, the charging requirements of an electric bus fleet would show a discrepancy from that of electric scooters concerning speed, location, method, and ownership. Similarly, with other conditions remaining the same, the charging frequency needed for an EV would vary depending on battery capacity. These nuances ought to be taken into consideration throughout policy development.

Hence, an innovative EV charging policy should provide a road map with the short, medium, and long run of the priority in the context of the EV characteristics (the priority of electrifying various modes of transport) and information on the target social geography (factors impacting the choice between coverage, demand, or mixed approach).

D. EASING OUT ADMINISTRATIVE BARRIERS FOR ESTABLISHING CHARGING STATIONS

Like setting up any new business, any entity to set up a public EV charging infrastructure needs to acquire several clearances and permissions (e.g., permission for land use) and are mostly handled by several different agencies that may or may not function in unison. Thereby, there is a likelihood of unforeseen delays and inefficiencies in establishing the infrastructure and building barriers to market entry. Therefore, the EV policy must embody provisions that identify and avoid administrative barriers to the inception of charging stations.

E. MANDATE ON USER DATA SHARING AND PRIVACY

Ingenious and quick innovation in information and communication technologies has paved the way for new opportunities and challenges in all sectors, including power and energy. One of the crucial discussions on this domain has been relating to the use and protection of consumer data and data privacy. In the European Union, the right to protect personal data is fundamental .

The EV charging industry could potentially clash with similar issues in the upcoming years. Technologies like smart chargers and smart grids would enable service providers to garner extensive data on consumer choices and behaviour, which can be a valuable resource for the service provider to optimize its operations, and its value could be monetized. However, there is also a significant threat of unauthorized misuse of consumer data. The privacy concerns arising from 'big-data' are discussed in detail by . Hence, the EV policy must acknowledge and mandate the development of a regulatory framework to govern consumer data and protect consumers' privacy.

F. MANDATE ON THE UTILIZATION OF V2X CAPABILITIES

For unlocking the full potential of the V2X services that the EVs can provide, the EV charging policy must provide a comprehensible direction on the initiation of regulations and guidelines on different aspects of the V2X services. This would clarify the possible service providers, network operators, and other consumers of these services. It is to be noted that V2X is still in an early stage of development and would potentially gain greater relevance in the future.

G. FOCUS ON RE INTEGRATION AND EV CHARGING

As EV usage grows, EV charging infrastructures are installed in more public spaces. With Renewable Energy based sources such as solar energy from photovoltaic (PV) panels and wind sources having great potential to produce electricity can be used to provide sustainable and clean energy as appropriate sources to be integrated with EV charging stations both public as well as residential/ workplace. The integration of renewable energy and EVs is crucial to shape the future mode of transportation.

A.2.2 Enabling EV charging on demand-side

The demand side involves the EV user who would ultimately use the charging infrastructure and its services. Therefore, the remaining six elements are applied to qualitatively assess whether and to what extent a particular EV policy enables the “demand-side” in terms of ease of use.

A. TECHNICAL STANDARDIZATION OF CHARGERS FOR INTEROPERABILITY

Interoperability of charging infrastructure is crucial in enabling the demand-side . The critical element of interoperability is the technical standard used for the charger. In general, charger standardization can either take place in a top-down or bottom-up approach. In the former, the concerned authority specifies standards and charging service providers must provide at least the standard chargers, thus ensuring interoperability. The latter is more evolutionary where no standards are specified, and eventually, a dominant or consensus design emerges, which becomes the standard over time. In either situation, the EV policy needs to specify the approach that is to be followed.

B. DIRECTIVE FOR THE DEVELOPMENT OF DIGITAL PLATFORMS AND DATABASE MANAGEMENT SYSTEMS

The rapid innovation in information and communication technologies has provided users with instant access to information in a distinctive way. Any activity from banking to shopping requires digital platforms like websites and mobile applications regularly.

In EV charging, these systems can be utilized to provide the EV user with detailed information on the charging network. This data could range from the identification of the nearest charging point to reserving it and beyond. Thus, digitalization has a positive impact on enabling the demand-side. Therefore, the EV policy can mandate the development of these digital platforms and define their basic functionality.

C. SPECIFICATIONS RELATED TO THE USE OF A WIDE RANGE OF PAYMENT METHODS

Today, consumers have widespread access to multifarious payment methods that go beyond just cash payment and include different modes of online currency. The payment method preference among customers may differ depending upon constraints on a case-to-case basis. The availability of a broad range of payment options available at the charging station would positively impact the demand-side and could be promoted through the EV policy.

D. SPECIFICATION OF MINIMUM FACILITIES TO BE PROVIDED AT CHARGING STATIONS

Like most services, there must be a minimum standard and quality of facilities for consumers. Having minimum requirements would positively impact the demand side since the consumer would know what to expect at the charging station. For example, specifying the minimum vehicle parking space requirement within the charging policy will also guarantee that the owner of a large SUV is assured of having sufficient parking space during charging. Hence, this factor will play a key role in enabling the demand-side. Thus, the EV policy must consider minimum standard facilities and their quality at a charging station.

E. HARMONIZATION OF INTRA/ INTERSTATE MOBILITY OF EVS AND USER REGISTRATION

The long-distance and cross border usage of EVs necessitate more than just compatible physical charging infrastructure. Different countries and states will most certainly have different market designs and charging service providers. Thus, depending upon the regulation, these charging stations may require EV users to register with each of these service providers separately, following their processes and requirements. This issue may also come up in an intra-state context with an in-market competition where separate suppliers will ask for independent registration.

An unharmonized registration system can create an obstacle on the demand side and hinder EV adoption. There will be a hint of doubt among EV users on whether they would charge the vehicle when crossing borders and driving over long distances in an inter-state context. In addition, EV owners may or may not comply with the varying registration requirements in different states or suppliers. In an intra-region context, an unharmonized registration system can also restrict the access of EV users to charging stations constructed only by the companies with which the users are registered.

Another aspect of the installation of charging stations along major national/state highways helps in increasing the confidence of EV users without worrying about running out of power during long travels.

F. SETTING UP OF A MECHANISM TO ADDRESS CONSUMER COMPLAINTS

Attending to consumers' concerns rapidly and efficiently would lead to greater trust in the functioning of the public charging services. Most commercial establishments have mechanisms for addressing complaints in today's competitive environment with widespread access to social media. However, forcing the establishment of a robust mechanism to address consumer complaints (in a time-bound fashion) within the EV policy would ensure validity to the existence and quality of such a mechanism instead of leaving it to the discretion of the service provider and enabling the demand-side further.

A.2.3 Additional Mentions

This section includes elements which are aimed at qualitatively assessing various factors mentioned in the respective state EV policies other than those related to EV charging infrastructures.

A. EV MARKET SUPPORT SERVICES TO PROVIDE EV ADOPTION

This section deals with the various measures taken to promote EV market players such as consumers, manufacturers, and technology providers, includes fiscal and non-fiscal incentives, subsidies, tax exemptions along with various infrastructure supports given to value chain players of EV sector.

B. INSTITUTIONAL FRAMEWORK FOR ROLL OUT OF POLICIES

This includes policy guidelines and institutional mechanisms for roll-out of policies, responsibilities of various key sectors such as DISCOMs, industries, transport etc.

C. ENHANCEMENT OF EV VALUE CHAIN PERIPHERAL ECOSYSTEM

In this, various policy features and characteristics associated with EV value chain peripheral ecosystem enhancement are included, such as skill development, R&D development, amendment in regulations and policies, by-laws, technical and non-technical measures of EV market promotion, data sharing, promotion of shared mobility, commercialization of EV fleet etc.

D. PROMOTION OF BATTERY RECYCLING AND SCRAPPING FACILITIES

Battery recycling is an effective way of optimally utilizing rare elements such as Lithium, Nickel and Cobalt which with increase in use could lead to supply chain issues in future as their availability is concentrated in few countries only. Another advantage of battery recycling is it reduces negative environmental impact as well as has the potential to reduce the overall cost of a battery and therefore EVs. Promotion of battery recycling will help evolution of new business models like trading of recycled raw materials in the exchange market, or physical reuse of aged batteries in other applications.

A.3 Nameplate details of EV chargers in India

1. Delta Electronics India

Delta Electronics India- AC Slim II		
Power Input	Input Rating	200 V-240 V (or 100 V-120 V) single phase, max 13 A, 50 Hz/60 Hz
	Input Plug Type	Subject to the region or country standards
Power Output	Output Rating	200 V-240 V (or 100 V-120 V) single phase, max 13 A, 50 Hz/60 Hz
	Charging Interface	IEC 62196-2 Type 1, Type 2 or GB/T tethered plug
	Electrical protection	Over-current, Under voltage, Over-voltage, Residual current, Over temperature, Ground fault
User Interface & Control	Status Indicators	AC Present, Charging, Over Temperature, Fault
Environmental	Operating Temperature	-40 □ to +50 □
	Storage Temperature	-40 □ to +85 □
	Humidity	< 95 % relative humidity, non-condensing
	Altitude	Up to 2000 m
Mechanical	Ingress Protection	IP 67, excluding plug and cable
	Cooling	Natural cooling
	Dimensions (W * H * D)/Weight	152 * 76 * 40 mm/600 g, excluding plug and cable
Regulation	Certificate/Compliance	Subject to the region or country standards

Delta Electronics India- AC Mini Plus		
Power Input	Input Rating	230 V AC, single phase, 32 A max, 50Hz/60 Hz
	Number of Phases/Wire	L, N, and PE (Ground), Hardwired with terminal block
	Standby Power	< 2 W (Basic model)
	Internal RCD	DC 6 mA RCD function
Power Output	Output Rating	230 V AC, single phase, 32 A max, 50Hz/60 Hz, 7.4 kW max
	Charging Interface	IEC 62196-2 Type 1 or Type 2 tethered plug, 5 m cable IEC 62196-2 Type 2 Socket
Protection	Upstream	Per local regulations
	Electrical Protection	Over-current, Under voltage, Over-voltage, DC Residual current, Short circuit, Over temperature, Ground fault, plug-out protection
	Cold-Load Pickup	Randomized delay before charge resume after power failure
	Automatic recovery after nuisance trip	No user intervention required
User Interface & Control	Status Indicators	Power, Status, Charging, Fault
	Buttons and Switch	Key switch, On/Off switch, Reset button, or Emergency stop button
	Charger configuration	Maximum Charging current
Communication	Network Interface	Ethernet (standard), WLAN (optional), 3G (optional) for backend communication
	Charging Protocol	OCPP

Delta Electronics India- AC Mini Plus		
Environmental	Operating Temperature	-30 □ to +50 □
	Storage temperature	-40 □ to +80 □
	Humidity	‹ 95 % relative humidity, non-condensing
	Altitude	Up to 2000 m
Mechanical	Ingress Protection	IP 55
	Enclosure Protection	IK08 according to IEC 62262
	Cooling	Natural cooling
	Dimensions (W * H * D)/Weight	363 * 318 * 136 mm, excluding charging cable, mounting plate, and cable holder 4.4 kg (with plug)/3 kg (socket model)
Regulation	Certificate/Compliance	CE; IEC 61851-1, IEC 61851-22

Delta Electronics India- AC Max			
Part Number	EVAAU	EVVAE	EVAAG
Power			
Output Power	11.5 kW, 19.2 kW	7.4 kW, 11 kW, 22 kW	7.4 kW, 11 kW, 22 kW
Output Interface	SAE J1772	IEC 62196-2 Type 1or Type 2 tethered plug IEC 62196-2 Type 2 Socket IEC 62196-2 Type 2 Socket with shutter	GB/T 20234-1 / -2
User interface			
User Authentication	ISO/IEC 14443 RFID card Reader		
Communication			
Network Interface	Ethernet, Bluetooth, WLAN, Cellular		
Protocol	OCPP1.SS, OCPP 1.6J, upgradable to OCPP2.0		
Mechanical Design			
Dimensions	218*317*167 mm (8.6 * 14.6 * 6.6 inch)		
weight	3.8 kg (8.3 lbs)		
Installation Option	Wall mounted, stand		
Available Region			
	America	Europe, Australia, New Zealand, Southeast Asia	China

2. Indegreen Technologies Private Limited

IP Rating	IP65
Current Rating	0-300
Rated Voltage	380
Interlock Facility	Yes
Brand	OEM
Pin Type	3 Pin
No. Of Pin	3

3. Evlion

Brand	Evlion
AC Power Connection	3P+N+PE
Input Voltage Range	400 V AC ± 10%
Input Frequency	50 Hz
Input Current	66 A
Input Power	46 kVA
Power Factor	0.96
Max. Output Power	43.5 kW
Output Voltage Range	400V ±10 %
Max. Output Current	3x63 A
Efficiency	96 %
Connection Standard	EN 61851-1 2010
Plug Type	IEC 62196 Model 3, Type 2

Bharat AC 001	
IP Rating	IP55
Brand	Evlion
Battery Backup	1 Hr
Input Voltage	415V(374-440V AC)
Input Frequency	50±1 Hz
No of Wires	5 (L1, L2, L3, N, PE)
No of Outputs	03
Output Connector	IEC 60309 (3 Pin Female Connector)
Output Voltage	230 V AC
Output Frequency	50 Hz
Output Power	3.3 kW Max.
Output Current	15 A
Ambient Temperature	-30 □ to 55 □
Storage Temperature	-40 □ to 70 □
Altitude	2000 m
Humidity	95 % Non-Condensing
Language	English
Display Size	4.3 Inch TFT with touch
User Authentication	OCPP
Visual Indication	Using LED (Available charging fault)
Enclosure Protection	IK10 vandal proof
Cooling Type	Natural Cooling
Dimension	380 x 530 x 150 mm

Bharat DC 001	
IP Rating	IP 54
Current Rating	200 A
Rated Voltage	48 V/60 V/72 V
Interlock Facility	Yes
Brand	Evlion
Pin Type	CCS2/CHAdeMO/GBT
Material	MS
MCB Protected	Yes
Key Lock Facility	Yes
Country of Origin	Made in India
Peak Efficiency	>92 %
Vehicle Type	Electric Vehicle
Input Voltage	415 V AC, 3 Phase, 5 Wire System (3Ph+N+E)
Power Factor	>0.9
Input Frequency	50±1 Hz
No of Wires	5 (L1,L2,L3,N,PE)
No of Outputs	01
Output Connector	CCS2.0 / CHADEMO / GB/T 20234.3
Output Current	Max. 200 A
Output 1 Rating	15 kW Max. at 48 V/60 V/72 V
Ambient Temperature	0 □ to 55 □
Storage Temperature	0 □ to 70 □
Altitude	2000 m
Humidity	95 % Non-Condensing
Display Size	7 inch TFT LCD with touch
Language	English
Push Button	Display wakeup
User Authentication	OTP/RFID Optional Based
Visual Indication	Mains Available, Charging Status, System Error
Enclosure Protection	Vandal Proof Metal Enclosure
Cooling	Air Cooled
Wire Length	5 m

4. ECcharz

Bharat AC charger	
Input Voltage (AC)	3 Phase, 415 V AC (374 V-440 V AC)
Input Frequency	50±1Hz
Wires	5 wires: L1, L2, L3, N, PE
Battery Backup (Controller)	1Hr.
Output Power	
Number of Outputs	3 Nos.
Output Connector	IEC 60309, (3 Pin Female Connector)
Output Current	Max. 15 A, per output
Output Rating	230Vac, 50Hz, 3.3kW Max. per output
Environment	
Ambient Temperature	-30 □C to 55 □C
Storage Temperature	-40 □C to 70 □C
Altitude	<2000 m
Humidity	<95%, Non-Condensing
User Interface and Control	
Display	4.3 TFT LCD with touch
Language	English
Push Button	Emergency Stop (mushroom-headed push button)
User Authentication	OCPP
Visual Indication	Using LED (available, charging fault)
Protection	
Protection	Overvoltage, under-voltage, over-current, short circuit, surge protection, over-temperature, ground fault, residual current
Communication	
Charger and CMS	Protocol: OCPP 1.6 Interface: Ethernet, 2G/3G/4G
Mechanical	
Ingress Protection	IP 55
Enclosure Protection	IK10 vandal proof
Cooling	Natural cooling
Dimension(W*L*H)	380 mm * 530 mm * 150 mm

Bharat DC charger	
Input Power Input Voltage (AC)	3 Phase, 415 V AC, (374 V- 440 V AC)
Power Factor	>0.98
Efficiency	94 %
Input Frequency	50±1 Hz
Wires	5 Wire, L1, L2, L3, N, PE
Output Power	
Number of Outputs	1 Nos.
Output Connector	GB/T 20234.3

Output Current	Max. 200A
Output 1 Rating	15 kW (Max) at 48 V/60 V/72 V
Environment	
Ambient Temperature	0 °C to 55°C
Storage Temperature	0 °C to 70°C
Altitude	<2000 m
Humidity	<95%, non-condensing
User Interface & Control	
Display	7" TFT LCD with Touch
Language	English
Push Button	Display Wake up, Emergency Stop
User Authentication	OTP/RFID (Optional) Based
Visual Indication	Mains Available, Charging Status, System Error
Protection	
Protection	Over Voltage, Under Voltage, Over Current, Short Circuit, Surge Protection, Over Temperature, Ground Fault, Residual Current
Communication	
Charger & Vehicle	CAN Communication
Charger & CMS	Protocol: OCPP 1.6 (Open Charge Point Protocol) Interface: Ethernet, 2G/3G/4G, Wi-Fi (Optional)
Mechanical	
Ingress Protection	IP 55
Enclosure Protection	Vandal Proof Metal Enclosure
Cooling	Air Cooled
Wire Length	5 m
Dimension (WxHxD)	765 mm X 1800 mm X 400 mm

DC Quick charger	
Input AC Connection	3L + N + PE
Input Voltage (AC)	3 Phase, 415 Vac +/- 10%, 50Hz
Power Factor	>0.98
Current Nominal	120 A per phase
Efficiency	94%
Mains Terminal	Terminal blocks 3L + N + PE
Transient	Class II/C protection
DC Charging Points	CCS & CHAdeMO
DC Output Voltage	200-500 V DC
Maximum Charge Power	50 kW DC
Cable Length	5 m
Protections	Over Voltage Protection, Under Voltage Protection, Over Current circuit breaker, Short Circuit Protection, Isolation Monitoring, Earth Monitoring
DC Charging Point	CCS
Compliance	IEC 61851-23 / -24,IEC 62196-3,DIN 70121
Rating cable & gun	125 A DC/600 V DC
DC Charging Point	CHAdeMO

Compliance	IEC 61851-23 / -24,JEVS G 105,Rev. 1.2 compliant
AC Charging Point	
Compliance	IEC-61851-22
AC socket 22 kW charge point	IEC 62196-2 Mode 3, Type 2
Nominal AC voltage	400 V RMS
Maximum Charge Current/Power	3 x 32 ARMS @ 22 kW point
Protections	RCD Type B, Surge Protection, Over Current Breaker, Earth Monitoring
User Interface & Control	
Display	7" Graphical Colour display
Language	English
Push Button	Emergency Stop
User Authentication	OTP Based/ RFID (Optional)
Visual Indication	Mains Available, Charging Status, System Error
Communication	
Charger & Vehicle	PLC Communication(CCS) CAN Communication(CHAdeMO) Control Pilot (AC Type 2)
Charger & CMS	Protocol: OCPP 1.6 (Open Charge Point Protocol) Interface: Ethernet, 2G/3G/4G
General	
Ingress Protection	IP55
Cooling	Air Cooled
Ambient Temperature	– 25 □ to +45 °C
Relative humidity	95% max. non-condensing
Compliance	
Communication Compliance	Tested over OCA compliant OCPP test tool

DC wall mounted	
Input Rating	380 V- 415 V AC; 50/60 Hz; Three-Phase/ L1, L2, L3, H, PE
Power Factor (AC)	>0.98
Current THD	Compliant with IEC 61000-3-12
Efficiency	94 %
Output Power	
DC Output#1*	IEC CCS Combo 2,200 V- 500 V DC, 60 A max, 25 kW max (optional: SAE DC)
DC Output#2	CHAdeMO, 50 V- 500 V DC, 60 A max, 25 kW max, DLN 70121
Protection	
Protection	Over-current, Under voltage, Over-voltage, Residual current, Surge Protection, Short circuit, Over temperature and ground fault
User Interface & Control	
Display	2.7□ OLED screen
Language	English (Other languages available upon request
Push Button	Multi-functional buttons(LED light: Orange, Blue)/Emergency stop button(Red)
Charge Options	Charge options to be provided upon request: Charge by duration, Charge by energy
User Authentication	ISO/IEC 14443 Type A/B RFID for user authentication
Communication	
Network Connectivity	Ethernet(standard); 3G(optional)

Environmental	
Operating Temperature	-30 °C to +50 °C (-22 °F to +122 °F)
Storage Temperature	-40 °C to +85 °C (-40 °F to +185 °F)
Humidity	<95% relative humidity, non-condensing
Altitude	Up to 2000 m (6500 ft.)
Mechanical	
Ingress Protection	IP 55
Enclosure Protection	Ik10
Cooling	Forced air
Charging Cable Length	4 m (13 ft.)
Dimension (W x H x D)/Weight	680*430*230 mm (27*17*9 in.), 47kg (104 lb), excluding plug and cable
Regulation	
Certificate	CE
Compliance	CHAdeMO/IEC 61851-1/IEC 61851-23

5. PlugnGo

Bharat AC 001	
Input power	
Input Voltage(AC) 3 Phase	415 V AC (374 V-440 V AC)
Input Frequency	50±1 Hz
Wires	5 wires: L1, L2, L3, N, PE
Battery Backup(Controller)	1Hr.
Output power	
Number of Outputs	3 Nos.
Output Connector	IEC 60309, (3 Pin Female Connector)
Output Current	Max. 15 A, per output
Output Rating	230 V AC, 50 Hz, 3.3 kW Max per output
Environment	
Ambient Temperature	-30 □C to 55 □C
Storage Temperature	230 V AC, 50 Hz, 3.3 kW Max. per output
Altitude	<2000 m
Humidity	<95%, Non-Condensing
User interface and control	
Display	4.3 TFT LCD with touch
Language	English
Push Button	Emergency Stop (mushroom-headed push button)
User Authentication	OCPP
Visual Indication	Using LED (available, charging fault)
Protection	
Protection	Overvoltage, under-voltage, over-current, short circuit, surge protection, over-temperature, ground fault, residual current
Communication	
Charger and CMS	Protocol: OCPP (Open Charge Point Protocol) Interface: Ethernet, 2G/3G/4G

Mechanical	
Ingress Protection	IP55
Enclosure Protection	IK10 vandal proof
Cooling	Natural cooling
Dimension(L*W*H)	380mm*530mm*150mm

EVM DCFCLV-18kWCombo	
AC Input	3 Phase 4 wire, AC 380 V-480 V (Standard)
AC Input	0.99
Efficiency	93%
Display	7" LCD Touchscreen
Output	
Cooling System	Fan
Certification	ARAI: AIS138 (Under low voltage category)
Dimensions(W x H x D)	500mm x 1750mm x 395mm

Bharat DC001	
AC Input	3 Phase, 415 V AC, (374 V-440 V)
AC Output Power	10 kW/15 kW/5 @ 40V/60V/72V
Charging Standard	GB/T 20234.3
Output Current	Max. 200 A
Charger & CMS	Protocol: OCPP 1.6 (Open Charge Point Protocol) Interface: Ethernet, 2G/3G/4G
Display	7" TFT LCD with touch
Ingress Protection	IP 55
Dimensions(W x H x D)	765mm x 1800mm x 400mm

DC 30 kW		
AC Input	DC Output Voltage Rating	48 V/60 V/72 V DC
	Power Rating	30 kW
	Connector	Output connector with GB/T (Bharat DC001)
	No. of guns	2
	Efficiency	≥ 94 %
Power Input	Input Voltage	≥ 94 %
	Input Frequency	50Hz±5Hz
	THD	≤ 5 % @Nominal Voltage
	Power factor	≥ 0.99 (Full Load)
Protection and Safety	Safety Parameters	Over Current, Under Voltage, Over Voltage, Surge Protection, Short Circuit, Over Temperature

User Interface and Control	Display	Over Current, Under Voltage, Over Voltage, Surge Protection, Short Circuit, Over Temperature
	Support Language	English
	Push Button	Mushroom Type Emergency Stop Switch (Red)
	Charge Option	Grid responsive metering
	Visual Indication	Error Indicator, Presence of Input Supply; State of Charge Indicator
	User Authentication	Over Current, Under Voltage, Over Voltage, Surge Protection, Short Circuit, Over Temperature
Payment	Smart Card, QR/OTP/APP Server-based Online Payments	
Communication	B/w EVSE and Vehicle	Can based communication as per AIS - 0138-2
	B/w Charger and Central Server	OCPP v1.6 - 10/100 - T Ethernet (Standard)/ Optional GSM Model (4G Fall-back 3G)
Mechanical	Ingress Protection	IP 54
	Cooling	Forced Air Cooling
	Charging Cable Length	5 m
Environmental	Operating Temperature	-20 °C to +75 °C (derating from 50)
	Humidity (Non condensing)	0 % to 95 %
	Storage Temperature	-20 °C to +80 °C
	Altitude	Up to 3000 m

A.3 Application form for setting up of E-Vehicle/ E-Rickshaw charger in BRPL

BSES Rajdhani Power Limited

CONSUMER SERVICES GROUP

APPLICATION FORM FOR NEW CONNECTION

(Please refer instructions overleaf to help us serve you better)

FOR REGISTERING YOUR REQUEST / TO KNOW STATUS OF YOUR APPLICATION OR ANY FEEDBACK CALL @ 39999707 OR LOG ON TO **www.bsesdelhi.com**

Also, e-mail us on **brpl.customercare@relianceada.com** for any information grievance, feedback, appreciation or suggestion

Registered office: BSES Rajdhani Power Ltd. (A joint venture of Reliance Infrastructure Ltd. and Govt. of NCT of Delhi)
BSES Bhawan Nehru Place, New Delhi 110019
CIN : U40109DL2001PLC111527, GSTIN : 07AAGCS3187H2Z3 Tel. 3999 9707, Website : www.bsesdelhi.com

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BSES Rajdhani Power Limited

General Instructions

(Please go through the instructions before filing up the form)

1. All forms of BRPL are **free of cost.**
2. In case where a copy of certain documents has to be submitted, the applicant needs to produce the original documents for verification by BRPL representative at the time of submission; the original documents must be retained by the Applicant. However, a photocopy attested by Gazetted officer / notary etc. is also acceptable. The copy submitted to BRPL must be self-attested by the Applicant.
3. Applicant should insist on **checking the Identity Card of BRPL representative** visiting the premises. In case of any feedback or complaint against our executive, please report to our helpline 011-39999707.
4. **Applicant must not pay any money to any BRPL representative in cash** including those providing application forms, visiting premises or installing meter. In case of any feedback, appreciation or complaint against our executive, please report to our helpline 011-39999707.
5. All payments should be made against computerized Demand Note(s) **at BSES counter/online,** and receipt thereof must be obtained and kept safely by the applicant.
6. Applicant should pay the Demand note amount within the stipulated time at designated cash counters only at the Division Offices. Please note that payments of Rs. 20001/- and above should be made by way of DD/ pay order only payable at Delhi/New Delhi in favour of "BSES Rajdhani Power Limited "
7. Only complete documents shall be accepted by our executive. However, in case of non-availability of any document at the time of visit, our executive shall assist in preparing the documentation and issue a deficiency letter indicating the document to be attached with the filled up prescribed forms / available documents left with you, for submission of the same when completed, to your nearest customer care centre.
8. Applicant must ensure that wiring in his premises is complete and suitable metering space/protective devices at applicant side are provided including Earth Leakage Protective Device (ELCB) which is mandatory as per regulation - 42 of CEA. (Measures relating to Safety and Electricity Supply) Regulation 2010, and amended there on.
9. **BRPL has launched Door Step Services with the sole objective to facilitate our consumer in documentation and delivery of services without the help of any middlemen. Please help us in our fight against this menace.**

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Paste (Do not staple) self attested passport size photograph of consumer/authorized signatory in case of a firm

NEW CONNECTION SERVICE(S) FORM

Please fill the form in CAPITAL Letters (Please √ on the Appropriate Box), refer respective section of user manual

REQUEST NO.

Section 1. Applicant Details (Fill as applicable)

1a. Name of Applicant (specify as mentioned in proof of photo identity applicable for individual) / Organization Name (applicable for Organisation)
F I R S T M I D D L E L A S T

1b. Additional Details (Applicable for Individual)
Title: Mr. Mrs. Ms. Others (Please Specify) ....
Male/Female: M F Others — Date of Birth: D D M M Y Y
Father's/Husband's Name: Mr. F I R S T M I D D L E L A S T
Mother's Maiden Name: Mrs. F I R S T M I D D L E L A S T

1c. Additional Details (Applicable for Organisation)
Name of Authorized Signatory: F I R S T M I D D L E L A S T
Designation of Signatory
Type of Organization (Refer Section 1c of New Connection Application Manual) — Date of Incorporation: D D M M Y Y

Section 2. Address

2a. Communication Address (applicable for Individual) and Registered Address (applicable for Organisation) / Billing / Landlord Address
House No.
Building Name
Street
Area — PIN 1 1 0 0
Landmark
Mobile — Landline
Email @

Please provide your contact details to help us serve you better

2b. Premises Address at which Connection is required
House No
Building Name
Street
Area — PIN 1 1 0 0
Landmark
Mobile — Landline
Email @

Section 3. Category

3a. Category for Electricity Usage (As per applicable Tariff Schedule)

i	Domestic Category-Residential/Hostels/Hospitals/Educational Institutions/Religious/Charitable/Others		vii	DJB	
ii	Non Domestic - Banks/Chemist/Tailors/Others		viii	DIAL	
iii	Industrial		ix	Railway Traction	
iv	Agricultural		x	DMRC	
v	Mushroom		xi	Advertising	
vi	Public Lighting		xii	Temporary Supply (Refer Annexure 1)	
			xiii	E-Rickshaw / E-Vehicle	

3b. **CONNECTION SERVICE REQUIRED**

NEW CONNECTION: PERMANENT CONNECTION; TEMPORARY
EXISTING CONNECTION: RECONNECTION (DORMANT)
BILLING TYPE: PRE-PAID; POST-PAID
E-BILL REGISTRATION: YES; NO

3c. **Type of Area**: RH (Residential Area); HB (High Rise Building); UC (Unauthorised); JJ (Jhuggi Jhopri); DD (DDA Flat); CGHS (Flats); VI (Village Area); IA (Industrial Area); SA (Shopping Complex or Area); FA (Farm House); GOVT. (Flats)

3d. **Type of Premises**: Owned; Rented/Lease DD MM YYYY Valid till; Company Provided; Govt. Provided; Others

Date D D M M Y Y

Signature of Applicant/Authorized Signatory

Registered office: BSES Rajdhani Power Ltd. (A joint venture of Reliance Infrastructure Ltd. and Govt. of NCT of Delhi)
BSES Bhawan Nehru Place, New Delhi 110019
CIN : U40109DL2001PLC111527, GSTIN : 07AAGCS3187H2Z3 Tel. 3999 9707, Website : www.bsesdelhi.com

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REQUEST NO.

Section 4. GENERAL PARTICULARS

4a Purpose/usage of new connection - Refer to Section 4 of Application Manual and mention relevant Code here and
Mention Description of purpose/usage as mentioned in Section 4 of Application Manual here

4b Meter Choice BSES Meter Applicant's Meter Prepaid Post Paid

4c Desired Load (kW/kVA) Voltage Level LT HT EHV Phase 1ph 3ph

4d PAN Number (if available)

4e Aadhar/Voter ID/Passport No. (if available).

4f GSTIN : (if available).

Section 5. Near by Installation Pole No. / Feeder No. Meter No. House No.

Section 6. ELCB installed Yes/No MCCB/Main Switch Yes/No

Section 7. List of documents attached

7a	**Identity proof submitted along with this application form**	
	If applicant is a person (tick any one)	
i	Electoral Identity card	
ii	Passport	
iii	Driving licence	
iv	Ration card having photograph	
v	PAN card	
vi	Aadhaar card	
vii	Photo identity card issued by any government agency	
	If applicant is an organization (If applicable)	
i	Certificate of incorporation/registration issued by the Registrar/ Resolution of Board	

7b	**Proof of ownership or occupancy of premises** for which	
1	Certified copy of title deed	
2	Certified copy of registered conveyance deed	
3	General Power of Attorney (GPA).	
4	Allotment letter/possession letter.	
5	Valid lease agreement alongwith undertaking that the lease agreement has been signed by the owner or his authorized representative.	
6	Rent receipt for the last 3 months / Lease agreement along with no objection certificate and proof of ownership of landlord	
7	Mutation certificate issued by a Government body.	
8	Sub-division agreement.	
9	For bonafide consumers residing in JJ clusters or in other areas with no specific municipal address, the licensee may accept either ration card or electoral identity card mandatorily having the same address as a proof of occupancy of the premises.	

7c	**a. Industrial**	
	Valid Industrial License / Factory License / Lal Dora Certificate in case of rural village	
	b. Agricultural Consumers	
	i. Certificate of Residence from Block Development Officer	
	ii. No Objection Certificate from Development Commissioner / Block Development Officer Delhi Jal Board for tube wells	
	c. Non-domestic for Khokhas and Temporary Structure	
	i. Teh Bazaari Receipt Number	
	ii. No Objection Certificate for Khokha/Temporary Structure for single delivery supply	

** Select whichever is applicable*

Date D D M M Y Y

Signature of Applicant/Authorized Signatory

Acknowledgment

Documents Received :

Identity Proof: ____________________

Ownership/Occupancy Proof: ____________________

Others: ____________________

Request No.

Signature of BRPL Representative

Name

Designation

Employee ID

1. For all queries related to Billing, Metering and New Connection or complaint relating to power supply, corruption or theft, please contact BRPL Call Centre 39999707
2. Once message about Demand Note is received, you can download same from BSES Website www.bsesdelhi.com
3. Do not make any cash payment to any BRPL representative except at the cash counters at BRPL Division offices.

Registered office: BSES Rajdhani Power Ltd. (A joint venture of Reliance Infrastructure Ltd. and Govt. of NCT of Delhi)
BSES Bhawan Nehru Place, New Delhi 110019
CIN : U40109DL2001PLC111527, GSTIN : 07AAGCS3187H2Z3 Tel. 3999 9707, Website : www.bsesdelhi.com

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Declaration

REQUEST NO. | | | | | | | | | | | | | |

I, ______________________ Son/Daughter of ______________ Resident of ______________ (hereinafter referred to as "Applicant", which term shall mean and include executors, administrators, heirs, successors and assigns), do hereby swear and declare as under :

Or

The ________________, a company incorporated under the provisions of the Companies Act, 1956 or as amended, having its registered office at ______________________________________ (hereinafter referred to as "Applicant", which expression shall, unless repugnant to the context or meaning thereof, include its successors and assigns), through its Authorized representative Mr.____________, do hereby swear and declare as under :

Or

A Sole proprietorship / a partnership firm having its office at ____________________ (hereinafter referred to as the applicant which unless the context otherwise provides includes its successors and assigns), through Mr.____________, who is a partner or an authorized representative do hereby swear and declare as under :

THAT the Applicant is a lawful occupant of the premises at ________________________ (hereinafter the "Premises").

THAT the Applicant has requested the licensee to provide a service connection at the above-mentioned premises in the Applicant's name for the purpose mentioned in the application form.

THAT in furnishing the present Declaration, the Applicant has clearly understood that should any of the statements in this declaration prove to be false or incorrect at any later stage, the licensee shall be within his lawful rights to disconnect supply to the premises without any prior notice and proceed to adjust electricity supply dues payable by the applicant against consumer security deposit and /or recover the same in accordance with Law.

THAT the Applicant has complied with all requirements under all statute for the time being in force and the Applicant himself/herself shall be held legally responsible for any issue arising out of any such noncompliance for which the licensee may initiate action in accordance with applicable law.

That I, the Applicant hereby agree and undertake :

1. That no objection certificate for seeking electricity connection from the co-owner has been obtained (in case the applicant is not the sole owner of the premises).
2. To indemnify the licensee against all proceedings, claims, demands, costs, damages, expenses that the licensee may incur by reason of a fresh service connection given to the Applicant.
3. That to the best of applicant's knowledge, all electrical works done within the premises are as per Central Electricity Authority (Measures relating to Safety and Electricity Supply) Regulations, 2010 as amended from time to time.
4. That the internal Wiring at the premises has been tested by a Licensed Electrical Contractor/ designated officer of the Government* and the test certificate is available with the applicant:

*in case of Government quarters / offices,

5. *That the building has been constructed as per prevalent building Bye-Laws and the total height of the building on the date of seeking service connection;
   (i) does not exceed 15 meters without stilt parking or 17.5 meters with stilt parking.
   Or
   (ii) is more than 15 meters without stilt parking or 17.5 meters with stilt parking and Fire Clearance Certificate is available with the applicant.

6. *That there is a provision of lift in premises and the applicant has obtained the lift fitness certificate from the Electrical Inspector for the lift in the said premises and the same is available with the applicant.

*Strike out which is not applicable

7. That the applicant has applied for the correct category of tariff as per the applicable tariff schedule. For either of the following categories of connection, the applicant has the relevant documents available with him.

A. Industrial (Tick whichever is available)

a. (i) Valid Industrial License; or
(ii) Factory License; or
(iii) Household licence; or
(iv) Lal Dora Certificate in case of rural village; or
(v) Any other document authorizing the applicant to run the industry

OR

b. (i) Occupancy-cum-completion certificate from concerned Municipal Corporation or DDA; or
(ii) Consent to Establish from Delhi Pollution Control Committee(DPCC);or
(iii) Provisional Industrial License; or
(iv) Sanctioned building plan from concerned Municipal Corporation or DDA

B. Agricultural Consumers

i. Certificate of Residence from Block Development Officer; or
ii. No Objection Certificate from Development Commissioner/Block Development Officer Delhi Jal Board for tube wells

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REQUEST NO.

C. ***Non-domestic for Khokhas and Temporary Structure***
   i. Teh Bazaari Receipt Number; or
   ii. No Objection Certificate for Khokha/Temporary Structure from concerned Municipal Corporation of Delhi or Delhi Development Authority or any other concerned Land Owning Agency
   Please provide following information in respect of certificate available with the applicant.
   (Certificate No., issuing authority, date of issue, Purpose, validity, if applicable)

D. **Charging station for electric vehicles**
An undertaking by the applicant that the charging station for electric vehicles is as per the specifications as may be specified by Central Electricity Authority or Bureau of Indian Standards from time to time.

8. *That the industrial connection is taken based on the documents mentioned in clause 7A(b) above and I shall obtain the valid document as mentioned in clause 7A(a) above within a period of 3 months from issue of electricity connection.
   *Strike out if not applicable
9. That above referred applicable documents/certificates indicated at various points are available with me and can be inspected by the Licensee at any time. In case of failure or reluctance to produce/allow the inspection of said documents/certificates the licensee may disconnect the connection granted owing to such failure/, reluctance
10. That I shall provide a legible and certified copy of any of above applicable documents to the licensee pursuant to order/request of any government agency, judicial forum or any other authority seeking such information.
11. That my industry/trade has not been declared to be releasing obnoxious hazardous/pollutant by any government agency and that no orders of any Court or judicial authority would be breached by running of my industry/trade or granting any electricity connection to the same. The licensee is indemnified against any loss accrued by the applicant on this account that on an Order issued by a Court of law or judicial authority or any government agency for disconnection of electricity, the licensee may disconnect the supply.
12. That I shall indemnify and hold harmless, the licensee, in case of any injury or incident on account of any fault in electrical work in the premises, and the licensee shall not be liable for any mishap or incident occurring at the premises to the applicant on account of any faulty/defective/inferior quality wiring at the premises for which the connection is being applied.
13. To pay the electricity consumption bills and all other charges at the rates set out in the licensee's Tariff Schedule and miscellaneous charges for supply as may be in force from time to time, regularly as and when the same becomes due for payment.
14. To deposit the additional security deposit and additional service line cum development (SLD) charges, if any from time to time based on the prevailing Orders/rules, directions and Regulations of the Commission.
15. To abide by the provisions of the Electricity Act, 2003, all applicable laws, conditions of Supply/Tariff Orders and any other Rules or Regulations as may be notified by the Commission, as applicable from time to time.
16. That licensee shall be at liberty to adjust the electricity consumption charges due/outstanding along with any other charges against the Consumer Security Deposit paid by the Applicant, in the event of termination of the agreement prior to expiry of the contracted period or in case of any contractual default as per provisions of regulations/rules/orders/directions of the Commission.
17. That as per Delhi Electricity Regulatory Commission (Supply Code and Performance Standards) Regulations, 2017 or as amended from time to time, I shall provide suitable and adequate land space for installation of the meter/electrical equipments where the licensee may have ready access to thesame.
18. To allow clear and un-encumbered access to the meters for the purpose of meter reading and it's checking etc.
19. That the licensee may disconnect the electric supply under reference, in the event of any default, non-compliance of statutory provisions and in the event of a legally binding directive by Statutory Authority (ies) to effect such an order. This shall be without prejudice to any other rights of the licensee including that of getting its payment as on the date of disconnection.
20. All the above declaration given by the Applicant shall be construed to an Agreement between the licensee and the Applicant.
21. That the applicant is having the approval for safety and/or fire clearance for EV charging station wherever applicable from the concerned department such as Petroleum and Explosives Safety Organization (PESO), Fire Department etc.

Signature of Applicant
Name of the applicant

SIGNED AND DELIVERED
In presence of witness

Name of Witness

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NEW CONNECTION SERVICE(S) MANUAL

(Not to be submitted with Application. To be retained by Applicant)

Introduction

This manual helps you with applying to BRPL for a permanent new electricity connection. As an Applicant for such a connection, you need to fill up the following forms and submit specified documents as per of your application.

Official Forms of BRPL to be filled and submitted by the applicant (for all applications) :

1. New Connection Application cum Information Form for Permanent LT Connection along with self-attested passport size colour photograph of the applicant / authorized signatory (applicable in case of organisation) pasted on the form.
2. Declaration Supporting documents to be submitted by the Applicant (for all applications) :
   1. Copy of Proof of Identity of the applicant in whose name the connection is applied for
   2. Authorization in favour of signatory (applicable in case of organization)
   3. Copy of Proof of lawful ownership/occupancy of the premises for which the connection is applied for, in the name of the Applicant.
   4. Copy of proof of photo identity of the authorized signatory (applicable in case of organisation)

General Instructions :

1. All official forms of BRPL are free of cost.
2. In case where a copy of certain document has to be submitted, the Applicant needs to produce the original documents for verification by BRPL representative at the time of submission; the original documents must be retained by the Applicant. The copy submitted to BRPL must be self-attested by the Applicant.
3. The Applicant's photograph should be self-attested.
4. Applicant should insist on checking the Identity Card of BRPL representatives visiting his premises.
5. All payments should be made only against computerized Demand Note(s), and receipt thereof must be obtained and kept safely by the applicant. In case of any complaints of harassment or corruption, please report on Helpline No. : **39999707**
6. Applicant should pay the Demand Note amount within the stipulated time at the cash counter only, at the Division Offices/ Payment Counters. Please note that Payments of amount of Rs. 4001/- & above should be made by way of D. D./Pay Order payable at Delhi/New Delhi in favour of BSES Rajdhani Power Limited.

Space Requirement

The minimum space required to be provided by the developer / applicant for installation of distribution transformers shall be as under :

Sl. No.	Category	Description	Minimum Size (Meters)
(i)	For a load of 100kw to 300 kw or the plot size of 300 sq. meter to 1000 sq. meter	Installation of one number of 11kv Pole Mounted Distribution Transformer	4Mx 4M
(ii)	For a load of 100kw to 300 kw or the plot size of 300 sq. meter to 1000 sq. meter	Installation of one number of 11kv Plinth Mounted Distribution Transformer	8Mx 5M
(iii)	For a load above 300kw to 700 kw or the plot size of 1000 sq. meter to 2000 sq. meter	Installation of one number of 11kv Plinth Mounted Distribution Transformer	9Mx 5M
(iv)	For a load above 700kw to 1500 kw or the plot size of 2000 sq. meter to 4000 sq. meter	Installation of two number of 11kv Plinth Mounted Distribution Transformer	10Mx 8M
(v)	Cases not covered above		Actual size based on load requirement

Section 1: Applicant Details

1a. Please specify applicant name as in the proof of identity of the applicant / organization.
1b. Please fill details as applicable.
1c. Please refer to this section and fill the applicable code in Section 1c. of the Application Form

Code	Type of Organization
1	Company registered under the Indian Companies Act 1956
2	Society registered under Societies Registration Act 1860
3	Trust whose trust deed is executed under the Indian Trusts Act 1882
4	Partnership whose partnership deed is executed under the Indian Partnership Act 1932
5	Proprietorship

Name of Authorized Signatory: Please specify applicant name of authorized signatory as it appears in the proof of identity of the signatory. Name of signatory cannot be a joint name, please mention a single individual's name only.

BSES Rajdhani Power Limited

Charges payable for New Connection

The charges payable by you to BSES for New connection depends on the Tariff Category and sanctioned load :

(i) Advance Consumption Deposit / Security Deposit depending on your Sanctioned load and tariff category, as Specified in Table 1 below :

TABLE-1

S. No.	Tariff Category (as per Tariff Order)	Security Deposit for Permanent Connection (Rs. Per kW or per kVA as the case may be)
(1)	(2)	(3)
1	Domestic	
(i)	Upto 2kW	600
(ii)	Above 2kW upto 5kW	900
(iii)	Above 5kW	1200
2	Non-Domestic	4500
3	Industrial	4500
4	Agriculture	300
5	Public Lighting	3000
6	Railway, DMRC, DIAL DJB	3000
7	Mushroom Cultivation	600
8	Advertisement and Hoardings	4500
9	Charging stations for E-Rickshaw/E-vehicle	2500
10	Any Other Category not Speci?ed above	To be decided by commission
S. No.	**Tariff Category (as per Tariff Order)**	**Security Deposit for Temporary Connection (Rs. Per kW or per kVA as the case may be)**
1	Refundable Security towards pre payment meter	3000

(ii) In case area / Colony is electrified, the SLD charges shall be payable by all the consumer irrespective of whether it is electrified or Unelectrified area, The SLD charges as given in Table no. 2 would be leviable.

TABLE - 2

S.No.	Type of area	Sanctioned Load	Amount (Rs.)	Road Restoration Charges	Total
1	2	3	4	5	
I	Electrified Area	Upto 5 KW	3000	Actual RR charges for service line	4+5
II		6KW - 150KW	Maximum of 25000 (3000 + 500 per KW or KVA)	Actual RR charges for service line	4+5
III		151KW-200 KW/ 215 KVA	25000 + 400 per KW or KVA	Actual RR charges for service line	4+5
i	Un-electrified Area	Upto 4 KW (Other than Agriculture)	8000 per KW	Actual RR charges for service line	4+5
ii		5KW - 10KW (Other than Agriculture)	12000 per KW	Actual RR charges for service line	4+5
iii		11KW - 200 KW/ 215 KVA (Other than Agriculture)	20000 per KW or KVA as may be	Actual RR charges for service line	4+5
IV		Upto 4 KW (Agriculture)	1600 per KW	Actual RR charges for service line	4+5
V		5 KW - 10 KW (Agriculture)	2400 per KW	Actual RR charges for service line	4+5
VI		11KW - 200 KW/ 215 KVA (Agriculture)	4000 per KW or KVA as may be	Actual RR charges for service line	4+5

OTHER MISCELLANEOUS CHARGES

TABLE - 3

S. No.	Description	Charges (Rs.)
1	Non-refundable registration cum processing fee of EHT and HT connection	1000
2	Field Inspection to be scheduled on a holiday for the Licensee	500
3	Security towards pre-payment meter	3000
4	One time non-refundable charges for temporary connections	
i	LT Supply	250 per KW(Max 25000)
ii	HT Supply	1000 per KW
5	Shifting of meter and service line 1 on the same premises	
i	Single phase connection	500
ii	Three phase connection	1000
6	Installation Inspection Fee other than at the time of energising new connection	
i	Upto 5 kW	120
ii	More than 5kW upto 10 kW	200
iii	More than 10 kW	400
iv	HT Installation	1000

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7	Special Meter Reading charges	
i	LT connection	50
ii	HT connection	200
8	Charges for reconnection in case of change of occupancy or temporary disconnection	
i	Single phase connection	200
ii	Three phase connection	500
9	Meter testing charges	
i	Single phase	200
ii	Three phase	500
iii	CT meter	1000
iv	HT meter	4000
10	Copy of duplicate bill (> one)	20

Instructions for completing the New Connection Application cum Information Form for Permanent LT Connection

Section 4 : General Particulars

4a: Details about purpose / use of electricity for which the connection is applied for

Please refer to the table below and depending on the purpose / use, for which a new connection is required, specify the applicable code and description in Section 8 of the Application-cum-Information Form.

Code	1. Domestic	Code	2. Industrial (except Household Industry)	Code	3. Agriculture
1.1	Domestic/residential lighting	2.1	Industry in conforming areas	3.1	Tube well for irrigation (except for activities listed in Code 4.8 of this Table)
1.2	Common meter - compound lighting/portico/staircase lighting/lifts/water pump/fire-fighting equipment in residential complexes	2.2	Industry in non-conforming area/urban area	3.2	Threshing and kutti-cutting in conjunction with pumping load for irrigation purposes
1.3	Co-operative group housing	2.3	Industry in rural area	3.3	Lighting in kothara
1.4	Domestic farmhouse - available for loads up to 21 kW to farmhouses for bonafide domestic self use and bounded farm houses having minimum 50% of the total land for agriculture/ vegetable cultivation			3.4	Mushroom cultivation
1.5	Professionals like architects/engineers/doctors/lawyers/CA's with an area upto a maximum of 50% of the area cover for carrying out professional work				

1.6	Erstwhile DVB Staff S1 employed 2. S2 employed 3. S3 employed 4. DS1 5. DS2 6. DS3 7. DS4 8. DS5 9. DS6 10. DS7

Code	4. Non-Domestic	Code	5. Other Specific purposes / uses
4.1	Shops/Commercial complexes/Offices	5.1	Places of worship - temple/mosque/gurudwara/ Church
4.2	Khokas/kiosks/temporary structures such as pan shops	5.2	Hostels of recognized/aided institutions of MCD/GoNCTD
4.3	Hotels/restaurants/ice-cream parlours/eateries/inns/ Guest houses	5.3	Dispensary/hospitals/public libraries/working women's hostel/orphanage/charitable homes run by MCD/GoNCTD
4.4	Auditoriums/cinema/libraries	5.4	Health centres approved by Department of Health, GoNCTD for providing charitable service only
4.5	ATMs/Banks	5.5	Recognized centres for welfare of blind, deaf and dumb, spastic children, physically handicapped persons as approved by GoNCTD
4.6	Petrol pumps	5.6	Chesire homes/orphanage
4.7	Farmhouses used for commercial activities such as marriage/parties etc.	5.7	Electric crematorium
4.8	Cattle farms, fisheries, piggeries, poultry farms, floriculture, horticulture, plant nursery	**Code**	**6. Charging of E-Rickshaw / E-Vehicle**
4.9	Hostels/schools/colleges/Hospitals, nursing homes/diagnostic centres (other than those run by MCD/GoNCTD)	6.1	Charging Stations for E-Rickshaw / E-Vehicle on Single Delivery point
4.10	Household Industry	6.2	Charging E-Rickshaw / E-Vehicle at own premises other than Charging Station
4.11	Any other purpose/use not indicated in any list		

No Objection from Landlord / Co-Owner

REQUEST NO. | | | | | | | | | | | | | |

I/We Mr./Ms/M/s.____
(in case Landlord is individual)
son/daughter/wife of______________________________________aged____________(years)
resident of (permanent address in case landlord is an individual/Registered Address in case landlord is an organization)
____
____

do hereby declare that :-

1. I/We own the premises/building bearing municipal no. and address :
   ____
   ____
   ____
   (hereinafter referred to as the "premises").
   In case Landlord is an Organization, I, the undersigned, declare that I am an authorized signatory, empowered to sign. on this No Objection Letter on behalf of the Landlord. As proof of this authorization, I have attached a certified true copy of :
   ____
   (specify one that applies – Power of Attorney duly extended in favour of signatory, or, Board Resolution authorizing the signatory).
2. That I/we have rented my premises to :
   ____
   (full name of tenant, hereinafter referred to as the "Tenant").
3. That I/we have no objection if the tenant applies for a new electricity connection on the said premises, and the same is provided by BRPL.
4. That, if at any stage, the aforesaid facts in No Objection Letter are found to be untrue, then BRPL will have absolute right to disconnect electricity supply of the said electricity connection, as may have been provided against the application for new connection submitted by the tenant at the said premises.

I_______________________________ Son/Daughter of Shri ______________________________ Age ____ years resident of _________________________________ do hereby affirm and declare that the information given above and in the enclosed documents is true and correct to the best of my knowledge and belief and nothing material has been concealed therein. I am well aware that concealment of facts and giving false information in punishable offence and in case I am guilty of giving false information or concealment of facts herein, I will be liable to be punished with imprisonment and/or fine as per the relevant provisions of law. I also undertake that the benefits availed by me by furnishing such false information or concealment of the facts shall be liable to be summarily withdrawn.

Signature of Applicant________________________

Name of Applicant ________________________

Signature of Landlord

Place________________________

Landlord's Full Name:____

ARCHITECT CERTIFICATE

(Letter Head of Architect)

Ref. No.____________

TO WHOMSOEVER IT MAY CONCERN

This is to certify that :

1. I have personally inspected the building bearing municipal number and address as________________________________.
2. The said building has been constructed as per the applicable building Bye-laws duly sanctioned by the competent authority.
3. The said building comprises of _________________ (specify basement, ground-floor, first floor, second floor, third floor etc).
4. The total height of the said building does not exceed 15 (fifteen) metres as measured in accordance with the building Bye-laws applicable in NCT of Delhi / National Building Code.
5. The Fire Safety Clearance Certificate from the Delhi Fire Service is not required in the case of the said building as per the prevalent building Bye-laws in NCT of Delhi.

Signature of Architect

Date_____________ Place_____________

Architect's Name : ___________________________________

Architect's Registration Number : _______________________

SEAL

Inspection Report

(This Installation Test Report is to be certified by a Licensed Electrical Contractor. This is for reference of consumer.)

From: M/s.. (Wiring Contractor)

Reg. No...

To : M/s. BSES Rajdhani Power Limited (Name of the Licensee)

Dear Sir,

We hereby inform that Electrical inspection at the premises bearing No. / situated on Road / Street (as per address given below) occupied by (as per Applicant's name and signature as given below) has been completed by us and is ready for your engineer to test and connect up with your mains (As per CEA measures relating to safety and electric supply) regulation 2015 was tested by us on date ....and the installation resistance as per regulation 34 was .... mega ohms.

ELCB (as per regulation 42) found installed : Yes (   ) NO (   ) Make : .... Capacity : ....

No. of circuits left to right on Distribution	Size of Conductor	Lamps		Fans		Plugs (5 Amp)		Plugs (15 Amp)		Other Domestic appliances		Total kW
		No	Watt	No	Watt	No	Watt	No	Watt	Description	Watt	
Circuit No. 1												
Circuit No. 2												
Circuit No. 3												
Circuit No. 4												
Circuit No. 5												
Circuit No. 6												
											Total	

Licensed wiring Contractor Name, Seal & Signature	License No.	Date	D D M M Y Y Y Y
Address			
City		PIN	

Name of the Applicant		S/o.	
Address where supply is required			
City		PIN	
Address where bill is to be sent			
City		PIN	
Signature of AMPS/DGM (Licensee) Date :		Signature of Applicant	

Note: As per notification no F.11(149)/2004 Power/2386 & 2387, Use of ISI marked motor pump sets, power capacitors, Foot/Reflex Valves in Agriculture sectors and use of CFL and electronic chokes in Govt. buildings / Govt. aided institutions / Boards / Corporations is mandatory.

As per CEA guideline Regulation 14 Suitable cut out should be provided at the consumer premises.
As per CEA guideline Regulation 16 earth terminal on consumer premises.
As per CEA guideline Regulation 42 earth leakage circuit breaker whose maximum earth leakage thershold for tripping should not exceed 30 milli amp. for domestic connection and 100 milli amp. for all other installation.

Power Helpline

Nature of Services/Complaints	BRPL
Power Supply/ Billing & Metering/ Anti Corruption/ Door Step Services	39999707

FOR REGISTERING YOUR REQUEST / TO KNOW STATUS OF YOUR APPLICATION / OR ANY FEEDBACK.
CALL @ 39999707 OR LOG ON TO www.bsesdelhi.com
OR E-mail at brpl.customercare@relianceada.com

For setting up of EV charger in locations served by BYPL

BSES
BSES Yamuna Power Limited

An Electric Vehicle Owner and wants to know more about EV and Charging Infrastructure

- Are you a BSES Yamuna Power (BYPL) Customer : Yes ☐ NO ☐
- If Yes, Please provide CA number : ....
- Name : ....
- Address : ....
  ....
  ....
- Phone / Mobile No. : ....
- E-mail ID : ....
- Electric Vehicle Owned by You (Pl. tick) : Scooter/ Car/ E Rikshaw/ Other
  If Other, please specify : ....
- Manufacturer Name : ....
- Model of Vehicle : ....
- Year Of Purchase : ....
- Query

Please download the same and submit filled form to bypl.evi@relianceada.com or may us on 011-39997141 for any query. We will be back to you after receiving your request.

BSES
BSES Yamuna Power Limited

An Electric Charging Infrastructure Company and wants to know more about Electric connection etc.

- Are you having EV Charging Connection with BYPL : Yes ☐ NO ☐
- If Yes, Please provide CA number : ....
- Name : ....
- Address : ....
  ....
  ....
- Phone / Mobile No. : ....
- E-mail ID : ....
- Charging Infrastructure Location Finalised : Yes ☐ NO ☐
- If Yes,
  - Location details : ....
  - Coordinates of Location : ....
- Charging Infrastructure details
  - Slow Charger : Nos. .... KW Load ....
  - AC Fast Charger : Nos. .... KW Load ....
  - DC Fast Charger : Nos. .... KW Load ....
- App. Connected Load Requirement : ....
- Make and Model of Charger :
  - Slow Charger : ....
  - AC Fast Charger : ....
  - DC Fast Charger : ....
- Query

Please download the same and submit filled form to bypl.evi@relianceada.com or may us on 011-39997141 for any query. We will be back to you after receiving your request.

A.5 Details of Maharashtra EV charger installation plan

Location of charging station in Maharashtra phase I, phase II, and phase III is given in Table A. 2, Table A. 3, and Figure A. 1.

Table A. 2: Location of charging station in phase I

Sr No	City	Area	EV Location
1	Thane	Vasant Vihar	22/11KV Vasant Vihar substation
2	Thane	Vasant Vihar	22/11KV Roma Substation
3	Thane	Dhokali	22/11KV Hiranandani substation
4	Thane	Khopot	22/11KV Eternity substation
5	Thane	Khopot	22/11KV Tarangan substation
6	Vashi	Vashi Railway stn	33/11KV Raghuleela sector 30
7	Vashi	Kharghar	33/11KV Kharghar sector-2
8	Pune	Hadapasar	22/11KV Malwadi substation
9	Pune	Hinjawadi	22/22KV IBP switching station
10	Pune	Kharadi	22/22KVTuskan switching station

Table A. 3: Location of charging station in Phase II

Sr no	Qty	City	Location
1	2	Bhandup	MSEDCL Bhandup Zone Office
2			Lokpriya Sub-station
3	3	Mulund	Nr. To BEST Bus Depot
4			Pioneer
5			PMGP Sub-station
6	4	Thane	Vikas Complex
7			Lodha Paradise
8			Hari Om Nagar
9			Byer India
10	3	Navi Mumbai	Sector-19, DAPMC
11			Airoli Sector-15
12			NRI Sub-station Nerul
13	3	Panvel	Taloja MIDC Pl.L-102
14			Roadpali
15			Bhingari Sub-station
16	8	Nagpur	Khamla (Congress Nagar)
17			Diksha Bhoomi (Congress Nagar)
19			Dharampeth (Congress Nagar)
20			Somal Wada (Congress Nagar)
21			Kalamna (Gandhibag)
22			Model Mill division office (Gandhibag)
23			Gaddi godam (Aashi Nagar)

Sr no	Qty	City	Location
24	4	Nashik	Merry
25			Datta Chowk
26			Satpur Pole Factory
27			Dwarka (Pathardi)
28	4	Pune	Dewagi, Kothrud
29			Sangvinagar, Shivajinagar
30			Sector-10, Switching S/s, Bhosri
31			4. CDC Switching Station, Bhosri
32	4	Mumbai-Pune Express Way	Sanjgaon
33			Urse
34			Nr. Hotel Pooja
35			Dahiwali
36	5	Aurangabad	33/11 kv STPI Chikalthana
37			33/11 kv Waluj E-sector
38			33/11 Kv Chavni
39			33/11 kv Sundar wadi
40			33/11 kv Power house

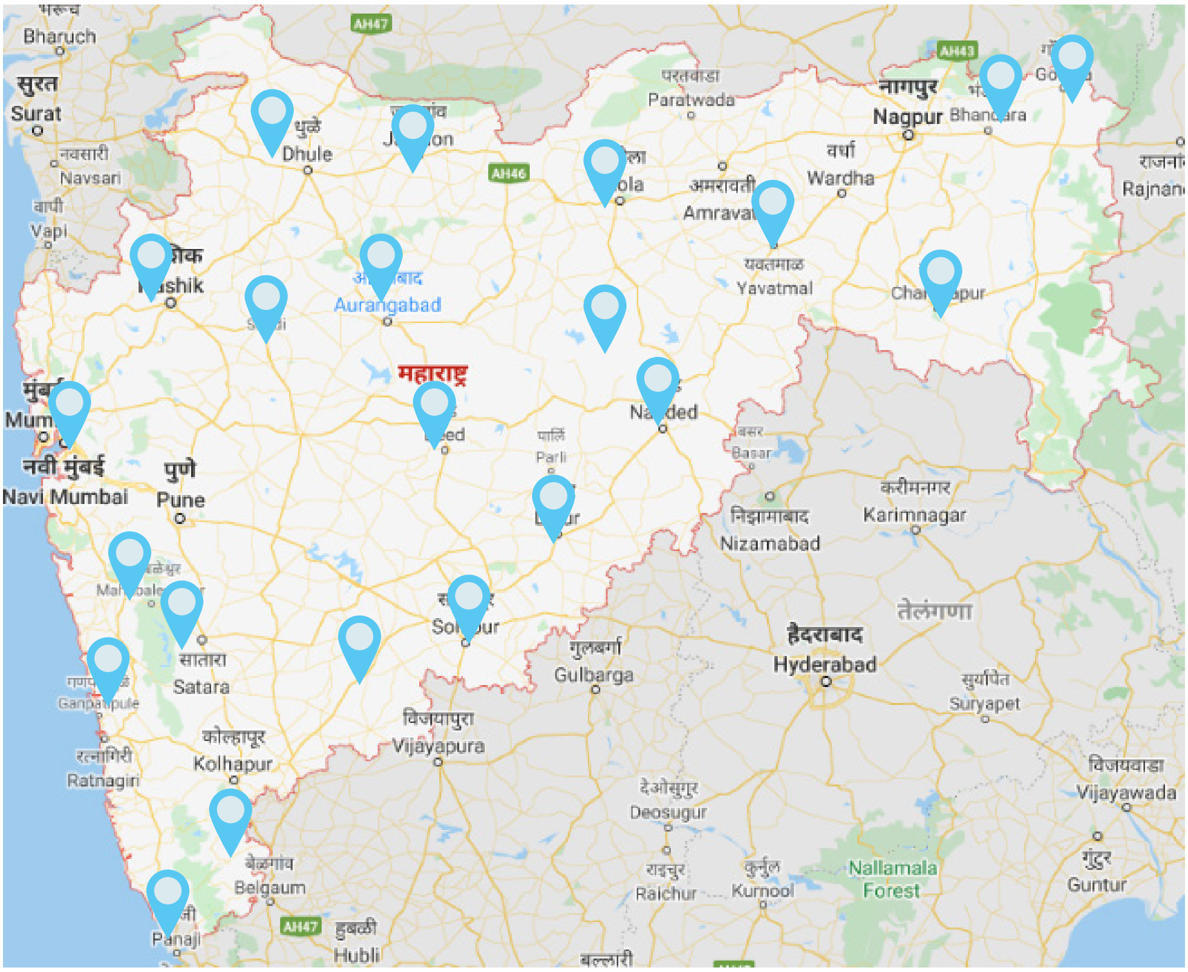

Figure A. 1: Location of charging station in phase III

Published by the
Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

On the behalf of
Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV)

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Designed by:
Aspire Design, New Delhi

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