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ENABLING THE SHIFT TO ELECTRIC AUTO-RICKSHAWS

A Guidebook for Electrification of Auto-rickshaw Fleets in Indian Cities

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ABOUT THE PARTNERS

This guidebook is a collaborative effort between WRI India and the National Institute of Urban Affairs (NIUA) under the aegis of the City Investments to Innovate, Integrate and Sustain (CITIIS) program.

WRI India, an independent charity legally registered as the India Resources Trust, provides objective information and practical proposals to foster environmentally sound and socially equitable development. Our work focuses on building sustainable and liveable cities and working towards a low-carbon economy. Through research, analysis, and recommendations, WRI India puts ideas into action to build transformative solutions to protect the earth, promote livelihoods, and enhance human well-being.

National Institute of Urban Affairs is a premier institute dedicated to urban research and capacity building in India. NIUA plays a pivotal role in promoting sustainable and inclusive urban development across the nation. The CITIIS program is a joint initiative of the Ministry of Housing and Urban Affairs (MoHUA), the Agence Française de Développement (AFD), the European Union (EU), and the NIUA, that endeavors to transform Indian cities into vibrant and resilient urban spaces, aligning with global best practices and innovation.

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ABBREVIATIONS

2W	Two-Wheeler
3W	Three-Wheeler
AC	Alternating Current
ACMA	Automotive Component Manufacturers Association
AfD	Agence Française de Développement
AGR	Annual Growth Rate
AIS	Automotive Industry Standard
AMC	Annual Maintenance Contract
AMRUT	Atal Mission for Rejuvenation and Urban Transformation
ARAI	Automotive Research Association of India
ASCL	Amritsar Smart City Limited
AuSa	Auto Savari
BaaS	Battery-as-a-Service
BEE	Bureau of Energy Efficiency
BIS	Bureau of Indian Standards
BSES	Bombay Suburban Electric Supply Limited
CAGR	Compound Annual Growth Rate
CEA	Central Electricity Authority
CEO	Chief Executive Officer
CESL	Convergence Energy Services Limited
CiSTUP	Centre for infrastructure, Sustainable Transportation and Urban Planning
CITIIS	City Investments to Innovate, Integrate and Sustain
CNG	Compressed Natural Gas
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CPO	Charge Point Operator
CRUT	Capital Region Urban Transport
DC	Direct Current
DDC	Dialogue and Development Commission of Delhi
DFC	Delhi Finance Corporation
DHI	Department of Heavy Industries
DISCOM	Distribution Company
DMRC	Delhi Metro Rail Corporation
DSEU	Delhi Skill and Entrepreneurship University
DST	Department of Science and Technology
DTL	Delhi Transco Limited
E-2W	Electric Two-Wheeler
E-3W	Electric Three-Wheeler
E-4W	Electric Four-Wheeler
EESL	Energy Efficiency Services Limited
EJADCS	Ernakulam Jilla Auto-Rickshaw Drivers' Co-operative Society
EMI	Equated Monthly Instalment
EPCA	Environment Pollution (Prevention and Control) Authority
EV	Electric Vehicle
EVSE	Electric Vehicle Supply Equipment
FAME	Faster Adoption and Manufacturing of Electric Vehicles
FC	Finance Commission
FY	Financial Year
GCF	Green Climate Fund
gCO_2e	Grams of carbon dioxide equivalent
GDP	Gross Domestic Product
GHG	Greenhouse Gas

GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
GoI	Government of India
GST	Goods and Services Tax
ICE	Internal Combustion Engine
IEA	International Energy Agency
IoT	Internet of Things
IPT	Intermediate Public Transport
ITF	International Transport Forum
KMC	Kochi Municipal Corporation
KMRL	Kochi Metro Rail Limited
KSEB	Kerala State Electricity Board
kWh	Kilowatt-hour
LEV	Light Electric Vehicle
LPG	Liquified Petroleum Gas
LTVR	Loan-to-Value Ratio
MFI	Micro Finance Institution
MoEFCC	Ministry of Environment, Forest and Climate Change
MoHUA	Ministry of Housing and Urban Affairs
MoP	Ministry of Power
MoPNG	Ministry of Petroleum and Natural Gas
MoRTH	Ministry of Road Transport and Highways
MoU	Memorandum of Understanding
MSME	Micro, Small & Medium Enterprises
MUDRA	Micro Units Development and Refinance Agency Limited
NAAQS	National Ambient Air Quality Standards
NABL	National Accreditation Board for Testing and Calibration Laboratories
NBFC	Non-Banking Financial Companies
NCAP	National Clean Air Programme
NCT	National Capital Territory
NOx	Nitrogen Oxides
OEM	Original Equipment Manufacturer
PAT	Perform Achieve Trade
PCS	Public Charging Stations
PLI	Production Linked Incentive
PM	Particulate Matter
PMC	Pole Mounted Charger
PMMY	Pradhan Mantri MUDRA Yojana
PPCB	Punjab Pollution Control Board
PPP	Public Private Partnership
PTI	Press Trust of India
PUC	Pollution under Control
RAAHI	Rejuvenation of Auto-Rickshaw in Amritsar through Holistic Intervention
RBI	Reserve Bank of India
RTA	Regional Transport Authority
RTO	Regional Transport Office
SBI	State Bank of India
SERC	State Electricity Regulatory Commission
SIAM	Society of Indian Automobile Manufacturers
SNA	State Nodal Agency
SOUA-DTGA	Statue of Unity Area Development and Tourism Governance Authority
STA	State Transport Authority
TCO	Total Cost of Ownership
TOI	Times of India
TS-REDCO	Telangana State Renewable Energy Development Corporation Limited
TWU	Three Wheels United
UITP	Union Internationale des Transports Publics
ULB	Urban Local Body
UMTA	Unified Metropolitan Transport Authority
USD	United States Dollar
VKT	Vehicle Kilometers Travelled
WEF	World Economic Forum
YoY	Year-on-Year

Foreword

Shri Hardeep Singh Puri
Minister of Housing and Urban Affairs; and
Petroleum and Natural Gas,
Government of India

हरदीप एस पुरी
HARDEEP S PURI

आवासन और शहरी कार्य मंत्री
पेट्रोलियम एवं प्राकृतिक गैस मंत्री
भारत सरकार
Minister of
Housing and Urban Affairs; and
Petroleum and Natural Gas
Government of India

Foreword

India stands at a pivotal juncture in its journey towards sustainable urban development. The nation's inevitable economic growth is intricately linked to its urbanisation. As we embrace this transformation, the role of our cities becomes increasingly significant, and their sustainability and resilience are paramount.

Under the visionary leadership of the Hon'ble Prime Minister, India has adopted innovative technologies and sustainable practises, particularly in the realm of urban development. With the rapid growth of urbanisation and the resulting challenges, it becomes imperative to harness technology and policy measures that not only address these challenges but also pave the way for a cleaner, greener and more efficient urban landscape.

India, as a global leader in urban transformation, has set its sights on electrifying auto-rickshaw fleets, contributing not only to reducing pollution but also to creating new economic opportunities and enhancing the quality of life for our citizens.

This document "Enabling the Shift to Electric Autorickshaws: A Guidebook for Electrification of Autorickshaw Fleets in Indian Cities" signifies our commitment to fostering sustainable urban mobility. It recognises that auto-rickshaws, which are an integral part of urban transport, can be a driving force in creating eco-friendlier and efficient transportation systems.

This transition to electric auto-rickshaws aligns with our broader efforts to integrate green technology into urban mobility solutions. I compliment the CITIIS program by NIUA and WRI India for producing this invaluable resource which will no doubt guide our efforts towards replicating this innovation in cities across India.

(Hardeep S Puri)

New Delhi,
06 October, 2023


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Message

India's rapid urbanisation is closely tied to its economic growth. As more people move to cities, there's a need to ensure that this growth is beneficial for all. Cities contribute almost two-thirds of the country's economic output. Therefore, it's crucial to focus on making cities more liveable and sustainable.

The document, "Enabling the Shift to Electric Auto-rickshaws: A Guidebook for Electrification of Auto-rickshaw Fleets in Indian Cities," reflects the commitment to promoting sustainable urban mobility in India. It recognises that the auto-rickshaw segment, an integral part of urban transportation, has the potential to reduce pollution and contribute to an eco-friendlier transportation system. The guidebook is expected to act as a practical guide to help cities and stakeholders transition their auto-rickshaw fleets to electric ones.

The transition to electric vehicles, including in the auto-rickshaw segment, is seen as part of a larger narrative of innovation and sustainability. It represents a positive step toward a more sustainable future. This guidebook provides a good illustrative mention of several key strategies and actions that can be taken in this regard. The government is providing financial incentives, subsidies, and tax breaks to both auto-rickshaw manufacturers and buyers to make electric auto-rickshaws more affordable along with establishing clear regulations and standards for electric auto-rickshaws, including safety, emissions, and performance standards. Examples mentioned in the guidebook demonstrate various steps that can be taken to promote financial inclusion by providing banking and digital payment solutions to auto-rickshaw drivers, making it easier for them to manage their finances and repay loans.

Shri Kunal Kumar

Joint Secretary and Mission Director, Smart Cities Mission
Ministry of Housing and Urban Affairs
Government of India

Message

I am delighted to introduce this document, which represents the culmination of extensive research, collaboration, and a shared commitment to addressing crucial issues in the field of urban development. This document is an indication of our collective dedication to progress and excellence. It encapsulates the wisdom, expertise, and dedication of the individuals and teams that have contributed their time and energy to its creation. It is a symbol of our commitment to making a positive impact in sustainable mobility.

As we explore the contents within these pages, I invite you to consider the insights, recommendations, and best practices presented. They are the product of countless hours of work, thoughtful analysis, and the desire to effect meaningful change. I encourage you to engage with the material, ask questions, and explore new avenues for collaboration and improvement.

This document is not just a collection of words and ideas; it is a call to action. I would like to express my deepest gratitude to all those who have contributed to the creation of this document. Your dedication and expertise have been instrumental in shaping its content and vision.

To our readers, I extend my warm thanks for your interest and engagement. Your commitment to positive change is what will ultimately propel us forward on our collective journey.

Thank you for being a part of this important endeavour.

Shri Hitesh Vaidya
Director
National Institute of Urban Affairs
New Delhi

Message

India aims for an urban future that is economically vibrant and environmentally friendly. A key step towards this vision is the adoption of electric vehicles that can cut down transport emissions and make our cities sustainable. The transition to electric auto-rickshaws signals a pivotal shift toward cleaner transport in urban India. The electrification of auto-rickshaws promises a multitude of benefits, from reduced air pollution and greenhouse gas emissions to enhanced livelihoods for drivers and improved access to safe, affordable mobility for all.

Ever since their introduction in the late 1950s, auto-rickshaws have grown to emerge as the linchpins of India's urban mobility network. They offer crucial first and last-mile connectivity through a vast fleet of over 7 million vehicles and cater to passengers from diverse socio-economic backgrounds. Auto-rickshaws have evolved in terms of better efficiency, reduced emissions, improved engines, and the introduction of compressed natural gas (CNG) operations. Their electrification will mark the next chapter in this fascinating journey of transition.

Our new guidebook serves as a guiding light in the dynamic urban mobility landscape. It offers a roadmap for policymakers to create policies and regulations that accelerate the transition to electric auto-rickshaws. It provides practical examples of partnerships and collaborations necessary to implement the transition on-ground. Our aim with this guidebook is twofold: to provide cities with a comprehensive roadmap for transitioning to electric auto-rickshaws and to emphasize the significance of equity and inclusion in India's electrification journey. We understand that real progress goes beyond mere technological change; it lies in ensuring that the benefits of this transition are accessible to all, particularly to marginalised communities and women.

This guidebook is a product of the collective efforts of stakeholders working for cleaner and more inclusive urban transport. It highlights the crucial role of auto-rickshaw drivers and the commitment of cities to transform their mobility systems.

At WRI India, we have long been committed to advocating the role of auto-rickshaws as a clean, safe and affordable mode of transport in our cities. Over the past decade, we have published a range of research findings and undertaken several initiatives to strengthen India's auto-rickshaw sector. We are grateful to have contributed to the development of this guidebook, further pursuing our commitment to promote auto-rickshaws as a low-carbon and accessible mode of transport. We hope this guidebook can support cities and states in achieving our shared vision of efficient, affordable and equitable urban mobility for all.

Shri Madhav Pai
CEO
WRI India


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Executive Summary

Highlights

- This guidebook provides a roadmap for governing authorities and policymakers to create an enabling policy and regulatory framework for an accelerated transition to electric auto-rickshaws.
- Auto-rickshaws (autos) are an important mode for shared mobility, and first and last-mile connectivity in cities, with about 7.1 million vehicles across India contributing to a quarter of urban trips.
- Electric auto-rickshaws (e-autos) have significant environmental and socio-economic benefits, with the potential to reduce carbon emissions, improve air quality, and reduce vehicle operating costs for drivers.
- While the central and state governments have notified policies to promote electric vehicles (EVs), barriers such as restrictive permit regulations, limited choice of e-auto models, high upfront costs, lack of charging infrastructure, and poor access to financing impede electrification of auto-rickshaws.
- The guidebook provides direction to states and local bodies to work with relevant government authorities and private enterprises to implement a robust support ecosystem towards reducing entry barriers, installing efficient charging infrastructure network, and improving access to affordable EV financing.
- We discuss three cases of auto-rickshaw electrification initiatives in Indian cities, to highlight the challenges in enabling an effective transition to e-autos as well as the policy and regulatory measures and the stakeholder participation needed for an equitable transition.


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Context

The transport sector is one of the highest and fastest growing contributors to greenhouse gas (GHG) emissions and urban air pollution in India (Hagemann et al. 2020; GoI 2022b; Banerjee et al. 2022). In addition, the rising price of crude oil and India's high dependence on its imports (MoPNG 2018) highlight the need for alternative fuel technologies. EVs powered by a progressively cleaner electricity grid with a growing share of renewable energy can decarbonise the carbon-intensive road transport sector and enable the transition towards sustainable mobility. EVs, which have zero tail-pipe emissions, can also contribute to reduced urban air pollution and its adverse health impacts.

The Government of India has committed to achieving a 30 percent market share of EVs among new vehicle sales by 2030 (Clean Energy Ministerial 2023). With purchase subsidies, exemptions on road taxes and registration fees, and other incentives, central and state-level authorities are promoting the shift to electric mobility. The transition is expected to be driven by two- and three-wheelers, which are targeted to capture 80 percent market share among new vehicle registrations by 2030 (NITI Aayog and RMI 2019).

Auto-rickshaws are an important mode of shared mobility in Indian cities, typically accounting for 5-25 percent of all motorised trips (Thakur et al. 2018; Mani et al. 2012). With their role in providing access to transportation for lower-income groups, and their high daily utilisation, there are environmental as well as socio-economic benefits to electrifying auto-rickshaws. Not only do e-autos help reduce transport emissions, but also help reduce operating costs (in terms of maintenance and energy costs) that can improve driver income and reduce travel expenditure for low-income urban residents.

With a 5 percent EV penetration rate among auto-rickshaws, the e-auto transition is still at a nascent stage. This is unlike the more ubiquitous e-rickshaws, which are a 3-wheeled low-speed vehicle operated by a lead-acid or lithium-ion battery, intended to provide last-mile connectivity for passengers. These have grown at a rapid pace in Delhi, Uttar Pradesh, Bihar and other regions, and account for 91 percent of all e-three-wheelers (e-3Ws) on road (MoRTH 2023). E-autos have higher upfront costs and are more heavily regulated (more stringent homologation norms, fare and permit regulations, etc.), which has resulted in low levels of adoption despite their positive total cost of ownership (TCO) benefits and lower operating costs as compared to their internal combustion engine (ICE) counterparts (WRI India 2020). Additional barriers such as lack of charging and battery swapping infrastructure and lack of access to financing further impede uptake by fleet operators and individual owner-drivers. These barriers need to be mitigated to increase adoption and achieve an accelerated transition to electric auto-rickshaws that benefits the drivers, the commuters as well as the environment.

Key considerations for an integrated and accelerated transition to e-autos

Subnational and local authorities must work with one another and private sector partners for an integrated approach to auto-rickshaw electrification, as part of a comprehensive EV transition. Manufacturers need to ensure the availability of good quality products with specifications that match the requirements of auto-rickshaw drivers, such as adequate vehicle range and compatibility for fast charging. Public and private sector stakeholders, including urban local bodies, smart city corporations, state government departments, nodal agencies for transport electrification, metropolitan transport authorities, distribution utilities, fleet operators, charging infrastructure operators, and financing institutions, should work together to create a roadmap for the e-auto transition, with supporting policies and regulations, and effective implementation strategies and partnerships.

Demand and supply side policies and regulations can provide the necessary Impetus for increased e-auto adoption. Purchase and operating incentives as well as regulatory measures like permit provisions improve the ease of procurement and cost-competitiveness of e-autos and support their adoption. Cities and states can implement good

practices based on ongoing initiatives across India and formulate policies to support the e-auto ecosystem, including e-auto manufacturers, dealers and drivers.

An accessible charging infrastructure network is essential to enable efficient operations and mitigate range anxiety amongst e-auto drivers. Auto-rickshaw drivers often do not own their vehicles and may lack access to residential EV parking and charging facilities. Cities must plan for public charging networks that are integrated with available vehicular parking facilities, maximise accessibility and utilisation and ensure affordable charging services for drivers. Location planning for charging infrastructure should take major auto-rickshaw hubs and operating routes into consideration. For e-autos, cities can deploy a mix of slow chargers for overnight plug-in charging, fast chargers for opportunity charging, and battery swapping stations at designated parking spaces for increased utilisation through a mix of implementation models.

Affordable financing options for e-auto ownership can enable an equitable transition for auto-rickshaw drivers. Literature suggests that auto-rickshaw ownership offers better savings and higher overall incomes for drivers than renting (Khan 2017; Singh and Jena 2018). However, drivers often find it difficult to own vehicles due to lack of access to formal and affordable credit. State governments, non-banking financial companies (NBFCs), and fin-tech companies can ensure access to affordable e-auto financing through concessional and innovative measures, such as interest rate subvention, credit guarantee, increased loan payback duration, reduced or zero down payment, community engagement to support positive loan repayment behaviour among borrowers, and use of digital technologies to govern underwriting decisions. Alternate procurement or service provision models, such as demand aggregation, vehicle leasing or battery-as-a-service, can also reduce the upfront costs for drivers and promote access to affordable financing. Finally, green financing schemes (to supplement upfront financing) and climate financing schemes (to monetise carbon emissions reduction) can be developed and leveraged for commercial EV financing.

An inclusive and equitable e-auto transition requires a multi-pronged strategy with effective on-ground implementation. The cases in the guidebook, which include pilot initiatives from Amritsar, Kochi and Delhi, underscore the importance of a holistic approach. Such an approach not only aims to promote e-auto adoptions but also focuses on ensuring stable livelihoods, enabling the inclusion and participation of drivers and auto-rickshaw unions in the transition, and prioritising job creation and opportunities for women, and under-represented and marginalised groups. At the same time, they highlight the challenges of implementing inclusive measures, such as increasing women's participation in transport sector jobs. They also point to the need to understand and address the barriers in enabling an equitable transition.

About this guidebook

This guidebook provides a roadmap for passenger auto-rickshaw electrification, bringing much-needed focus on this critical vehicle segment within the urban transport ecosystem in India. It offers a comprehensive overview of policies, incentives, and regulations to promote the e-auto transition, with a focus on enabling measures such as charging infrastructure development and EV financing that are essential to catalyse the transition.

The primary audience for this guidebook is local and state government agencies responsible for driving the on-ground transition of e-autos, and policymaking and regulatory authorities at the central and state levels. The guidebook focuses on urban regions, ranging from smaller cities to metropolitan areas, which have higher concentrations of auto-rickshaws. However, semi-urban and rural areas are also likely to benefit from policy and regulatory changes at the state level and can use the roadmap laid out in the guidebook to support e-auto adoption in their regions. The secondary audience includes the e-auto manufacturers, mobility service providers or fleet operators, financing institutions, charging service providers, auto-rickshaw driver unions, and other stakeholder groups comprising the auto-rickshaw ecosystem in cities.

The guidebook is based on an extensive literature review of relevant publications (discussing the auto-rickshaw sector in India, planning processes for EV

charging infrastructure, total cost of ownership for EVs, mobilising financing for EVs, etc.), policy documents, such as EV policies and mobility plans from the central and state governments, and media sources, such as blogs, newspaper articles, and websites. Discussions with private sector stakeholders including vehicle manufacturers, charging service operators, fleet operators, investors, and financing agencies helped with the assessment of the industry landscape.

In addition, discussions with relevant government and non-government bodies in Amritsar and Kochi provided a better understanding of the status of the initiatives and the challenges in implementation. The document also uses data on permit regulations, road taxes, electricity tariffs for EV charging, etc., from state government agencies, such as state transport and energy departments, to inform the policy and regulatory recommendations, and the total cost of ownership analyses.

The scope of the guidebook is limited to passenger auto-rickshaw electrification and does not include e-rickshaws, which face different challenges, such as low-quality products, poorly regulated operations, and polluting battery recycling systems. Also, it does not cover the electrification of three-wheeler freight vehicles, the ecosystem for which involves different stakeholders and is governed by different economic and regulatory parametres.

The guidebook does not address the capacities and competencies of government authorities and other relevant stakeholders, nor does it consider external factors like supply side constraints, macroeconomic conditions, changes in global EV trends, or unexpected technological breakthroughs.

How to use the guidebook

This guidebook navigates the dynamic landscape of auto-rickshaw electrification with a pragmatic approach, providing actionable insights drawn from robust research, stakeholder engagements, and city examples, as discussed below:

1. Overview of electric auto-rickshaw ecosystem:

Chapter 1 discusses the urgency and significance of electrifying passenger auto-rickshaws. It delves into the unique challenges faced by this sector and outlines the broader socio-economic and environmental implications of electricfication.

2. Planning and policy roadmap for auto-rickshaw electrification:

Chapter 2 presents a comprehensive planning and policy roadmap for local and state government agencies, policymakers, and regulatory authorities. This chapter equips the readers to navigate the intricate policy landscape and establish the foundation for a successful transition.

3. Developing the charging infrastructure network:

Chapter 3 delves into the crucial topic of charging infrastructure. By unravelling the complexities of charging network implementation, this chapter guides stakeholders in building a robust ecosystem that supports the electrification of auto-rickshaws.

4. Financing and deployment models:

Chapter 4 presents e-auto financing models and innovative deployment methods, diving into the financial mechanisms and partnerships necessary to bridge the affordability gap and ensure a seamless transition for drivers and operators.

5. Transition pathways for cities:

Assessing city-level cases, and highlighting effective strategies and good practices, Chapter 5 offers valuable insights for an accelerated adoption of electric auto-rickshaws.

Introduction

In the past two decades, India has witnessed rapid urbanisation and motorisation, resulting in an increase in transport sector emissions. Between 2009 and 2019, vehicle registrations in the country have grown by a compounded annual growth rate (CAGR) of 9.96 percent (MoRTH 2019). The transport sector is the third highest and fastest growing contributor to CO_2 emissions in the country (Hagemann et al. 2020), with road transport accounting for 90 percent of all transport emissions (MoEFCC 2021b). Transport is also a major contributor to urban air pollution in Indian cities (Banerjee et al. 2022), which rank among the lowest in air quality in the world. Additionally, with a fuel mix comprising 72 percent diesel, 23 percent petrol, and CNG, LPG and other fuels making up the remaining 5 percent, the transport sector reinforces India's energy dependence on imported crude oil (MoPNG 2018).

There is a need for alternative fuel technologies, to mitigate transport sector emissions and prioritise India's energy security. Electric mobility, with its benefits of zero tailpipe emissions and reduced CO_2 emissions (which can be further amplified through a greener electricity grid), has been identified as a key decarbonisation pathway for the carbon-intensive transport sector. India has set an ambitious target of having 30 percent share of electric vehicles (EVs) among vehicle sales by 2030 (Clean Energy Ministerial 2023). This will result in estimated crude oil import savings of more than INR 1.1 lakh crores (USD 13.25 billion) (Soman et al. 2020). It will also contribute to India's updated nationally determined contribution (NDC) of 45 percent reduction in emissions intensity of Gross Domestic Product (GDP) from 2005 levels by the target year (GoI 2022b).

Contributing to the 30@30 target, the Government of India has targeted 80 percent EV penetration of two-wheelers and three-wheelers among new vehicle sales by 2030 (NITI Aayog and RMI 2019). Passenger auto-rickshaws comprise a major part of three-wheeler registrations — which was 75.5 percent in 2022 (MoRTH 2023) — excluding e-rickshaws, and offer an affordable and reliable means of personal and shared transportation. Further, given their substantial daily utilisation of 100–120 km (Thakur and Pal 2018), shifting from ICE to electric auto-rickshaws can significantly contribute to reducing vehicular emissions in cities.

However, the electrification of auto-rickshaws is still in its nascency, with challenges like lack of access to finance, inconsistent permit regulations, and lack of charging infrastructure resulting in slow uptake. Addressing these challenges requires a planned and comprehensive approach to accelerate the e-auto transition in towns and cities.

Designed to catalyse the electrification of passenger auto-rickshaws in Indian cities, this guidebook is intended to address the specific challenges and opportunities within this critical vehicle segment of urban transportation. With a targeted focus on passenger auto-rickshaws, this resource provides a roadmap that empowers local and state government agencies, policymakers and industry stakeholders, to navigate the complexities of the electrification of auto-rickshaws.

1

Overview of Electric Auto-rickshaw Ecosystem

Auto-rickshaws are a vital and iconic vehicle segment in India's urban transport systems, providing affordable and accessible mobility to millions of commuters daily. Their transition to electric operation has significant potential environmental benefits, through reduced CO_2 and criteria pollutant emissions. Auto-rickshaws are also operated and used by lower-income drivers and commuters, and hence electric autos will enable an inclusive and equitable EV transition.

E-auto suppliers, after some initial performance challenges, are offering more road-worthy vehicles that have lower total cost of ownership (TCO) than ICE auto-rickshaws over the life of the vehicle. However, challenges persist, hampering the accelerated adoption of e-autos, and will need to be tackled through a mix of policy and implementation measures.

1.1. Auto-rickshaws in Indian transport systems

Auto-rickshaws, also referred to as tuk-tuks, bajajis, bao-baos and baby taxis in different countries, are motorised, three-wheeled vehicles that are used for passenger transport, predominantly in parts of Africa, and South and Southeast Asia. Typically used as vehicles for hire or for shared mobility services, auto-rickshaws are characterised as intermediate public transport (IPT) and fill the mobility gap between private vehicles and formal public transport networks.

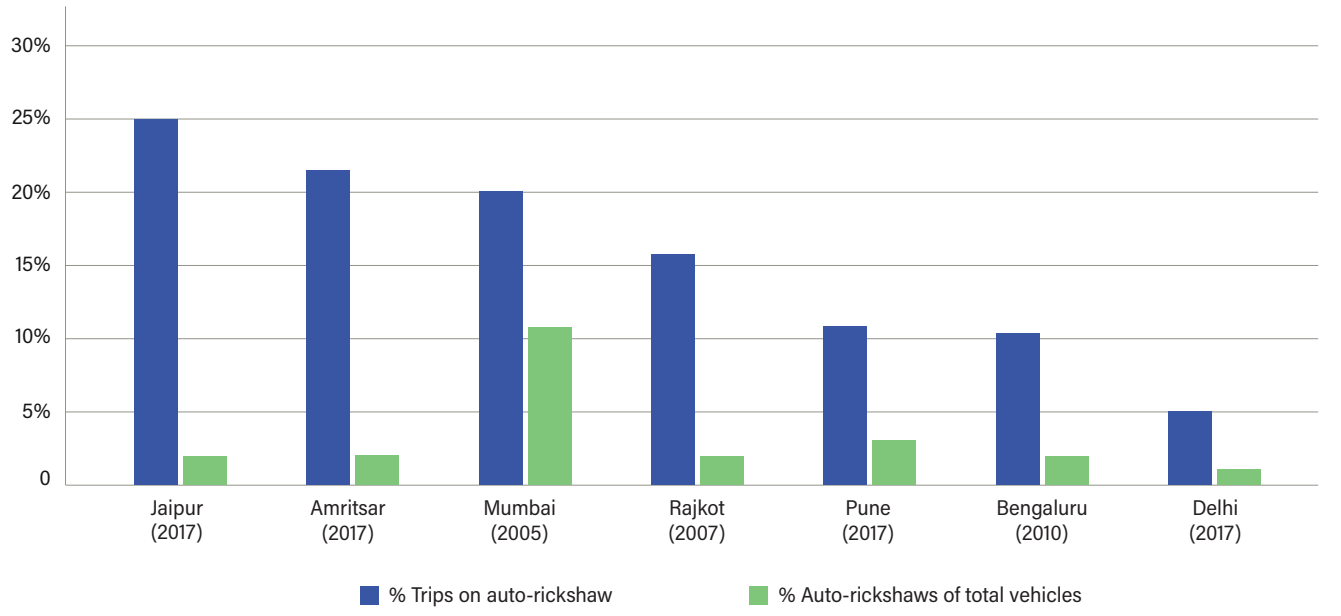
In India, auto-rickshaws operate on diesel, petrol, liquified petroleum gas (LPG), and compressed natural gas (CNG) variants, with carrying capacities ranging from 3-7 passengers. They offer contract carriage services, providing dedicated, door-to-door trips for commuters. They also ply as shared services along fixed routes, with frequent schedules between origins and destinations having high traffic but weak transit connectivity. In smaller cities and towns with minimal city bus services, auto-rickshaw fleets act as informal public transport. In metropolitan regions, they provide end-to-end trips for shorter distances and act as first and last-mile feeder services to public transit.

The average distance travelled by an auto-rickshaw is 100-120 km/day (Thakur and Pal 2018), with an average daily ridership of 45 passengers (Bagul et al 2021). A 2019 survey of commuters found that 30 percent of respondents from metro cities, 24 percent from tier-1 cities, and 22 percent from tier-2 cities commute using auto-rickshaws (Soman et al 2019).

In most cities, the mode share of auto-rickshaws is higher than their respective share in vehicle registrations. For example, in Amritsar and Jaipur, auto-rickshaws constitute only 2 percent of the motor vehicle registrations but carry 22-25 percent of all trips (Thakur et al. 2018). Figure 1 provides an overview of the mode share vs. vehicle registrations of auto-rickshaws in some Indian cities.

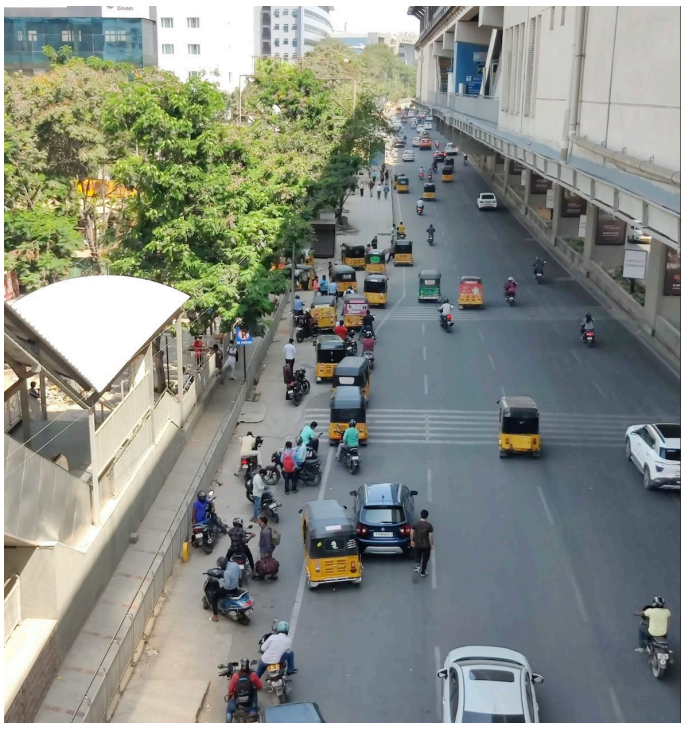
Being widely available and providing an affordable alternative to taxi services, auto-rickshaws improve mobility and access for commuters who do not own or use personal vehicles. They are also an important mode of mobility for women, who on average have lower vehicle ownership rates and whose travel needs are often not catered to by formal public transport networks (Shah et al. 2017).

FIGURE 1 | Share of auto-rickshaw trips vs registrations



Sources: Mani, et al. 2012 ; Thakur, et al 2018 ; BMRCL; DULT 2019; MCGM 2016.

FIGURE 2a | Auto-rickshaws near a metro station in Hyderabad
FIGURE 2b | Overcrowded shared IPT services carrying passengers in Bhopal



Credit: Kanika Gounder (WRI India)

1.2 E-auto technology and supply ecosystem

Internal combustion engine (ICE) auto-rickshaws have a traditional drivetrain with an engine, clutch, gearbox, differential, torque couplings, and a chassis that is built from heavier metal components. An e-auto on the other hand, is considerably lighter in its build, with an electric drivetrain having fewer moving parts. As a result, EVs require less maintenance and are more efficient, converting over 77 percent of electrical energy consumed to power, as compared to 12-30 percent for ICE vehicles (Lovell 2020). E-autos also have an advantage over ICE auto-rickshaws in peak power specifications, but they have a lower average driving range due to battery pack size limitations.

Table 1 provides a comparison of specifications of an ICE auto and an e-auto, based on Mahindra's Alfa petrol vehicle and Mahindra Treo, its electric drivetrain counterpart.

Appendix A provides detailed specifications of e-autos in the Indian market.

1.2.1 E-auto manufacturing landscape

India is a leader in the global three-wheeler market, with established original equipment manufacturers (OEMs) like Bajaj Auto, Mahindra, and Piaggio capturing more than 90 percent of the domestic market (Autocar Professional 2022). In the financial year FY 2021-22, the production volume in India crossed 7.5 lakh units, of which 4.9 lakh (60 percent) units were exported to other countries (SIAM 2022). By comparison, the manufacturing landscape for electric auto-rickshaws in the country is still nascent, with only 4,250 e-autos registered in the same financial year.

However, central government initiatives such as the Production Linked Incentive (PLI) scheme for advanced auto and component manufacturing, state government industry incentives, and growing consumer demand are promoting EV and component manufacturing, including for e-3Ws. Piaggio and Bajaj Auto are two such companies approved under the scheme for e-3W production in the country (MHI 2022b), while other major manufacturers include Kinetic Green and Mahindra Electric. Newer e-3W OEM startups like ETO Motors, Biliti Electric, E-Trio, and Baxy Mobility have also entered the market, introducing new e-3W models and ramping up manufacturing capacity.

TABLE 1 | Comparison of specifications for an ICE auto and an e-auto

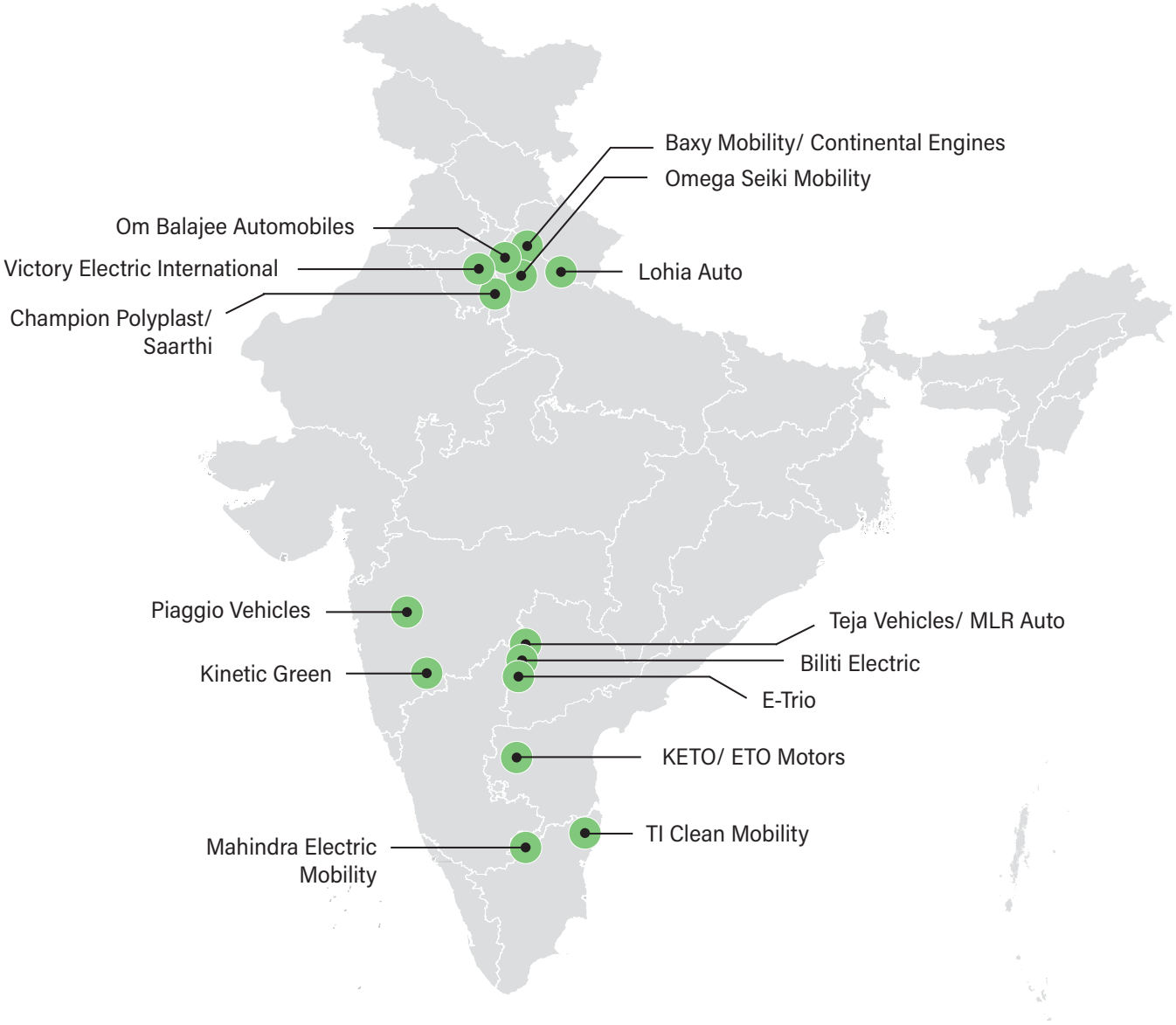
SPECIFICATION	ICE AUTO-RICKSHAW	ELECTRIC AUTO-RICKSHAW
Peak power	5.7 kW @ 3,600 rpm	8 kW
Peak torque	18 Nm @ 2,000-2,400 rpm	42 Nm
Maximum speed	53 km/hr	55 km/hr
Range	300 km	130 km (Drivable)
Fuel source	Petrol	48 V, 7.37 kWh lithium-ion battery
Gradeability	18%	12.7%
Vehicle curb weight	460 kg	367 kg

Source: Auto-rickshaw model specifications Mahindra & Mahindra Ltd. 2022; Mahindra Electric 2022.

FIGURE 3 | An electric auto-rickshaw in South Delhi

Credit: Kanika Gounder (WRI India)

FIGURE 4 | Current location of plants manufacturing electric auto-rickshaws



Note: This map is for illustrative purpose and does not imply the expression of any opinion on the part of WRI, concerning the legal status of any country or territory or concerning the delimitation of frontiers or boundaries.

Sources: Rohan Rao et al. 2021; ACMA and Yes Bank 2021; company websites Baxy Mobility 2023; Teja Vehicles 2023; Om Balajee Automobiles 2023; OSM 2023 ETEnergyworld 2022.

Electric three-wheeler manufacturing is concentrated in Delhi, Uttar Pradesh, Haryana, and Uttarakhand in the north and Maharashtra, Telangana, Andhra Pradesh, and Karnataka in the south. A key manufacturing challenge faced by OEMs is the scarcity and high cost of raw materials such as lithium-ion cells for batteries which increases the dependency on imports. This acts as a major roadblock towards investments in the sector (TOI 2022b), which can be reduced by localisation of the value chain. Also, being global leaders in the three-wheeler space, India can tap into export markets for enhancing scale. Companies like Biliti Electric export electric three-wheelers to the US, Europe and African markets (Financial Express 2022d). Other OEMs such as Omega Seiki Mobility and Altigreen also plan to export cargo electric three-wheelers to South Asian, African and South American markets for last-mile deliveries (PTI 2023; TOI 2022c). With the needed push from the government, the e-auto industry is expected to be fully localised by 2025, further reducing the manufacturing cost and increasing adoption (ACMA and Yes Bank 2021).

BOX A: RETROFITTED AUTO-RICKSHAWS

Much like the CNG and LPG retrofit kits that are available to convert diesel and petrol auto-rickshaws, EV retrofit kits may be used to convert a conventional auto-rickshaw into an e-auto. Retrofit kits, also known as electric propulsion kits, are governed by the Automotive Industry Standard AIS-123 (Part 3), published by the Automotive Research Association of India (ARAI) (ARAI and MoRTH 2018).

Retrofitting provides the opportunity to accelerate the e-auto transition by converting operational auto-rickshaws to electric vehicles. Moreover, it reduces the upfront cost of owning an e-auto, with retrofit kits costing about 75 percent of a new e-auto (including the EV battery cost) (Pers. Comm. 2021).

Retrofitting is a viable alternative for auto-rickshaws that are 4-5 years old, or older. With companies offering innovative solutions such as no-cost retrofit kits combined with battery swapping services for powering e-autos, this nascent market is expected to provide an alternative bridge to electrifying the auto-rickshaw segment. Companies in this space include Volta Automative India, Envirosmart, Retron Energies, and RACEnergy.

FIGURE 5 | A retrofitted e-auto at a battery swapping station in Hyderabad

Credit: Kanika Gounder (WRI India)

FIGURE 6 | A conventional auto-rickshaw being converted into an e-auto with a retrofit kit

Credit: Pers. Comm. 2022b

1.3 Benefits of electric auto-rickshaws

As of August 2023, there are more than 71 lakh (7.1 million) passenger auto-rickshaws registered in India, of which 44.5 percent are powered by diesel, 17 percent by petrol, 7.8 percent by CNG, and 1.5 percent by LPG. The rest are hybrid vehicles operating with a mix of petrol, CNG, and LPG (MoRTH 2023). ICE auto-rickshaws emit significant amounts of CO_2, particulate matter, black carbon, and nitrogen oxides (NOx), among other gases (Thakur et al. 2018). Lifecycle emissions for diesel and CNG auto-rickshaws, which include emissions from manufacturing, operations, and end-of-life processes, are 177 grams of carbon dioxide equivalent (gCO_2e) and 122 gCO_2e of GHG emissions per vehicle km respectively (World Bank and ITF 2023). Many ICE auto-rickshaws in India continue to operate on two-stroke engines, which are a major source of PM_{10} emissions. This is particularly evident in cities like Bengaluru, where these engines contribute approximately 114.6 tonnes of PM_{10} emissions annually. High emissions are caused due to the incomplete combustion of fuel, leading to environmental pollution and impacting the power and torque output of these vehicles. Since auto-rickshaws have a higher daily usage (vehicle kilometres travelled per day) as compared to other personal transport modes, a transition to e-autos can substantially reduce emissions of CO_2 and other pollutants, and produce health benefits for urban inhabitants (Thakur et al. 2018).

According to a 2017 study, about 1,200 tonnes of carbon emissions were generated every day by a fleet of more than 1.2 lakh (120,000) auto-rickshaws in Bengaluru. A 100 percent transition to e-autos could potentially reduce 0.45 million tonnes of carbon emissions per year (Thakur et al. 2018), which is equivalent to the impact of planting 22.5 million trees (One Tree Planted 2023). It could also reduce emissions of other pollutants, with estimated reductions of 164.6 tonnes of PM_{10} and 1,445.3 tonnes of NOx per year (Thakur et al. 2018).

In addition to the environmental benefits, e-autos have economic benefits for drivers earning their livelihood in the sector. The monthly operating costs of an e-auto, comprising of electricity and maintenance costs, are approximately one-third of that of an ICE auto-rickshaw (see Table 2). This results in a substantial increase in take-home income for e-auto drivers. This net benefit persists despite the higher purchase costs of an e-auto and the periodic battery replacement costs, as shown in Box C.

BOX B: GHG EMISSIONS FROM TRANSPORT SECTOR ACROSS MAJOR CITIES IN INDIA

Transport sector contributes a high share to GHG emissions. Depending on the mode share and travel characteristics, transport sector's GHG emissions ranges from 13-57 percent in seven major cities of India.

FIGURE 7a | Transport sector's GHG emissions in major cities in India (2015)

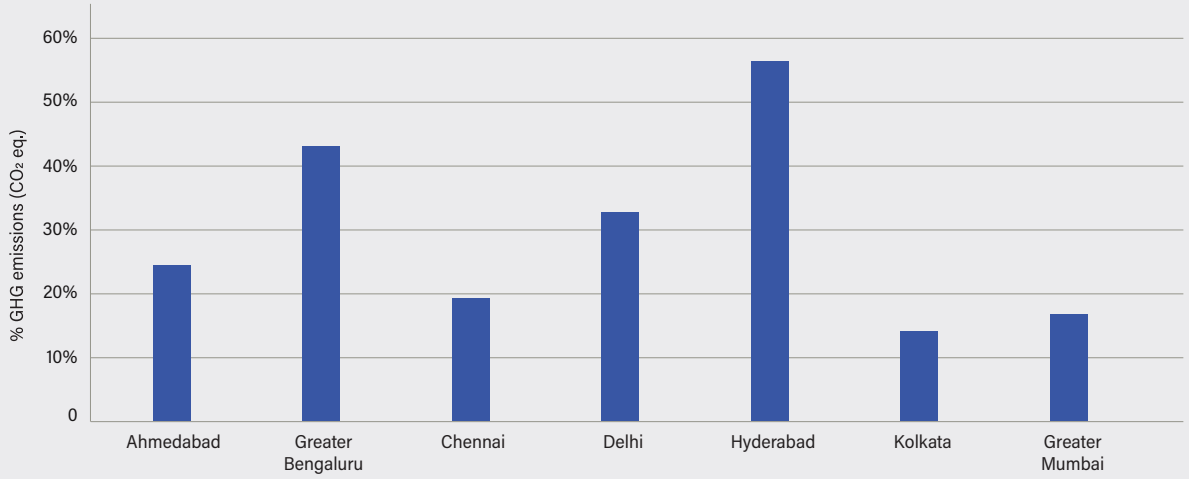
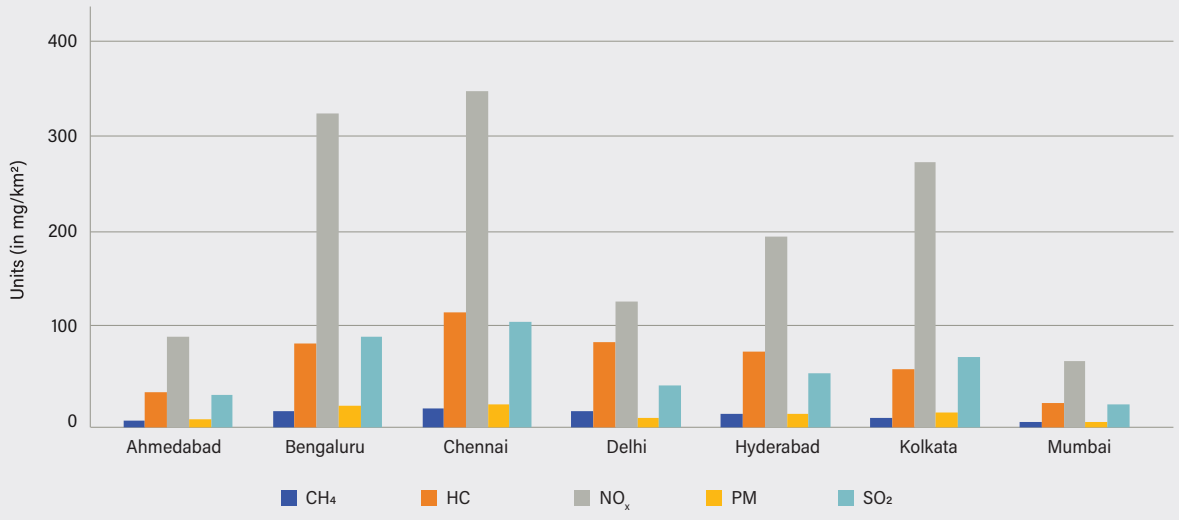


FIGURE 7b | Amount of other air pollutants emitted by the transport sector in major cities (2009)



Sources: Ramachandra et al. 2015; Ramachandra and Shwetmala 2009.

BOX C: TOTAL COST OF OWNERSHIP (TCO) OF AUTO-RICKSHAWS

Transitioning to e-autos can result in higher incomes and savings for drivers. Total cost of ownership (TCO) for an asset includes its purchase costs as well the operating costs over the asset's lifetime. The purchase cost of a new ICE auto-rickshaw at INR 2.9-3 lakhs (USD 3,615) is lower than that of an e-auto at INR 3.8 lakh (USD 4,580) after subsidies. However, even after accounting for two battery replacements, the operating costs for an e-auto for 10 years are substantially lower, resulting in a lower TCO per km for e-autos (see Table 2).

TABLE 2 | Total cost of ownership for auto-rickshaws by fuel type over a 10-year period.

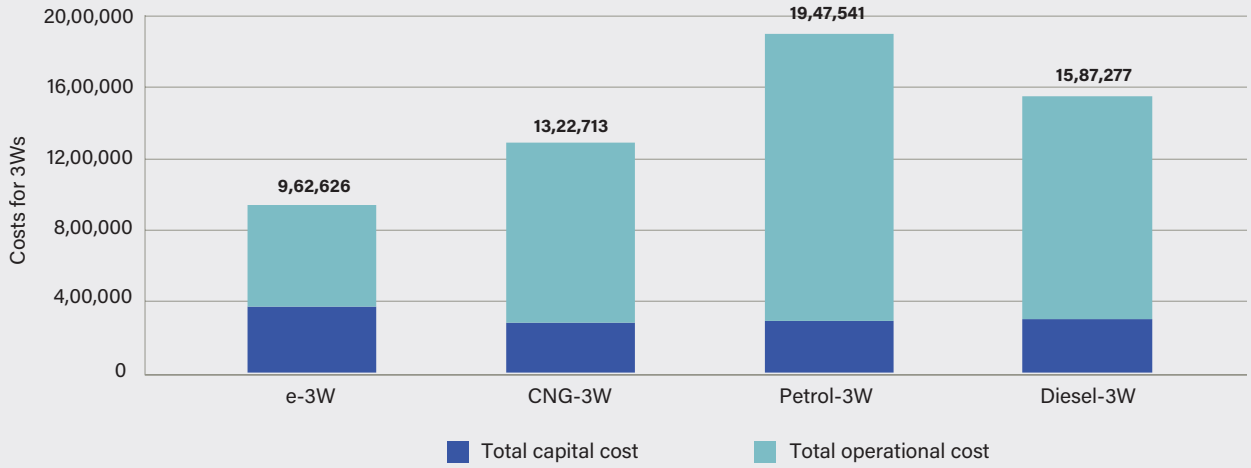
Type of cost		E-3W	CNG-3W	Petrol-3W	Diesel-3W
Capital Cost	Total Vehicle Cost (₹)	3,66,906	2,40,000	2,40,000	2,40,000
	Financial Incentive (₹)	66,523	-	-	-
	Tax (₹)	4,000	4,549	9,055	4,638
	Average 3-year Insurance Cost (₹)	7,500	5,040	7,515	13,254
	Effective Vehicle Cost (₹)	3,11,883	2,49,589	2,56,570	2,57,892
	Remaining Insurance Cost (₹)	17,500	11,760	17,535	30,926
	Interest Rate (%) for 3 years at 90% LTV ratio	14	10	11	10
	Additional Interest Paid (₹)	53,277	27,370	24,759	18,897
	Total Capital Cost (₹)	3,82,660	2,88,719	2,98,864	3,07,715
Operational Cost	Energy Cost (₹/kWh; ₹/kg; ₹/L; ₹/L)	8	75	95	90
	Mileage (km/unit energy)	10	28.4	20.1	25.4
	Average Yearly Energy/Fuel Cost (₹) (considering 100 VKT/day)	29,200	82,394	1,47,463	1,10,551
	Battery Replacement (₹)	1,83,956	-	-	-
	Annual Maintenance Cost (₹)	10,401	21,005	17,405	17,405
	Total Operational Cost (10 years) (₹)	5,79,966	10,33,994	16,48,677	12,79,562
Average TCO (₹/km)		2.53	2.90	3.31	3.17

Note: Assumptions like interest rates for loans (Revfin 2023) and charging cost per unit referred (Mehta and Mehrotra 2022) are subject to change as per market rates; VKT – vehicle kilometres travelled.

Source: TCO Evaluator developed and published by WRI India 2020.

On a per kilometre basis, the average TCO for CNG autos is about 15 percent higher than e-autos, and 31 percent higher for petrol autos. The total capital and operational expenses of e-autos for 10 years (Figure 8) are respectively 27 percent and 50 percent cheaper than CNG autos.

FIGURE 8 | Comparison of total cost of ownership (in INR) of auto-rickshaws by fuel type, at an average daily travel distance of 100 km for 10 years of operation



Sources: WRI India Analysis; Kumar and George 2020; Kumar and Chakrabarty 2020.

The transition to e-autos also offers an opportunity for the entry of women, transgenders, and other marginalised groups into the transport workforce. E-autos are easier to handle and maintain as they are gearless systems. They have lower noise emissions, fewer vibrations, and lower maintenance requirements. Further, government and private sector stakeholders are promoting women's inclusion in the sector through initiatives such as the provision of reserved e-auto permits for women (as in the case of Delhi, discussed in Chapter 5) and hiring of women drivers for e-auto fleets. However, systemic barriers such as entrenched gender norms, safety issues, access to finance, etc. will need to be addressed for the greater inclusion of women in the e-auto workforce.

1.4 Barriers to the growth of e-autos

Despite the potential socio-economic and environmental benefits of e-autos, there are several barriers associated with their adoption, such as lack of knowledge about e-autos, high capital costs, lack of charging infrastructure, inconsistent or unsupportive regulations, and lack of access to affordable financing (Kant et al. 2021).

Lack of knowledge

Drivers lack knowledge of EV technology and its benefits such as lower operational costs and zero tailpipe emissions. In many cases, they are also unaware of EV subsidies and beneficial permit norms for e-autos.

Low availibility of charging infrastructure

Auto-rickshaws serve trips within the city, but also travel to nearby towns or villages as a means of inter-city transport. Low availability of charging infrastructure, such as plug-in charging points and battery swapping stations, in cities and on highways causes range anxiety among drivers.

High upfront costs

The purchase cost for an e-auto (including the FAME-II subsidy) is still higher than an ICE auto-rickshaw. Without additional purchase subsidies or other financial support from the state, it is a challenge for the drivers to reduce the gap.

Unsupportive policy and regulatory environment

While the Government of India (GoI) has exempted all EVs, including e-autos, from permit requirements (MoRTH 2018a), most states are yet to implement this measure. Further permit related incentives like priority permits for e-autos, reservations for women or ownership of bulk permits by fleet operators, etc. are also inconsistent across states.

Increased downtime due to slow charging

Typical e-autos have an optimal driving range of 85-130 km on a fully charged battery. With average vehicle utilisation for auto-rickshaws going up to 120 km per day (Thakur and Pal 2018), e-auto drivers may need to charge the vehicle during the day.

Limited model availability

Currently the number of electric auto-rickshaw models in the Indian market is limited in contrast to the array of traditional ICE vehicles. Consequently, drivers might discover their choices restricted in relation to ICE auto-rickshaws.

Lack of access to financing

Formal banks often do not lend to 3W drivers due to the perceived risk in the sector, while other financing institutions offer expensive loans with high interest rates and short repayment tenure. Loans for e-3Ws are even more scarce and expensive, due to the associated technological risks and unknown resale value of EVs.

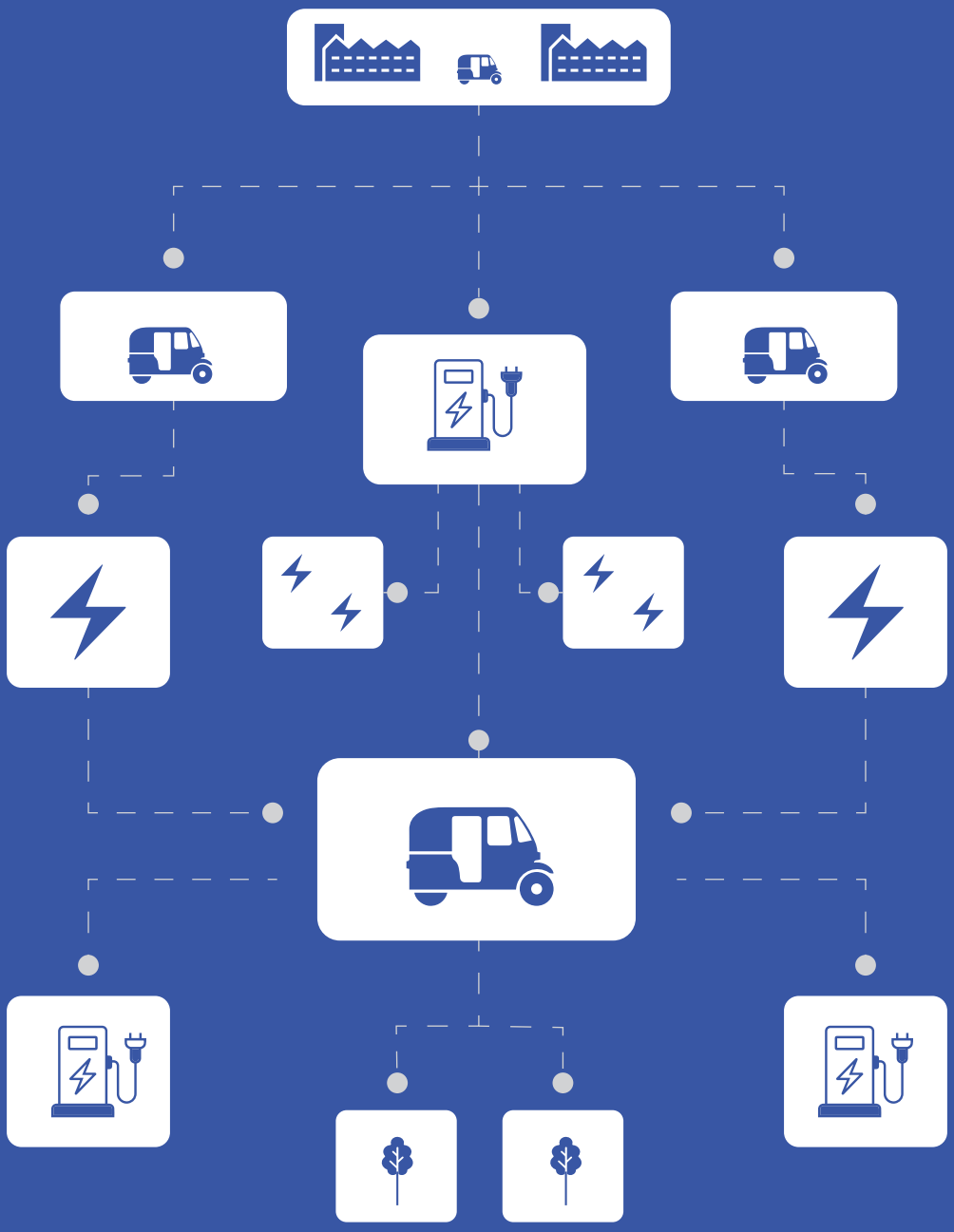
Other Barriers

While the transition to e-autos offers a livelihood opportunity for generating livelihoods for women and other marginalized groups, gender discrimination and exclusion from formal or informal auto-rickshaw drivers' networks can present additional barriers.

2

Planning and Policy Roadmap for Auto-rickshaw Electrification

The e-auto transition is at a nascent stage, with only 43,530 e-autos registered in the country (as of August 2023) (MoRTH 2023). Of the 3.17 lakh (3,17,503) passenger auto-rickshaws registered in 2022–23, 15,247 were e-autos, which equals an EV penetration rate of 4.8 percent for the segment. The International Energy Agency (IEA) projects a 48 percent market share of new auto-rickshaw registrations for 3-wheelers by 2030, for which 2.88 lakh e-autos will need to be registered annually by 2030-31 (IEA 2021b) (see Annexure B for details). Achieving this target will require a massive scale-up in the adoption of e-autos across metropolitan areas, smaller cities and towns.



BOX D: REGISTRATION AND CLASSIFICATION OF AUTO-RICKSHAWS ACROSS INDIA

In FY 2022-23, 3.06 lakh auto-rickshaws were registered across India. Of these, 71 percent were CNG and LPG auto-rickshaws, while 14 percent were diesel-powered and another 10 percent were petrol vehicles. Electric auto-rickshaws constituted only 5 percent of the total share (MoRTH 2023). While no reliable public data is available on the total stock of auto-rickshaws on Indian roads, the share of diesel auto-rickshaws is significantly higher, followed by petrol and CNG variants. E-autos constitute a negligible share of the total number of auto-rickshaws.

FIGURE 9a | Total passenger 3W registrations from 2014 to 2023

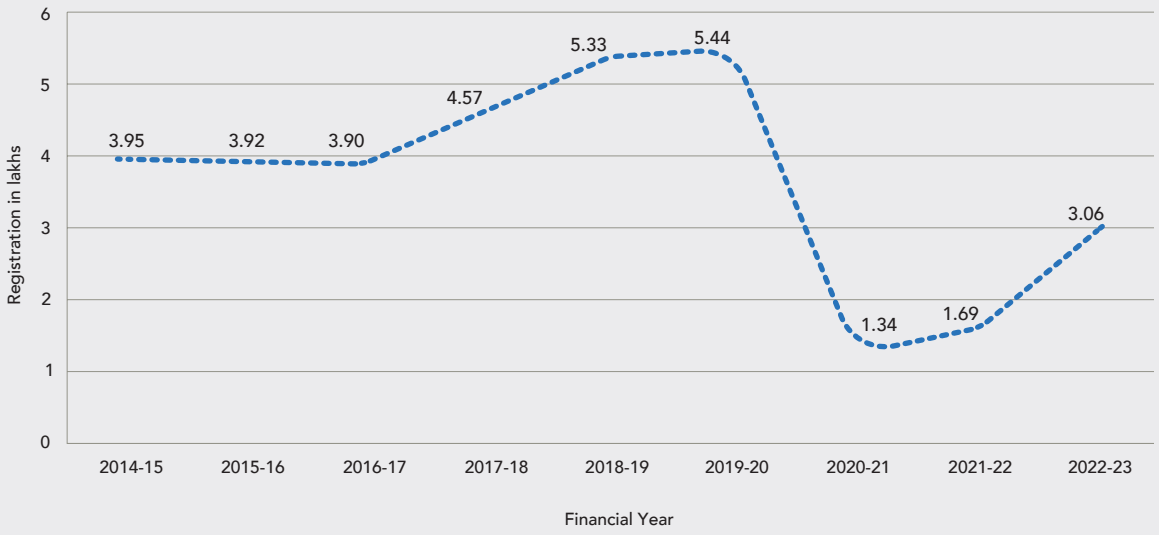
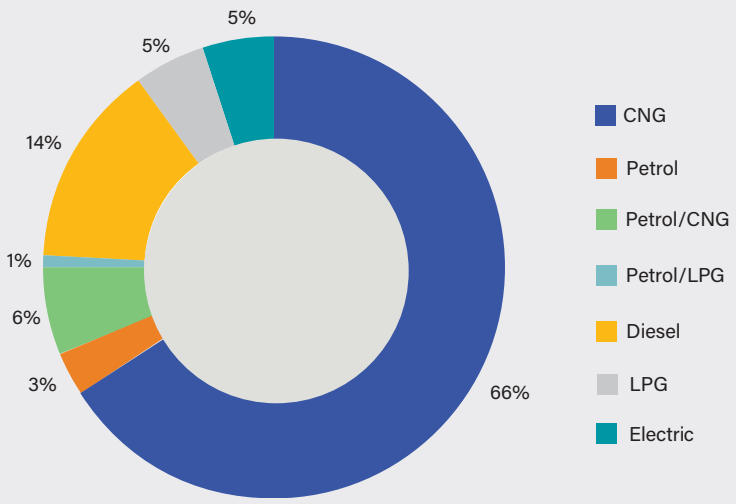


FIGURE 9b | Passenger 3W sales by fuel type in FY 22-23



Source: Vahan Database (MoRTH 2023)

State and local governments play an important role in enabling an accelerated and inclusive transition to e-autos, by developing a clear roadmap and supportive policy and governance frameworks. This chapter highlights the planning and policy measures required to promote the uptake of e-autos and an integrated governance structure across state and local governments, and non-government stakeholders.

2.1 Planning roadmap for auto-rickshaw electrification

The transition to e-autos offers an opportunity to undertake structured reforms for improved socio-economic and environmental outcomes in the largely informal paratransit sector. While the EV transition focuses largely on achieving environmental objectives, such as reduction of transport-related GHG emissions and air pollution, socio-economic objectives are equally important. For consumers, the e-auto transition should aim to enable more accessible and affordable urban transport systems. The transition can also be leveraged for socio-economic impacts, to enable better jobs and better livelihoods, and the inclusion of women in the transport workforce. In addition, the transition to e-autos can serve as a catalyst for improving road safety through the adoption of advanced vehicle technologies and enhanced safety features, such as seat belts and driver assistance systems.

This requires a programmatic approach using a well-designed mix of planning and policy measures, such as the multi-modal integration of e-auto fleets with other transport services, purchase incentives and permit regulations that promote e-autos, and the development of accessible charging infrastructure for enabling ease of operations.

Examples of auto-rickshaw electrification programmes in Indian cities, as described in Chapter 5, indicate that local and state governments are integrating measures for socio-economic outcomes, such as improving the quality of jobs and supporting workforce diversification, in their initiatives to enable a just and inclusive e-mobility transition.

2.1.1 Target-setting for e-auto adoption

State and local governments play an important role in establishing a roadmap for auto-rickshaw electrification, by setting time-bound and ambitious targets backed by policy and regulatory support. The ambition of the roadmap must be aligned with, or exceed, existing state and national targets for 3W electrification.

A local e-auto transition roadmap depends on the characteristics of the auto-rickshaw fleet in the city, including the total number of auto-rickshaws, and the age and make of the vehicles in the fleet. A detailed inventory of the city's auto-rickshaw fleet not only helps set targets for auto-rickshaw electrification, but also enables high-impact measures to convert the oldest, most polluting

TABLE 3 | State-level targets to accelerate e-auto adoption

STATE	POLICY PERIOD	TARGET
Karnataka	2017-2022	Transition to 100 percent electric auto-rickshaws by 2030.
Kerala	2018-2023	Procure 90,000 e-autos by 2022 with a pilot fleet of 50,000 by 2020.
Tamil Nadu	2019-2024	Conversion of all auto-rickshaws within 10 years in a phased manner.
Uttar Pradesh	2019-2024	Achieve 100% electric auto-rickshaw fleet in 5 major cities by 2030.
Punjab	2019-2024	25% of new auto-rickshaw sales to be electric by 2024.
Bihar	2019-2024	Phase out manually-pedalled rickshaws and upgrade them to 100% electric rickshaws by 2022.
Maharashtra	2021-2026	• At least 20% new 3W registrations to be electric by 2025. • At least 25% of the urban fleet operated by fleet aggregators and operators in the state to be EVs by 2025.
Assam	2021-2026	Deploy 75,000 e-3Ws by 2025.
Goa	2021-2026	30% of annual registrations to be electric from 2025.
Chandigarh	2022-2027	All new auto-rickshaw registrations to be electric by 2025.
Rajasthan	2022-2027	30% of all new 3-wheeler sales to be electric by 2027.

Sources: State EV policy documents: Karnataka 2017; Kerala 2018; Uttar Pradesh 2018; Punjab 2019; Bihar 2019; Delhi 2020; Maharashtra 2021; Assam 2021; Goa 2021; Chandigarh 2022; Tamil Nadu 2023; Rajasthan 2022

with most state targets extending only to 2025 and being significantly lower in ambition than what is required to achieve the national target.

within a city can be compiled to get the necessary information. For urban agglomerations, RTO data from neighboring administrative regions should also be considered to and from where auto-rickshaws may routinely ply.

E-auto targets of selected states, compiled from state EV policies, are provided in Table 3. It is observed that not all states have established targets for e-autos. Further, the states have varying targets for EV penetration over different time periods. Also, state targets do not align with the GoI target of achieving 80 percent e-3W market share by 2030, with most state targets extending only to 2025 and being significantly lower in ambition than what is required to achieve the national target.

Moreover, most states are not on track to achieving their e-auto targets. Targets, once established and aligned with the national roadmap, must be supported by appropriate policy and regulatory mechanisms, implemented through an integrated governance framework.

2.2 Institutional governance framework for e-autos

The central government has notified various policy measures and regulatory guidelines to promote EV adoption. Some of these, such as the notification permitting the sale of EVs without batteries or the notification recommending the exemption of commercial EVs from permit requirements, are meant to tackle barriers to e-auto uptake (see Annexure C for a comprehensive list of GoI measures supporting auto-rickshaw electrification). However, road transport being a state subject in the Indian Constitution (GoI 2020), it is the state and local authorities such as the transport and power departments, urban local bodies (ULBs) and power distribution companies (DISCOMs), that play an important role in the governance and implementation of the e-auto transition.

Auto-rickshaw electrification may be led by the state transport department, which is responsible for rules and regulations of auto-rickshaw operations, including commercial permits and tariff structures for auto-rickshaw services. This is suitable for state-level initiatives of 3W electrification, as part of the EV policy implementation or otherwise. In states which have a nodal department or

State Electricity Regulatory Commission (SERC)

State Power Department and Distribution Companies (DISCOMs)

State Urban Development Department

State Transport Authority (STA)

State Finance Department

Research and Development Organizations/ Institutions

State Pollution Control Boards

Other key stakeholders at the state level include:

- State electricity regulatory commission (SERC), which is responsible for regulating the EV tariffs.
- State power department and distribution companies (DISCOMs), which are responsible for electricity distribution and providing power supply connections for EV charging infrastructure.
- State urban development department, which is responsible for development control regulations for integrating EV charging in urban planning and building byelaws.
- State transport authority (STA), which is the arm of the transport department responsible for vehicle registrations across the state.
- State finance department, which is responsible for approving and allocating budgets for incentives for EV uptake.
- Academic institutions and research and development centres that play a significant role in advancing EV technologies, formulating policies, and devising strategies. They achieve this by conducting studies, engaging in research projects, and providing recommendations for policies.
- State pollution control boards that supervise environmental regulations and policies, often involved in establishing of emission standards and the promotion of EV adoption as a measure to mitigate pollution.

At the district and city levels, municipal corporations, municipalities, town panchayats, and other urban local bodies can anchor EV development initiatives, including for e-autos. Alternately, special purpose vehicles constituted by the government, like the smart city corporations or the Unified Metropolitan Transport Authorities (UMTAs), may also take the lead in supporting EV and e-auto adoption in urban areas.

Other relevant stakeholders at the local level include:

- Regional transport authorities (RTAs) and/or regional transport offices (RTOs), which are responsible for auto-rickshaw registrations and permit provision.
- Urban development authorities, which often share the responsibility for development control regulations at the local and building levels, alongside municipal bodies.
- Public transport authorities operating metro rail, bus rapid transit system or city bus services in cities.

Given the wide range of actors involved in various aspects of transport electrification including for e-autos, it is vital that a coordinated, programmatic approach be adopted. State government departments responsible for EV market development should work closely with local bodies to implement required initiatives for e-auto adoption. A regional approach is essential for auto-rickshaw electrification, especially in urban agglomerations that comprise of multiple urban local bodies.

Apart from government agencies, it is important to include non-government actors, such as automotive manufacturers and dealers, auto-rickshaw unions, financing institutions, EV manufacturers, EV fleet operators, and charging and swapping infrastructure operators, in planning and decision-making for auto-rickshaw electrification.

TABLE 4 | Demand-side incentives for e-autos in state EV policies

STATE	PRIORITY/ OPEN PERMITS	PERMITS FOR FLEET OPERATORS	PERMIT RESERVATIONS FOR WOMEN	VEHICLE SCRAPPING/ RETROFIT SUBSIDIES	PURCHASE SUBSIDIES	INTEREST SUBVENTION SCHEME
Andhra Pradesh	■	■				
Assam				■	■	
Bihar					■	
Chandigarh				■	■	
Delhi	■	■	■	■	■	■
Goa				■	■	■
Gujarat			■		■	
Haryana						
Karnataka	■					
Kerala	■					
Madhya Pradesh				■		
Meghalaya					■	
Maharashtra				■	■	
Odisha				■	■	
Punjab	■	■		■		
Rajasthan				■	■	
Tamil Nadu	■			■	■	
Telangana	■	■		■		
Uttar Pradesh					■	

Sources: State EV Policy Documents: Andhra Pradesh 2018; Assam 2021; Bihar 2019; Chandigarh 2022; Delhi 2020; Goa 2021; Gujarat 2021; Haryana 2022; Karnataka 2017; Kerala 2018; Madhya Pradesh 2019; Meghalaya 2021; Maharashtra 2021; Odisha 2021; Punjab 2019; Rajasthan 2022; Tamil Nadu 2023; Telangana 2020; Uttar Pradesh 2018

2.3 Policy and regulatory support for auto-rickshaw electrification

A successful transition to e-autos depends on a robust policy and regulatory framework. In addition to the GoI policies for electric mobility, 33 states and union territories have drafted or notified EV policies to promote adoption and manufacturing of EVs in their regions.

State EV policies vary widely in their ambition and deploy a range of incentives to achieve their objectives. Policy and regulatory incentives applicable to e-autos are presented in Table 4.

Based on a review of state EV policies in India and global best practices for promoting EV adoption, this chapter highlights key policy and regulatory measures to accelerate the e-auto transition. State and local governments will need to work together to effectively develop and implement enabling policies and regulations for e-auto adoption. Governments can also create institutional structures, forge partnerships, and promote innovative schemes (as discussed in the case studies) to undertake integrated efforts for auto-rickshaw electrification.

2.3.1 Awareness campaigns and road shows

A lack of familiarity with EV technology and limited knowledge of EV benefits are major barriers to adoption.

Local awareness campaigns and roadshows play an important role in raising awareness about EVs among transport stakeholders and the public. They allow auto-rickshaw drivers to examine and test ride different e-auto models, get information on their purchase and operational costs, and understand financing options. Word of mouth advertising from e-auto drivers is another effective means of building trust toward the new technology, which can be facilitated by peer-to-peer exchanges through awareness campaigns and EV roadshows. Fleet operators can also play a role in promoting e-autos, through ride hailing applications that permit commuters to choose e-autos for their trips and offering incentives to e-auto drivers to join their platforms.

State and local authorities can undertake awareness raising initiatives for auto-rickshaw drivers and owners, and fleet operators:

- Public funding, such as the funds provided under the "Go Electric" campaign coordinated by the Bureau of Energy Efficiency, a central government agency under the Ministry of Power (MoP), can be used for conducting workshops, roadshows, and technical discussions on e-mobility (MoP 2022c).
- Local authorities can partner with private companies, including EV manufacturers and fleet operators, to host EV rallies and exhibitions such as the Auto EV India 2022 in Bengaluru, the EV Trade Expo organised in Hyderabad, and Drive Electric Expo in Mumbai in 2022.
- Cities can launch local EV campaigns over an extended period, comprising of periodic events with different stakeholder groups and covering a wider range of topics including technology, charging infrastructure, and financing. The “Switch Delhi” campaign is a good example of this for mass outreach on EVs (see Box E for details).

FIGURE 10a and 10b | Roadshows under the Telangana “Go Electric” campaign

Note : The Telangana “Go Electric” campaign by TSREDCO conducted roadshows to create awareness for faster adoption of electric vehicles in Hyderabad.

Credit: WRI India

BOX E: "SWITCH DELHI" CAMPAIGN

The Government of Delhi undertook a mass awareness campaign entitled 'Switch Delhi' to encourage a switch from ICE vehicles to EVs among citizens, by providing information about e-mobility benefits and the incentives offered by Delhi's EV policy. This initiative included in-person meetings and interactions on social media to raise awareness, to address grievances and share success stories of EV buyers. An exclusive website for providing information on EV incentives, and to help locate EV charging and battery swapping stations in the city has been created (Delhi government 2023).

FIGURE 11a and 11b | Awareness drives with resident welfare association groups under the "Switch Delhi" campaign

Credit : WRI India

2.3.2 Purchase subsidies and tax exemptions

While the TCO for e-autos is more favourable than that for ICE auto-rickshaws, the higher purchase cost of e-autos remains a critical barrier to adoption. Reducing this price difference is essential to catalyse e-auto uptake.

The FAME-II scheme of the GoI offers a purchase subsidy on e-autos of INR 10,000 (USD 120) per kWh of battery capacity with a 20 percent cap on the cost of vehicle (MHI 2022a). For a typical e-auto with a battery size of 7 kWh, this results in a price reduction of INR 70,000 (USD 844). States such as Delhi, Maharashtra, Gujarat, and Assam, (refer Table 4) offer additional purchase subsidies on top of the FAME-II subsidy, further bringing down the purchase price of e-autos. Almost all states have exempted road and registration taxes for EVs (including e-autos), which are annually applied for commercial vehicles. Based on discussions with industry stakeholders and state transport departments, these taxes can add up to 2.5-10 percent to the on-road price of a vehicle.

States and local authorities can also tap into other sources of funding, including from the GoI, to provide subsidies and other incentives for the e-auto segment.

1. **Clean air programme grants:** The central government's National Clean Air Programme (NCAP) allocated more than INR 650 crores (USD 78.3 million) in 2019-22, for improving air quality in "non-attainment" cities that were not conforming to National Ambient Air Quality Standards (NAAQS) consecutively for five years (MoEFCC 2019). Further, the 15th Finance Commission provided a special grant of INR 4,400 crores (USD 530.3 million) to 42 cities with one million plus populations for improving air quality, with an additional INR 12,000 crores (USD 1.44 billion) allocated for the period 2021-2026 (MoEFCC 2021). State governments, by their own initiative or upon petitions from local authorities, can deploy these funds for subsidies or other incentives to public transport and shared mobility vehicles, such as e-autos.

2. **Urban rejuvenation missions:** The government's urban schemes, such as the Smart City Mission and Atal Mission for Rejuvenation and Urban Transformation (AMRUT), receive budget allocations from the centre, matched by state or municipal funding. For FY 2023-24, a budget estimate of INR 16,000 crores (USD 1.92 billion) was allocated by the GoI for these two missions

TABLE 5 | Lifetime registration tax for ICE auto-rickshaws in various states

STATE	LIFETIME REGISTRATION TAX (INR)	% VEHICLE COST (ASSUMING EX-SHOWROOM COST OF INR 2.35 LAKH)
Delhi	5,700	2.4%
Gujarat	-	2.5%
Haryana	-	5%
Punjab	400 per seat per annum	5.1%
Assam	-	10%

Sources: State Transport Departments: Commissionerate of Transport, Assam 2023; Commissionerate of Transport, Gujarat 2023; Transport Department, Punjab 2007; Transport Department, Haryana 2023; Pers. Comm. 2022a

(Economic Times 2023b). States and local authorities can utilise these discretionary funds for promoting e-mobility, with allocations for e-auto subsidies.

States can also tap other sources of financing to bolster the growth of the e-auto segment, including green funds aimed at promoting eco-friendly initiatives and sustainable transportation projects, environmental cess collections on activities contributing to pollution, revenues from pollution under control (PUC) fines, opportunities for public-private partnerships (PPPs), grants from bilateral and multilateral agencies, corporate funding through corporate social responsibility (CSR) initiatives, and leveraging revenues generated from local taxes, such as vehicle registration fees and road usage charges. Some of these are discussed in further detail in Chapter 4 .

BOX F: MAHARASHTRA UTILISES CLEAN AIR FUNDS TO ELECTRIFY PUBLIC TRANSPORT

In 2021, Maharashtra EV policy proposed 1.46 lakh (1,46,000) new battery-operated vehicles to be registered by 2025. As per the recommendations of the 15th Finance Commission (FC), Maharashtra was provided a corpus of INR 2,981 crores (USD 359.2 million) under the clean air initiative to address air pollution. The state has proposed to invest 80 percent of this fund for electrifying and deploying bus fleets in six major urban clusters, making it the only state to have utilised FC funds solely for public transportation (Desai 2021). Given the significance of auto-rickshaw fleets in providing shared mobility and alternate public transport services (in cities with small or non-existent public transport systems), similar initiatives may be adopted to support e-autos.

FIGURE 12a | Electric buses procured and deployed in Navi Mumbai
FIGURE 12b | Electric buses procured and deployed in Mumbai

Credit: WRI India

2.3.3 Permit incentives

Local contract carriage permits are issued to auto-rickshaws, which give them legal licence to ferry passengers as per the fares fixed by the state or regional transport authority (RTA). The number of auto-rickshaw permits is typically capped in large cities, to prevent over-supply of vehicles on the road and to ensure decent livelihoods for auto-rickshaw owners and drivers. As such, permits are an important regulatory tool to promote a transition to e-autos.

The 2018 notification by Ministry of Road Transport and Highways (MoRTH) directs states to exempt EVs from permit requirements (MoRTH 2018b). However, most states have not implemented the directive. While a complete permit exemption for commercial EVs may indeed lead to negative externalities such as over-supply of vehicles, there are various means by which states can use permit incentives to prioritise e-autos and de-prioritise ICE auto-rickshaws.

Permit exemptions for e-autos

State transport regulators can exempt e-autos from permit requirements for a fixed period of time, allowing them to be registered as commercial vehicles without the need for a permit. This incentivises the purchase of e-autos, as they will not be subject to the permit caps and fees that ICE auto-rickshaws must adhere to.

Priority permits and open permits for e-autos

Rather than offering permit exemptions, STAs can increase the permit cap in a city only for e-autos. Therefore, any new entrant into the 3W sector will be encouraged to purchase an e-auto, due to immediate permit availability, rather than wait for an ICE auto-rickshaw permit.

Ban on new permits and registrations for ICE auto-rickshaws

Alongside incentives for e-autos, disincentives can be levied on ICE auto-rickshaws to promote an accelerated transition. A ban on new permits for ICE auto-rickshaws does not impact existing permits in circulation, but it signals a political commitment to move away from ICE vehicles and confirms that new permits will not be available for ICE auto-rickshaws in future. Similarly, ban on registrations of petrol and diesel auto-rickshaws as introduced by the Commission for Air Quality Management (CAQM) in the National Capital Region in Haryana, Uttar Pradesh and Rajasthan (CAQM 2022), and as introduced by Punjab Pollution Control Board (PPCB 2019) in major cities of Punjab will improve uptake of e-autos.

Non-renewal of permits for ICE auto-rickshaws

To further expedite the transition of auto-rickshaws to electric, STAs can halt the renewal of ICE auto-rickshaw permits by requiring a mandatory conversion to e-autos to qualify for permit renewal. As auto-rickshaw permits must be renewed every five years, this will hasten the conversion of the existing auto-rickshaws on the road to EVs. Such a measure would need to be complemented by fiscal support instruments for e-autos and retrofit kits.

Permits for fleet operators and aggregators

Due to lack of access to financing or lack of knowledge on TCO benefits, independent owner-drivers may be slow to adopt e-autos. Allowing fleet operators and aggregators to own and operate e-auto fleets will provide a safeguard for payments, simplify the process of transferring the vehicles in the event of loan defaults, increase the share of the e-auto fleet in cities, and allow the market to grow rapidly.

BOX G: PERMIT INCENTIVES BY STATES

State EV policies have proposed a variety of permit incentives for e-autos and disincentives for ICE auto-rickshaws.

- **Priority permits and open permits for e-autos:** Andhra Pradesh offers priority permits for e-autos, whereas Delhi, Madhya Pradesh, and Tamil Nadu's policies discuss open permits for e-autos while exempting them from permit caps in effect.
- **Ban on new permits for ICE auto-rickshaws:** Delhi, Kerala, and Punjab propose that only e-autos will be granted fresh permits, which equates to a ban on new ICE auto-rickshaw permits.
- **Permits for fleet operators and aggregators:** States like Karnataka, Delhi, and Telangana allow fleet owners to own and operate e-autos, in addition to extending the same to individual drivers.

A mix of measures from the above-mentioned list can be deployed by states and cities. For instance, a one-year permit exemption for e-autos or a provision of priority permits for e-autos will increase the number of e-autos on the road. This may be supplemented by a ban on new permits for ICE auto-rickshaws or by halting the renewal of ICE auto permits, which will ensure the conversion or transition of existing auto-rickshaws to electric vehicles.

In addition to incentivising the uptake of e-autos, permit incentives for e-autos can help new drivers enter the market by increasing the supply and affordability of auto-rickshaw permits. An artificial supply scarcity in many cities has led to permit costs and vehicle transfer transactions being 2-2.5 times higher than official costs (EPCA 2010), in turn leading to debt burdens and low vehicle ownership rates among auto-rickshaw drivers.

2.3.4 Vehicle scrapping and retrofitting incentives

Scrapping and retrofit incentives are specifically targeted at accelerating the conversion of ICE vehicles on the road to EVs.

Scrapping policies and incentives offer a two-pronged strategy that not only removes polluting ICE vehicles from on-road operations but also provides added incentives to offset the purchase costs of new vehicles. The vehicle scrappage policy announced by the Government of India recommends the provision of financial incentives for the replacement of commercial vehicles that are older than 15 years. Financial incentives include scrap value of 4-6 percent of new vehicle cost from scrappage facilities, rebate of up to 15 percent on road tax from state governments, 5 percent discount on the cost of a new vehicle from manufacturers, and registration fee waiver on new vehicles purchased (MoRTH 2021).

While scrapping incentives may not be directly targeted at EV purchases, they encourage the timely replacement of older, polluting vehicle fleets with cleaner vehicles. Scrapping incentives may also be designed in tiers, with higher incentives for purchase of EVs as replacement vehicles, especially for commercial vehicle segments such as auto-rickshaws. States can consider the notification of vehicle scrappage policies and top-up scrapping incentives for EV purchases as complementary measures to other EV policies.

Retrofit incentives, in turn, support the cost-competitiveness of EV retrofit kits by providing additional purchase subsidies. Retrofitting targets older ICE vehicles with high operation and maintenance costs by promoting their conversion to EVs. This can be an affordable option for owner-drivers of ICE auto-rickshaws.

2.3.5 Usage incentives for e-autos

Apart from purchase incentives, states and cities can also deploy incentives for promoting the usage of e-autos.

Local authorities can implement various usage incentives such as free parking, intra-city toll waivers, and dedicated lanes and zones for low-emission or zero-emission vehicles. Ensuring the availability of affordable public charging infrastructure (which will be discussed in greater detail in Chapter 4) is also critical to tackle range anxiety and reduce the operating costs for e-auto drivers. Measures such as free parking and toll waivers also reduce the operating cost of e-autos vis-à-vis ICE auto-rickshaws.

BOX H: OTHER INCENTIVES FOR E-AUTO UPTAKE

States like Delhi, Odisha, Maharashtra, Chandigarh, and Goa offer scrapping incentives in their state EV policies, as an added inducement.

- Assam, Madhya Pradesh, Punjab, and Telangana offer retrofit subsidies to improve e-auto adoption.
- States such as Kerala, Punjab, and Andhra Pradesh have mandated the creation of green zones in key cities, where only EVs will be permitted to enter.
- States like Kerala and Madhya Pradesh offer exemption from parking charges for EVs. Punjab offers reserved parking slots for EVs in public parking spaces and proposes designated street parking spots equipped with street-pole charging. A dedicated parking spot with charging infrastructure available in dense urban areas would provide an additional charging spot to e-auto drivers.

Low emission or zero emission zones, which encompass specified areas in a city that permit only electric or other zero emission vehicles within their boundaries, incentivise the use of EVs through improved accessibility.

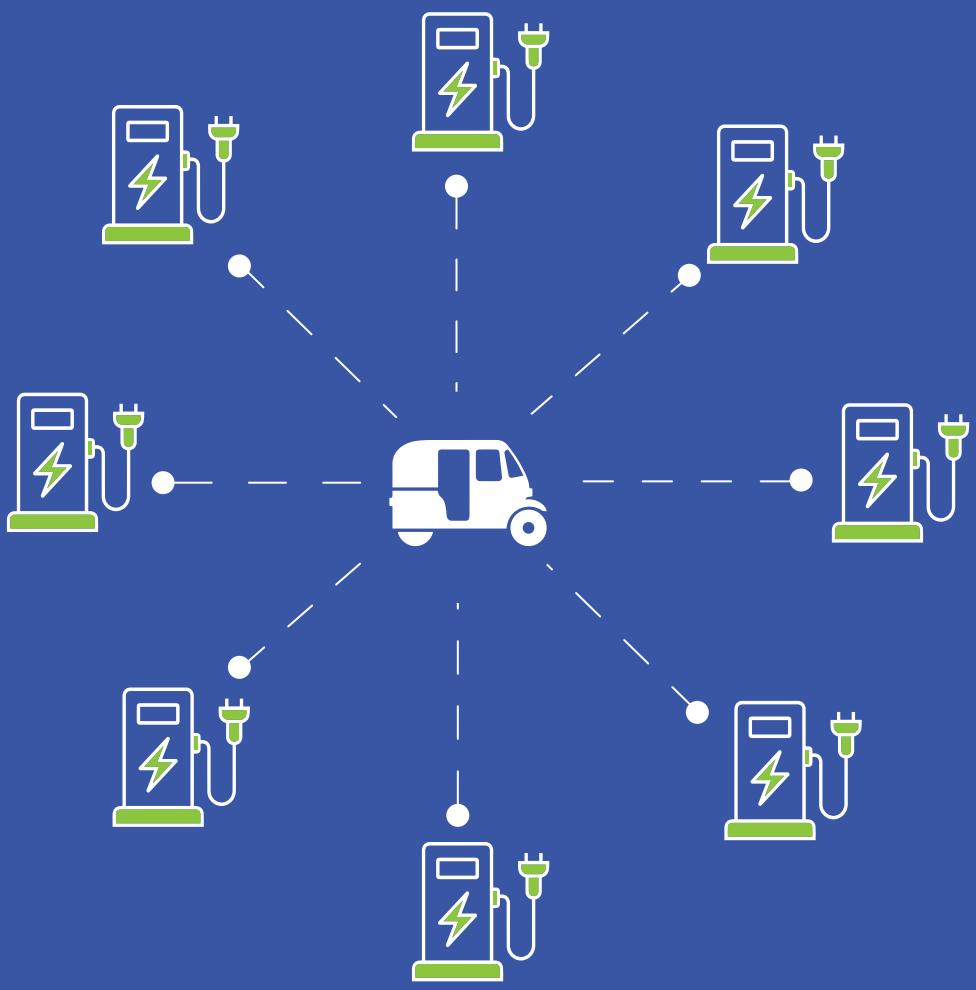
The incentives and disincentives discussed in this chapter comprise components of a holistic policy and regulatory framework to promote a shift away from ICE auto-rickshaws to e-autos. Not all policies and regulations will be suitable for every region, as each region will need a contextual and tailored policy framework that maximises impact and minimises negative externalities. States and local authorities should adopt a participatory approach in designing policies and incentives for e-autos, by consulting a wide range of stakeholders including auto-rickshaw unions and drivers, e-3W OEMs, charging infrastructure providers, and fleet aggregators.

3

Developing the Charging Infrastructure Network

An accessible and affordable charging infrastructure network is an essential prerequisite for EV adoption. The majority of auto-rickshaws are rented vehicles, and auto owners and drivers often live in housing without access to residential EV charging. Uptake of e-autos therefore needs a wide availability of parking spaces equipped with robust public charging infrastructure networks to serve the charging requirements of e-3W fleets.

Local authorities, in consultation with electricity distribution companies, need to plan for dense, accessible public charging networks to eliminate range anxiety, which remains a key barrier to EV adoption.



3.1 Charging infrastructure requirements for e-autos

Requirements of electric vehicle supply equipment (EVSE), or EV charging infrastructure, depend on the technical specifications and usage patterns of EVs. E-2Ws and e-3Ws in the Indian market are powered by low-voltage batteries (24-72V), with most models having voltages up to 60V. They require compatible charging infrastructure that is distinct from chargers that serve electric cars and buses, since the latter have high-voltage battery systems of 300-1,200V.

Fast charging solutions for e-autos, although highly beneficial in reducing charging time, have not yet become mainstream due to several key challenges like the high cost and infrastructure requirements, especially for smaller cities and regions, and the lack of standardisation and compatibility issues among different e-auto models and charging networks. However, with ongoing advancements in technology, cost reductions, and increased awareness, fast charging solutions are poised to play a more significant role in the future of e-autos.

In terms of usage patterns, commercial vehicles like e-autos run about 120 kilometres daily (Thakur and Pal 2018). With most e-auto models having a range of 100-120km, a mix of overnight slow charging and mid-day opportunity charging is required to fulfil charging requirements. Cities planning for public charging networks for their e-auto fleets can therefore consider a mix of slow and fast plug-in charging for low-voltage EVs, as well as battery swapping options.

3.1.1 Conductive charging

Conductive charging, or plug-in charging, is the mainstream charging technology in use for EVs. E-autos, like other e-2Ws and e-3Ws, are typically charged through alternating current (AC) chargers, with a portable charging cable that plugs into the vehicle at one end and into the charging point at the other end. Alternately, some e-autos may also permit direct current (DC) charging, also known as fast charging.

The "Charging Infrastructure for Electric Vehicles - Guidelines and Standards" issued by the Ministry of Power (MoP), the last consolidated revision of which was released in January 2022, recommends that public charging stations install any combination of specified charger types (MoP 2022). Table 6 highlights the charger types that are compatible with e-autos.

While any e-auto may charge at the Bharat AC-001 chargers and light EV AC chargers, e-autos charging at Bharat DC-001 or light EV DC chargers will need to be compatible with the charger connectors. Bharat AC-001 and DC-001 are older specifications for EV charging, which were released by the Department of Heavy Industries (DHI) to support EV charging for low voltage vehi-

TABLE 6 | Charger specifications for e-3Ws

CHARGER TYPE	POWER LEVEL	OUTPUT VOLTAGE	CHARGING DEVICE	EV-EVSE COMMUNICATION	CHARGE POINT PLUG/SOCKET	VEHICLE INLET/ CONNECTOR
Bharat AC-001	3 CG of 3.3 kW each	230V			IS-60309	As per EV manufacturer
Bharat DC-001	15 kW	48V				GB/T
Light EV AC	Up to 7 kW		IS-17017-22-1	Bluetooth low energy	IS-60309	As per EV manufacturer
Light EV DC	Up to 7 kW		IS-17017-25 [CAN]		Combined socket under development	IS-17017-2-6

Source: Charging Infrastructure for Electric Vehicles – Guidelines and Standards (MoP 2022)

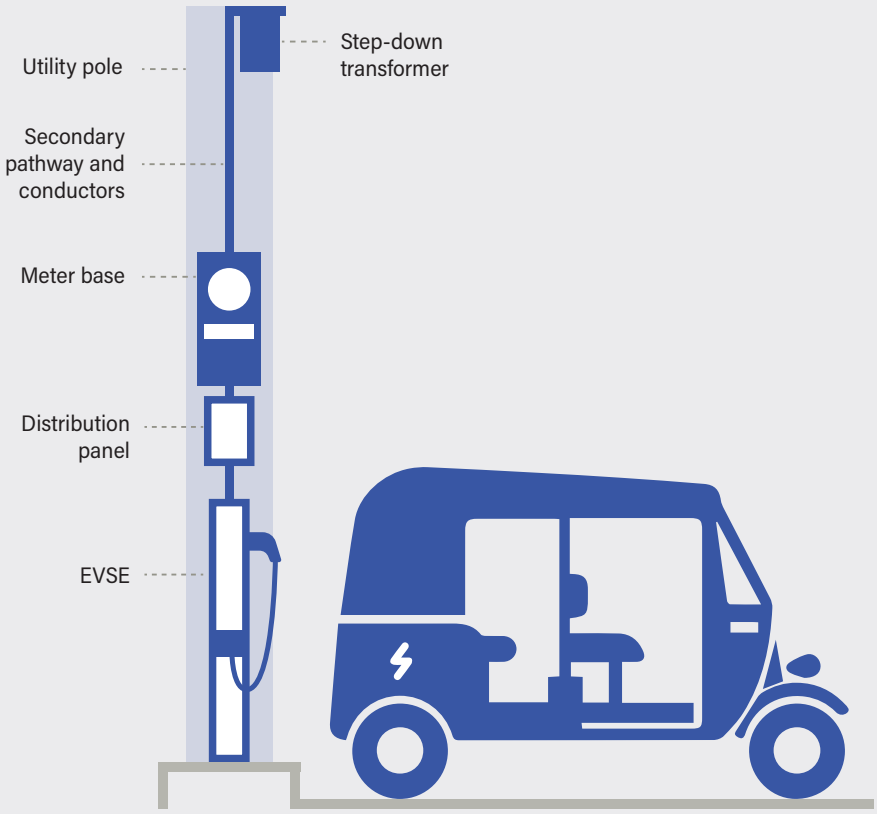
cles. The light EV AC and light EV DC charging standards, released by the Bureau of Indian Standards (BIS) in 2021 (MoP 2022), are expected to become the norm for light EV charging in future.

The MoP (2022) standards and guidelines state that any chargers other than the ones specified above may be used for public charging of e-2Ws and e-3Ws, provided that they are compliant with the technical and safety standards prescribed by the Central Electricity Authority (CEA). The guidelines also specify that all charger models should have been type tested by any agency or lab accredited by the National Accreditation Board for Testing and Calibration Laboratories (NABL) from time to time.

Cities should ensure that all public charging infrastructure installed in their regions should adhere to the standards and guidelines mentioned above. To enable this, local authorities may work with the designated state nodal agencies (SNAs) or with the serving DISCOMs to set out local guidelines for public EV charging.

BOX I: POLE-MOUNTED CHARGING (LEV AC, SC)

FIGURE 13 | Diagram for a pole-mounted charger



Pole mounted chargers (PMCs) are a type of low-cost charging infrastructure ideal for e-autos. Generally deployed on streetlights or utility poles for easier street side access to e-3Ws, PMCs provide greater manoeuvrability in installation and also enable more distributed installation of chargers.

An example of successful on-ground implementation of PMCs can be seen in Kerala, where the Kerala State Electricity Board (KSEB) deployed 1,150 PMCs across the state. Recognised by the India Smart Grid Forum for emerging innovation in the domain of electric mobility, the chargers are widely used by more than 4,500 e-autos (The Hindu 2023).

Source: Werthmann and Kothari 2021

3.2 Battery swapping

Battery swapping involves removing and replacing a drained EV battery with a fully charged battery, in compatible EVs with removable batteries. It is a type of 'battery-as-a-service' (BaaS) model, in which the cost of the EV battery can be decoupled from the cost of the vehicle. An EV buyer can therefore pay separately for the use of an EV battery through lease, subscription, or pay-per-use models.

Supported by the MoRTH notification permitting sale and registration of e-2Ws and e-3Ws without pre-fitted batteries (MoRTH 2020), battery swapping can significantly reduce the upfront purchase cost of an EV. An additional advantage of battery swapping is its speed. While charging an e-auto through plug-in charging may take anywhere from one hour (for DC charging) to 5 hours, battery swapping can be executed in 2-3 minutes. This significantly reduces the downtime of e-autos and increases earning potential for e-auto drivers.

A critical factor for the success of battery swapping is the establishment of a dense and well-connected network of interoperable swapping stations that align with auto-rickshaw travel patterns in a city. However, a lack of standards for battery swapping stations and swappable batteries has limited the use of battery swapping thus far, with EV manufacturers and battery swapping providers offering the functionality for a few light EV models, or for retrofitted e-2Ws and e-3Ws through closed loop operations. While a draft battery swapping policy developed by NITI Aayog in 2022 was expected to catalyse the battery swapping ecosystem, it is yet to be notified. However, given the advantages of battery swapping, especially for commercial EV users, it is expected to scale up for specific e-2W and e-3W applications, including passenger e-autos. Local authorities should therefore ensure that charging infrastructure plans include the provision of battery swapping stations.

FIGURE 14 | An e-3W battery-swapping station in Hyderabad

Credit: Kanika Gounder (WRI India)

BOX J: GROWTH OF BATTERY SWAPPING INFRASTRUCTURE IN INDIA

- Existing battery swapping players like Sun Mobility and RACEnergy have signed MoUs with oil companies to install swapping stations for e-3Ws at their locations across the country (ET 2020; Financial Express 2022a).
- Original Equipment Manufacturers have also entered the charging segment and set up battery swapping stations for two- and three-wheelers in Delhi in partnership with distribution companies like BSES Yamuna and BSES Rajdhani (Kant et al. 2021).

3.3 Planning the charging infrastructure network

Planning for a public charging infrastructure network requires a holistic approach. Local authorities need to assess the number of EV chargers required and plan their spatial distribution for optimal accessibility and cost efficiency. This will involve an assessment of current and future EV demand, projected changes in EV charging and battery technologies, travel patterns of different vehicle segments, and site identification for installing public charging stations (PCS).

The Ministry of Power (MoP) has established targets for public charging infrastructure, mandating the availability of at least one PCS in every 3x3 km grid in urban areas, and one PCS every 25 km on both sides of highways (MoP 2022). While charging infrastructure for e-autos (or e-2Ws and e-3Ws in general) may be integrated with the EV public charging network, e-autos providing shared mobility are likely to be the major users of public charging facilities. Planning for e-auto charging networks must also account for the unique travel patterns and the distribution of auto-rickshaw fleets in a city.

3.3.1 Assessing public charging demand

In addition to the minimum requirements established by MoP, cities should set their own charging infrastructure targets. A localised evaluation based on EV market share, EV charging demand and charging patterns can help set targets for the number of public chargers needed on a year-on-year basis.

In setting targets for EV charging infrastructure, governments typically adopt a target ratio of number of EVs to number of charging points. For instance, Delhi has adopted a target ratio of 15, i.e., one charging point for every 15 EVs. West Bengal, in its state EV policy, has an ambitious target ratio of 8, requiring one charging point for every 8 EVs registered in the state.

The target ratio of EVs to charging points offers high-level guidance for charging infrastructure planning. To assess requirements of the type and number of chargers more accurately, nodal authorities can follow a more granular methodology based on charger specifications and typical charger utilisation, comprising the following steps:

1. Estimate e-auto sales for the horizon years of 2025 and 2030 based on expected or target EV penetration rates.

2. Determine the daily distance travelled by auto-rickshaws using data from urban mobility or development plans; primary surveys may also be used, in case of data unavailability.

3. Calculate the daily energy demand for e-autos based on their average battery capacity and driving range.

4. Assign the proportion of charging to be met by public charging infrastructure based on market research and primary surveys with existing e-auto customers.

5. Specify the distribution of charger types that will serve the e-auto segment. For example, Light EV AC, Light EV DC, or battery swapping, based on the charging patterns and requirements of e-auto drivers for slow and fast charging options.

6. Calculate the number of public chargers of various types required, based on the expected utilisation rate for each charger, from market research and primary surveys of charge point operators (CPOs).

TABLE 7 | An estimate for the charging demand of e-3Ws in Hyderabad for 2025 and 2030

		2025	2030
Step 1	Penetration rate	40%	60%
	No. of e-autos on road (based on 4.15% Y-o-Y growth rate of 3W)	8,020	41,956
Step 2	Distance travelled/ day (km)	130	140
Step 3	Battery capacity (kWh)	9	9
	Driving range/ charge	162	168
Step 4	Proportion of charging by PCS	50%	50%
	Total charging demand at PCS/ day	28,902	1,57,398
Step 5	Specification of charger types	7kW & 15kW	7kW & 15kW
Step 6	Charger utilisation rate (based on 5% Y-o-Y growth rate)	35%	60%
	Max. power drawn (with 7kW and 15kW chargers)	3.3	3.3
	No. of chargers needed (cumulative)	1,043	3,312

Note: E-3W calculations here include both passenger and cargo vehicles

Source: Analysis by WRI India (detailed in Annexure D)

3.3.2 Location planning of charging infrastructure and battery swapping stations

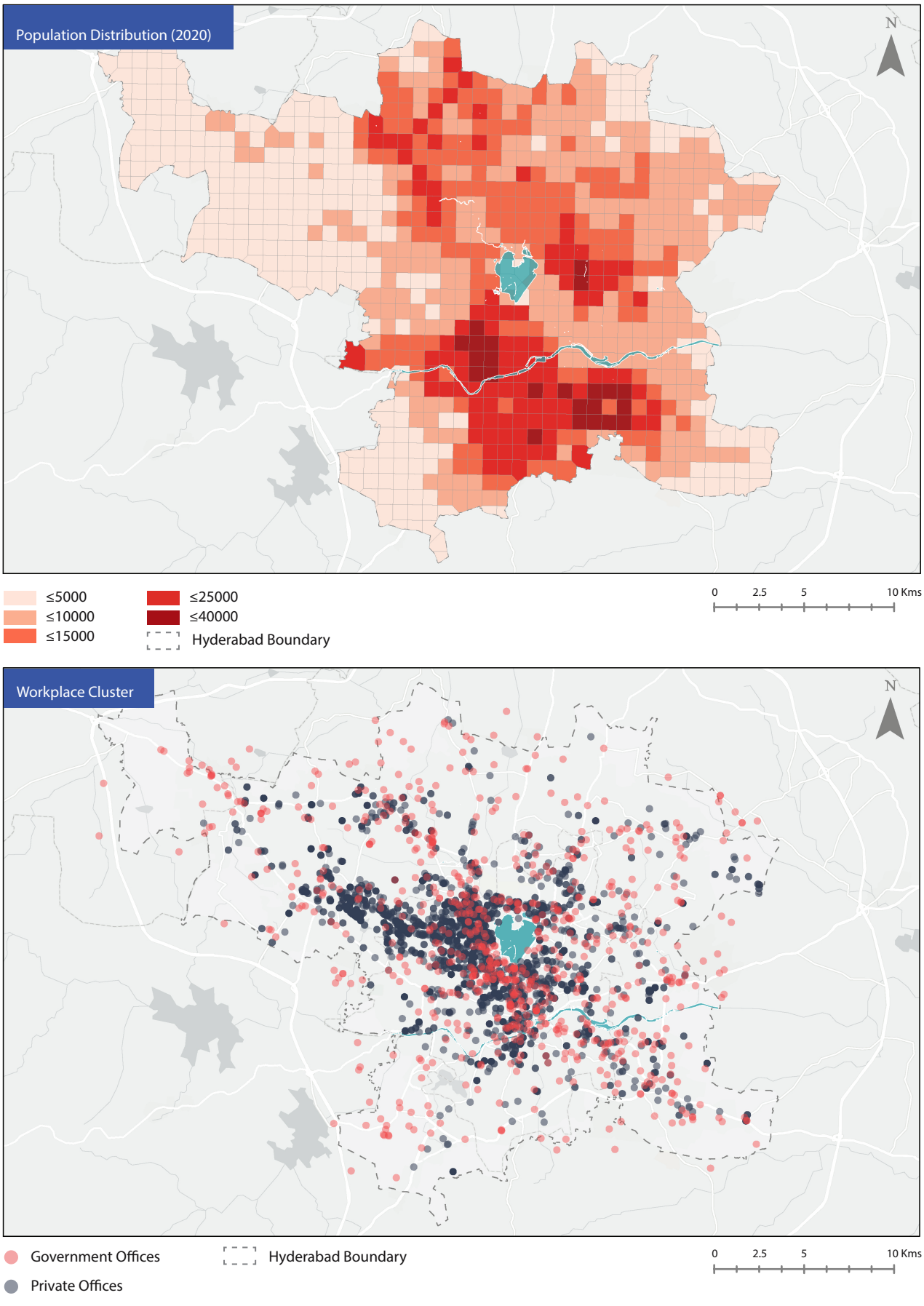
Once the required number of public chargers is established, cities must determine their optimal spatial distribution in order to identify and earmark public land parcels for installation. There are three key principles to consider while developing a location planning framework for public charging infrastructure:

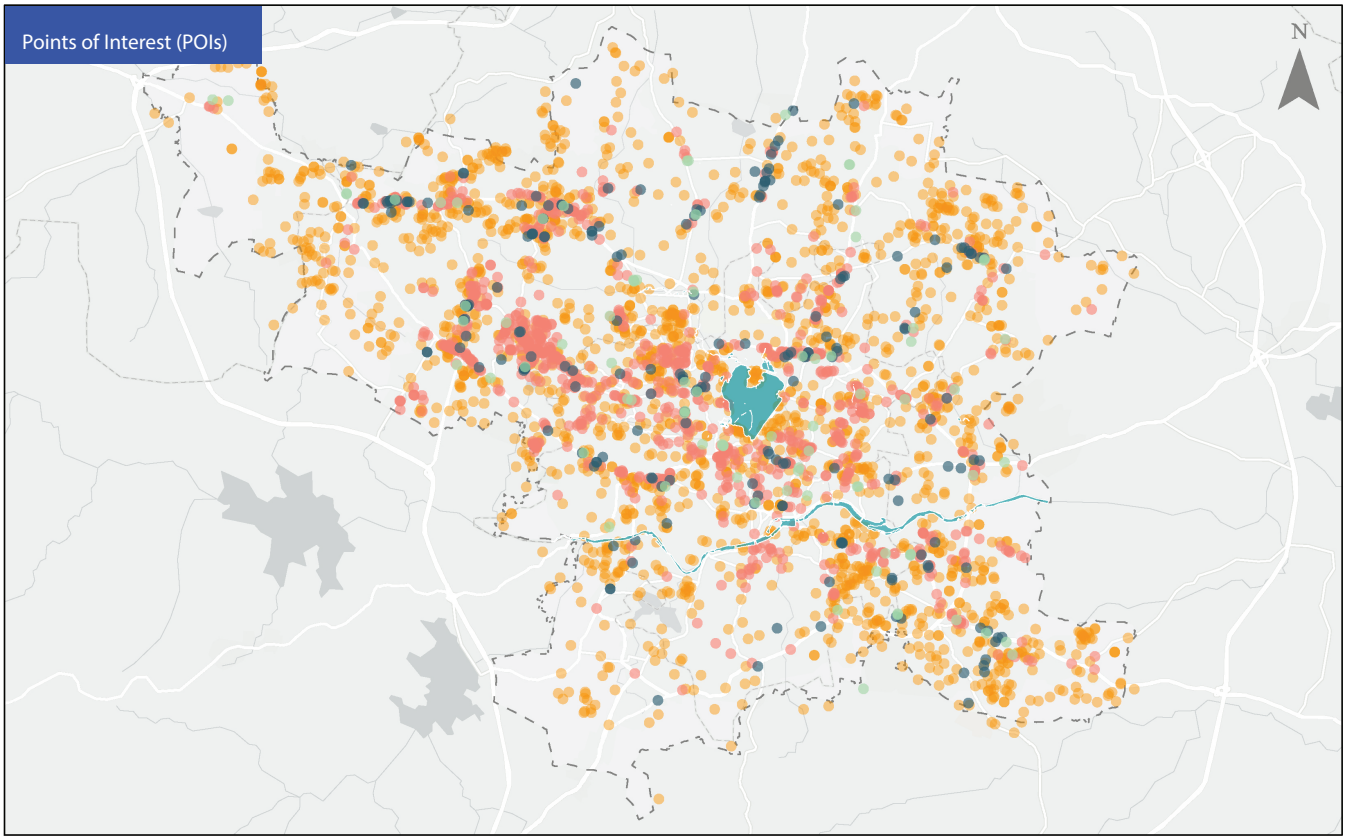
- **Maximise accessibility:** The charging infrastructure should be planned in such a way that drivers can easily find and reach it from any location.
- **Maximise utilisation:** The placement of the infrastructure should be planned in an area with high charging demand.
- **Minimise cost:** The high costs of the EVSE, the power supply and the land may be reduced with a distributed network of charging points.

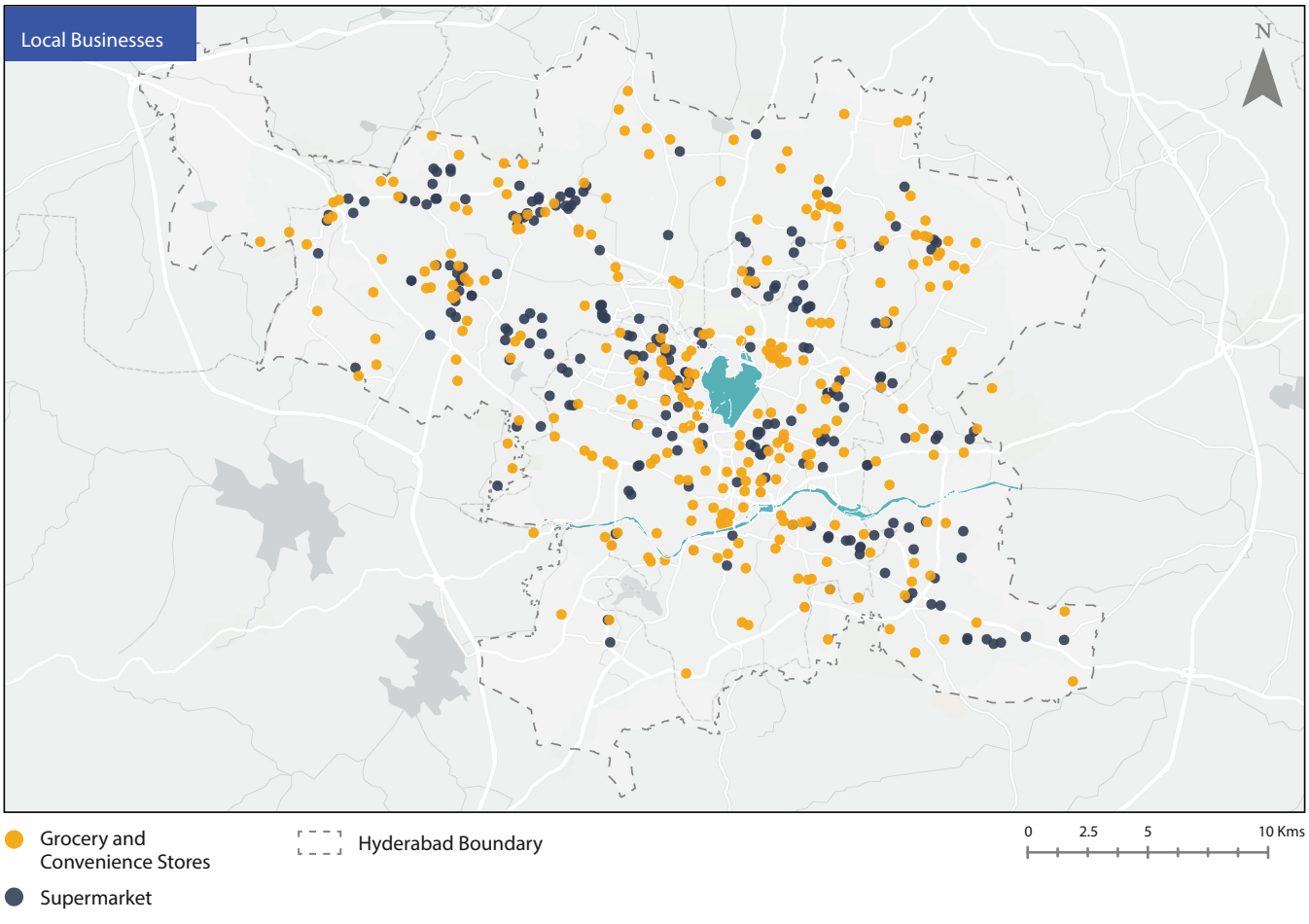
Location planning for charging infrastructure for e-autos may be undertaken at various scales, from a city-wide exercise to a neighbourhood-level activity. Cities can opt for a hybrid approach, combining digital geospatial analysis with on-ground site selection. Geospatial analysis maps the distribution of selected parametres such as locations of fuel stations and auto stands, proximity of points of interest and public amenities, transit networks, and commercial activity to assess charging demand for e-autos in different parts of a city. In addition, ensuring the availability of charging infrastructure in lower-income neighbourhoods where auto-rickshaw drivers may reside can ease access to overnight charging for e-autos. States can incorporate guidelines in the building byelaws to favour community charging spaces around residential areas.

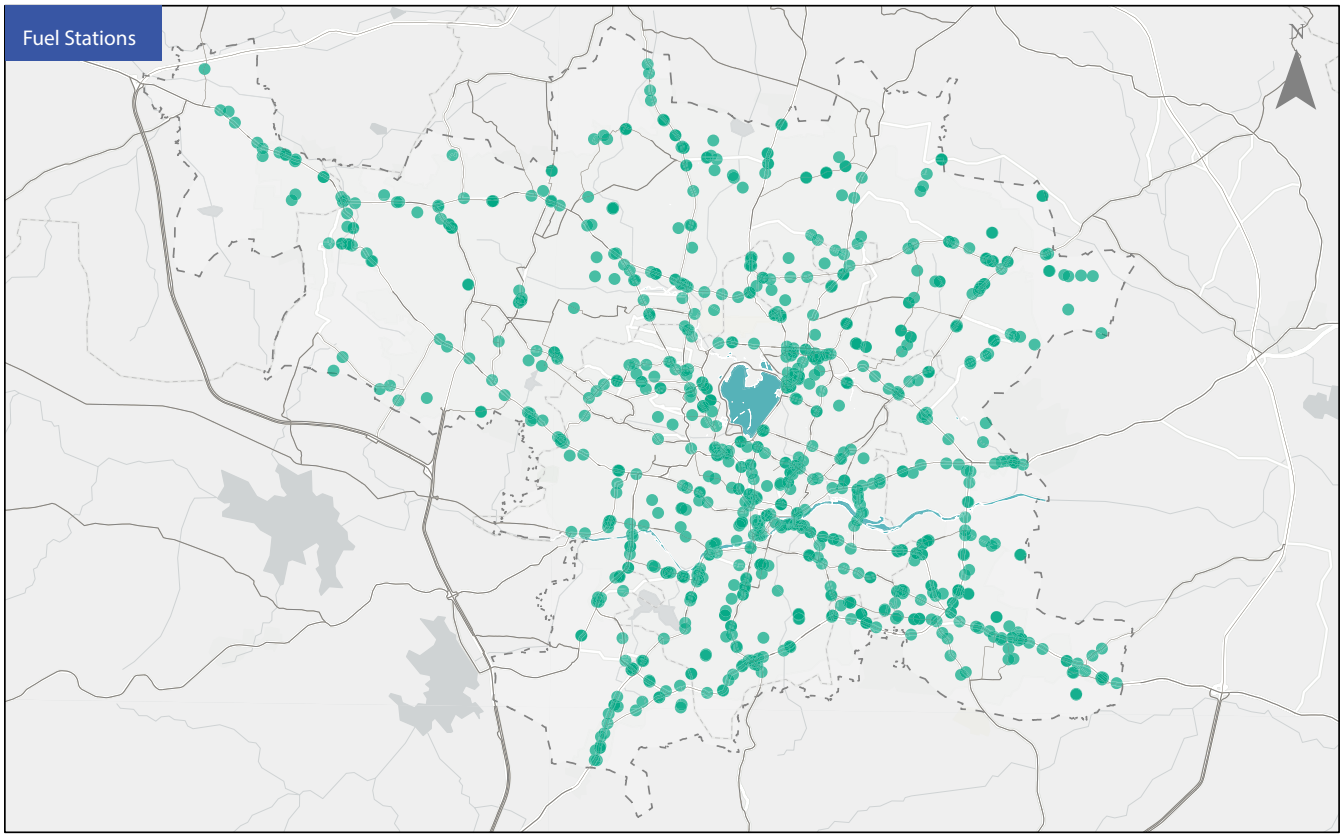
Local authorities may undertake a locational analysis to ensure the provision of adequate charging facilities in line with the charging demand in any area. Cities can also work with technical experts or industry stakeholders like CPOs or OEMs to establish charging demand maps for their regions.

FIGURE 15 | Spatial analysis for different parametres like population density, workplace locations, and points of interest in Hyderabad, overlapped to calculate EV charging demand.




Points of Interest (POIs)
N
Shopping Mall
Movie Theatre
Public Parks
Eateries
Hyderabad Boundary
0
2.5
5
10 Kms


Local Businesses
N
Grocery and Convenience Stores
Supermarket
Hyderabad Boundary
0
2.5
5
10 Kms


Fuel Stations
N
Petrol Pumps
Hyderabad Boundary
0
2.5
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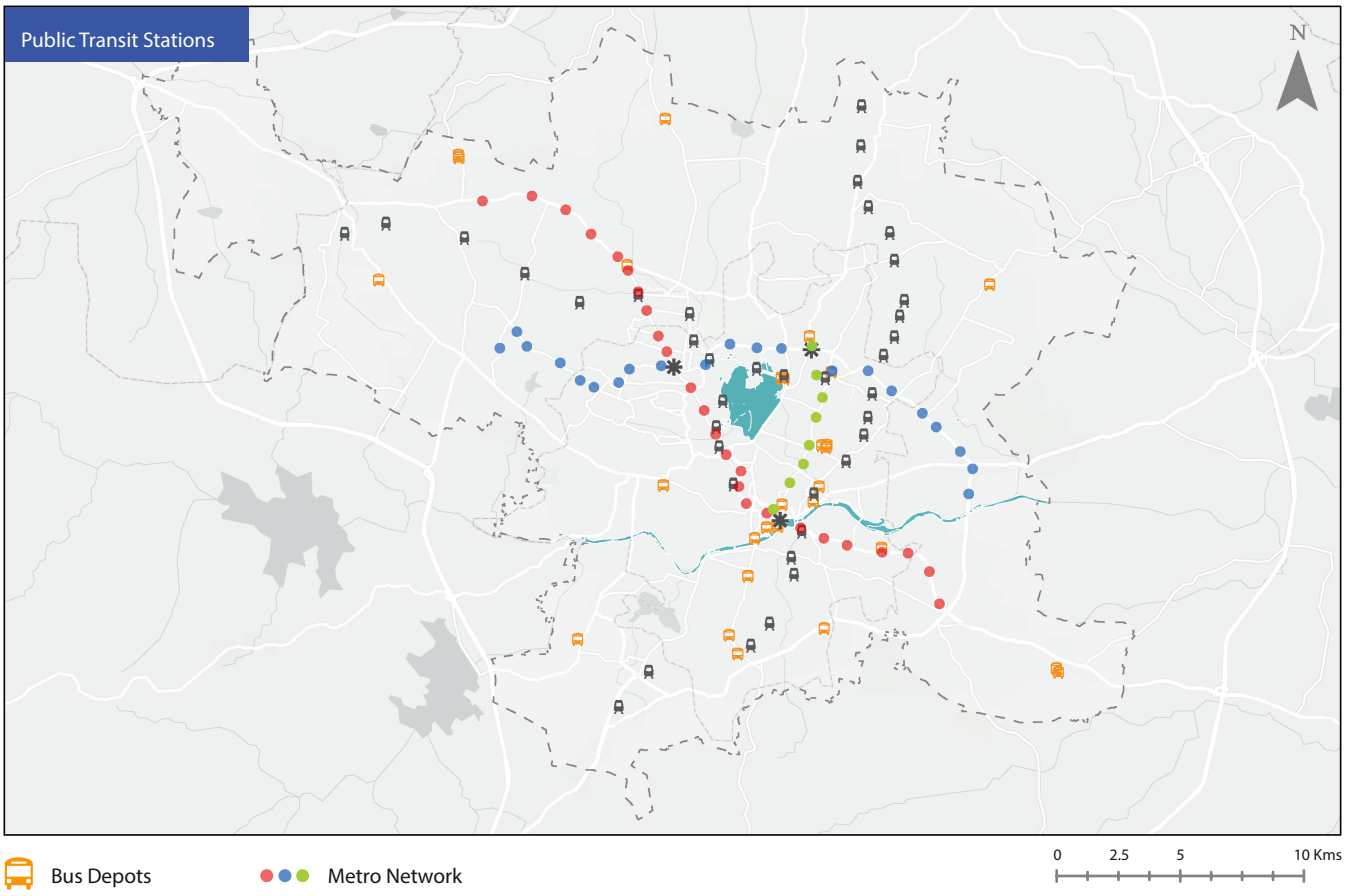
10 Kms


Public Transit Stations
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Bus Depots
Railway Stations
Metro Network
Hyderabad Boundary
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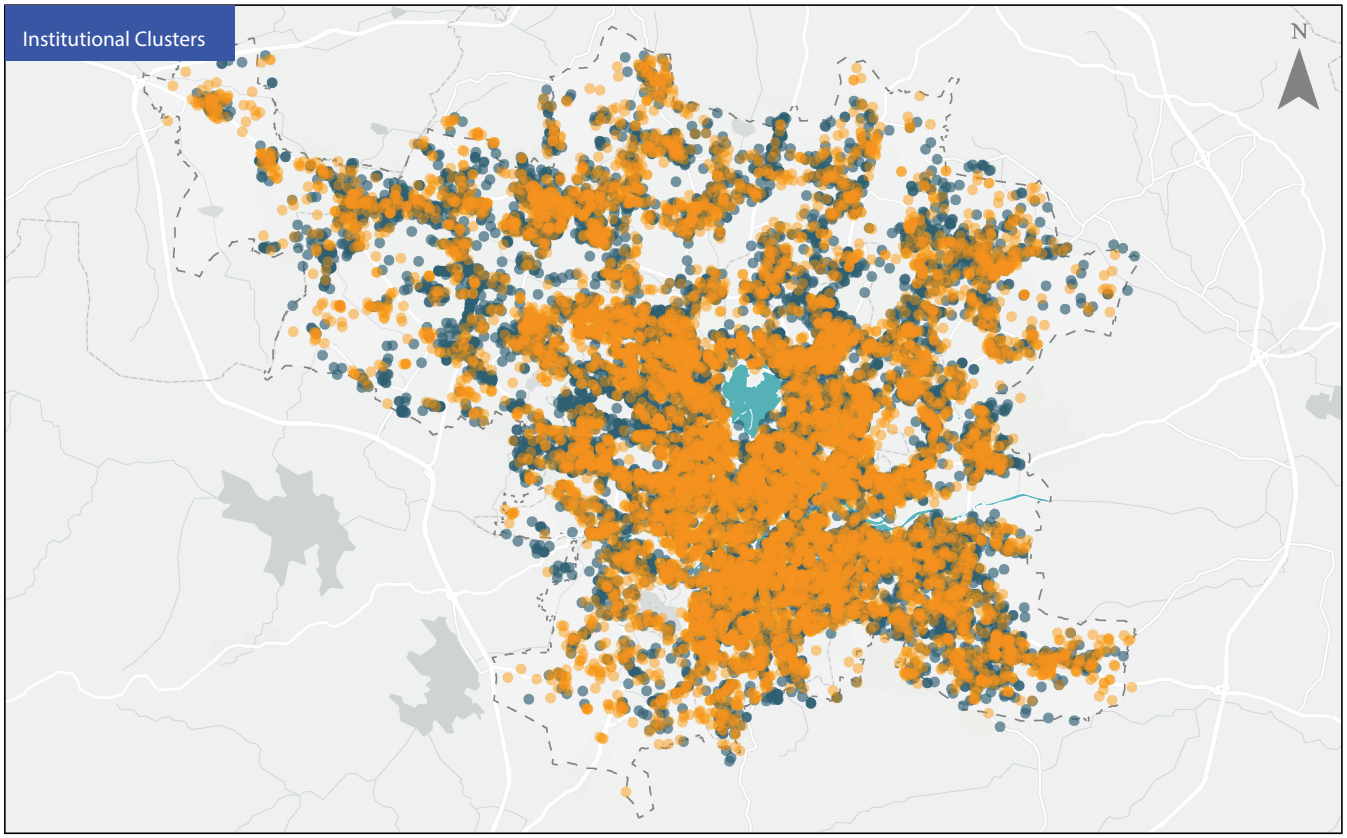
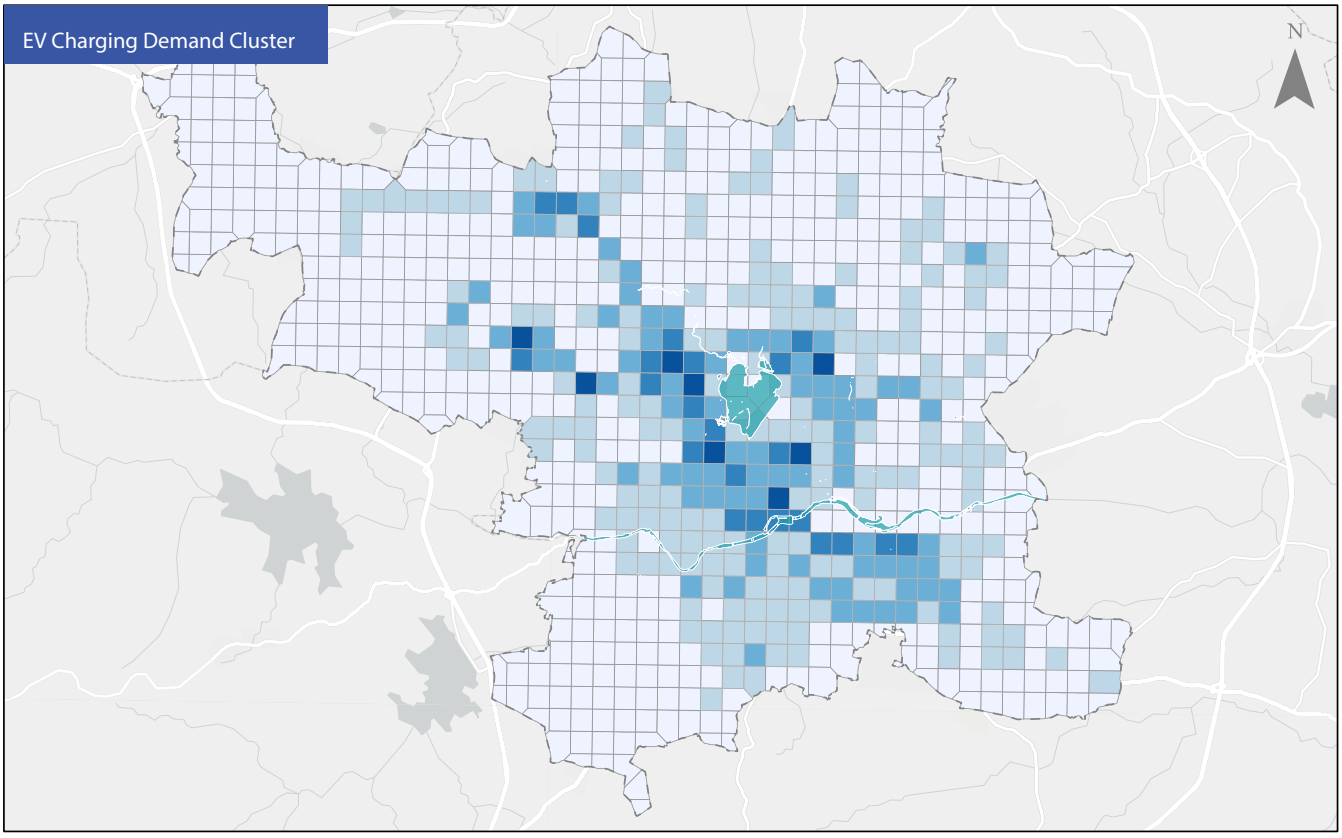




Note: The weightages assigned for demand score calculations are 20% for points of interest, 15% each for population count, workplace cluster, public transit, and fuel stations, and 10% each for local businesses and institutional clusters.

Source: WRI India analysis

3.3.3 Site Selection and Planning

Once charging demand has been mapped across a city, on-ground studies can be used to identify the traffic composition of electric as well as ICE auto-rickshaws, electrical grid capacity and site availability in each area for setting up e-auto chargers.

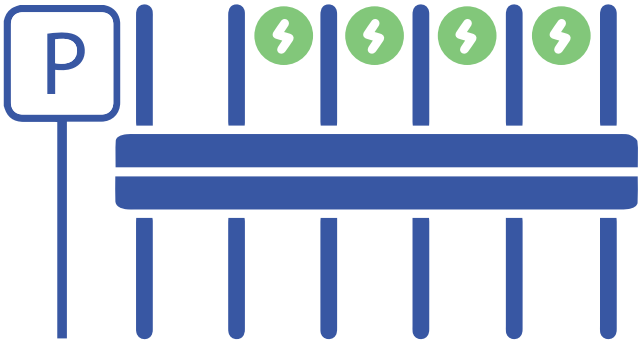
E-auto chargers may be installed at designated public on-street or off-street parking spaces, auto-rickshaw stands, transit station parking, and other sites in areas with high auto-rickshaw numbers. In terms of land availability, plug-in charging facilities require adequate space for simultaneous parking of the total number of e-autos that can be served together. Battery swapping facilities require less space, typically comprising of the battery swapping station area and 1-2 vehicle parking spaces where EVs can be stationed as they await their turn. Fuel stations, with their planned placement along road networks, are strategic locations for setting up battery swapping stations or installing EV chargers (space permitting).

E-auto chargers can be accommodated on single-phase electricity connections, making it easy to install them in any location with a power connection. However, a large number of chargers at one location increases the electricity load and may necessitate the augmentation of upstream electrical infrastructure. A distributed approach to locating and installing e-auto chargers, with multiple sites comprising a smaller number of chargers each, can significantly reduce land and power supply requirements at each location.

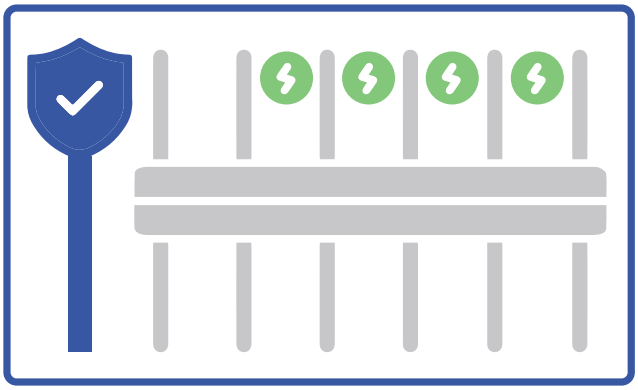
Local authorities and DISCOMs may also aim to integrate renewable energy for EV charging through on-site generation. This can be a feasible option for e-2W and e-3W charging stations as they require less power. Electric poles with solar panels can generate power for pole chargers for e-autos as well as streetlights. Higher share of renewable energy in EV charging contributes to reducing the overall GHG emissions of road transport and can also reduce the impact of EV charging on the electricity grid.

Selected sites for public e-auto charging should be visible from the road, easy to access, safe and secure and should not disturb traffic flows at entry and exit points. Sites should be accessibly located for e-auto drivers, many of whom rely solely on public charging infrastructure to charge their vehicles. Cities may establish guidelines on site planning and installation of public charging infrastructure for safety and accessibility, including the following criteria:

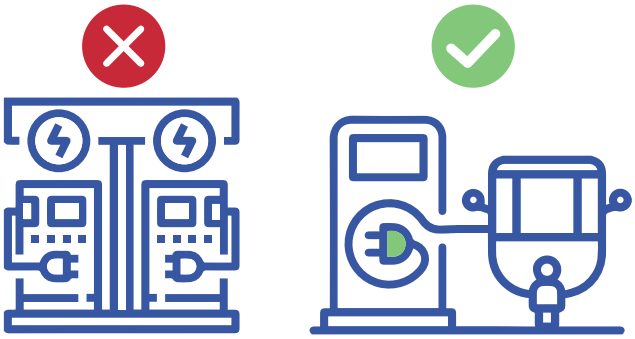
Designated area should be conveniently accessible and visible to e-auto driver from the site's entrance.



Suitable signage and markings should be used to clearly demarcate the parking spaces intended for e-auto charging.



Charging area should be safe from theft and damage.



If possible, charging spots with minimal civil work and wiring works should be chosen.

All safety measures for EV charging plans as outlined by the 2019 CEA (Measures Relating to Safety and Electric Supply) (Amendment) Regulations should be followed.

Enough circulation space must be provided for e-autos to enter and depart charging bays.

3.4 Implementation models for EV charging

Public charging infrastructure can be deployed through various implementation models, ranging from public or government-led models to private sector-led models. Any implementation model for public charging involves multiple stakeholders responsible for different aspects of implementation including land provision, charging infrastructure procurement, electricity supply, charging software solutions, and operation and maintenance of charging facilities.

Implementing government-led model of EV charging infrastructure involves local authorities (urban local bodies, transit agencies, DISCOMs or state nodal agencies) taking the lead in installing, owning, and operating charging infrastructure on publicly owned land, or working with CPOs in public-private partnerships. Implementation may also be driven by public or private sector CPOs, such as Energy Efficiency Services Limited (EESL), Tata Power, BSES Rajdhani, Fortum, Magenta, etc. for public or semi-public charging in public areas and in commercial and institutional properties.

For the government-driven model, whether self-provisioned or PPP-based, local authorities may fund or subsidise capital and operational costs, or they may only lease public land at concessional rates. PPP models, with the award of contracts on the lowest service charge bids, are well-suited to provide affordable and widely accessible charging services for e-autos. Public land parcels in strategic, high-demand locations should be selected and an adequate number of chargers should be installed to serve e-auto fleets. Local authorities should enforce strict requirements for service levels and safety of operations, to ensure that charging networks are operational and well maintained.

In addition to leading the installation of public charging infrastructure, states and local authorities may also establish rules and processes for safe and rapid provision of public charging infrastructure, such as charging safety, data sharing mandates on availability and utilisation of charging points and battery swapping stations, single-window systems for applications and clearances, and expedited processes for power supply connections.

BOX K: CHARGING INFRASTRUCTURE IN DELHI

Delhi's EV charging and battery swapping station tender is a typical example of a public-private partnership (PPP) using a revenue sharing model where the concessionaires are provided government land to install, maintain and operate public charging stations at their own cost and charge a service fee from the end consumer, for a specified lease period (Kant et al. 2021).

FIGURE 16 | Charging infrastructure for e-autos in Delhi

Credit: Smart-E

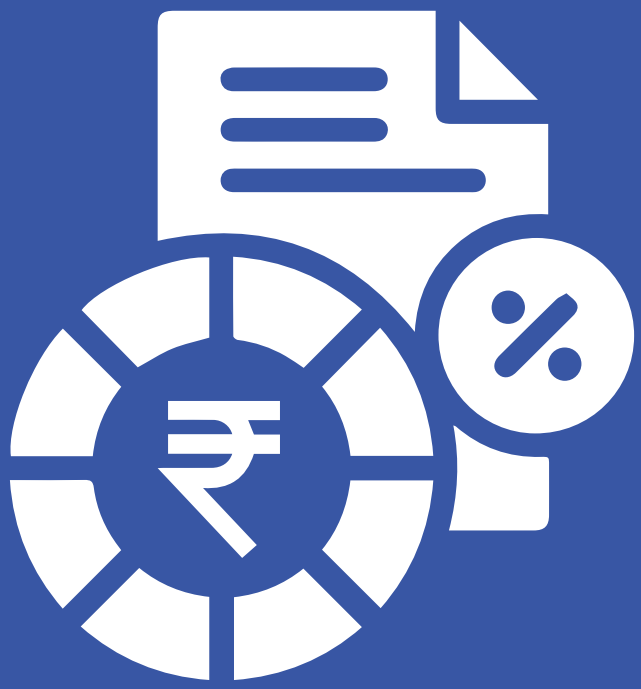
In this model, public land parcels were aggregated from the agencies concerned and grouped into cluster packages that include a mix of sites in dense as well as more distant locations, which were then tendered to the concessionaires and CPOs. Serving DISCOMs provided electricity connections up to 100 kW free of charge, and concessionaires are expected to pay INR 0.7 per kWh of power sold to the land-owning agency, as revenue sharing. Consortia of different charging and swapping operators were permitted, which allowed sites with less organic charging demand to be developed by captive fleet operators. At the end of the contract period, the model allows CPOs the choice to take ownership of the charging infrastructure equipment. Other states will need to consider comparable models with service level agreements to accelerate charging infrastructure implementation.

4

Financing and Deployment Models

Lack of access to financing is one of the biggest barriers in enabling a switch from ICE auto-rickshaws to e-autos. Even as more financing products for e-2Ws and e-4Ws are offered by banks and non-banking financial companies (NBFCs), loans for e-3Ws remain scarce and expensive. Pilot initiatives and innovative business models by government and private sector stakeholders, respectively, are demonstrating opportunities for increasing the availability of credit for e-3Ws. Cities can learn from these initiatives to contextually replicate them in their own regions for accelerating the e-auto transition.

This chapter highlights various financing mechanisms by the government and financial technology (fin-tech) companies to lower the barriers to e-auto ownership, as well as alternative deployment models such as Original Equipment Manufacturer (OEM) based leasing and fleet operator-owned e-auto services.



4.1 Financing challenges faced by auto drivers

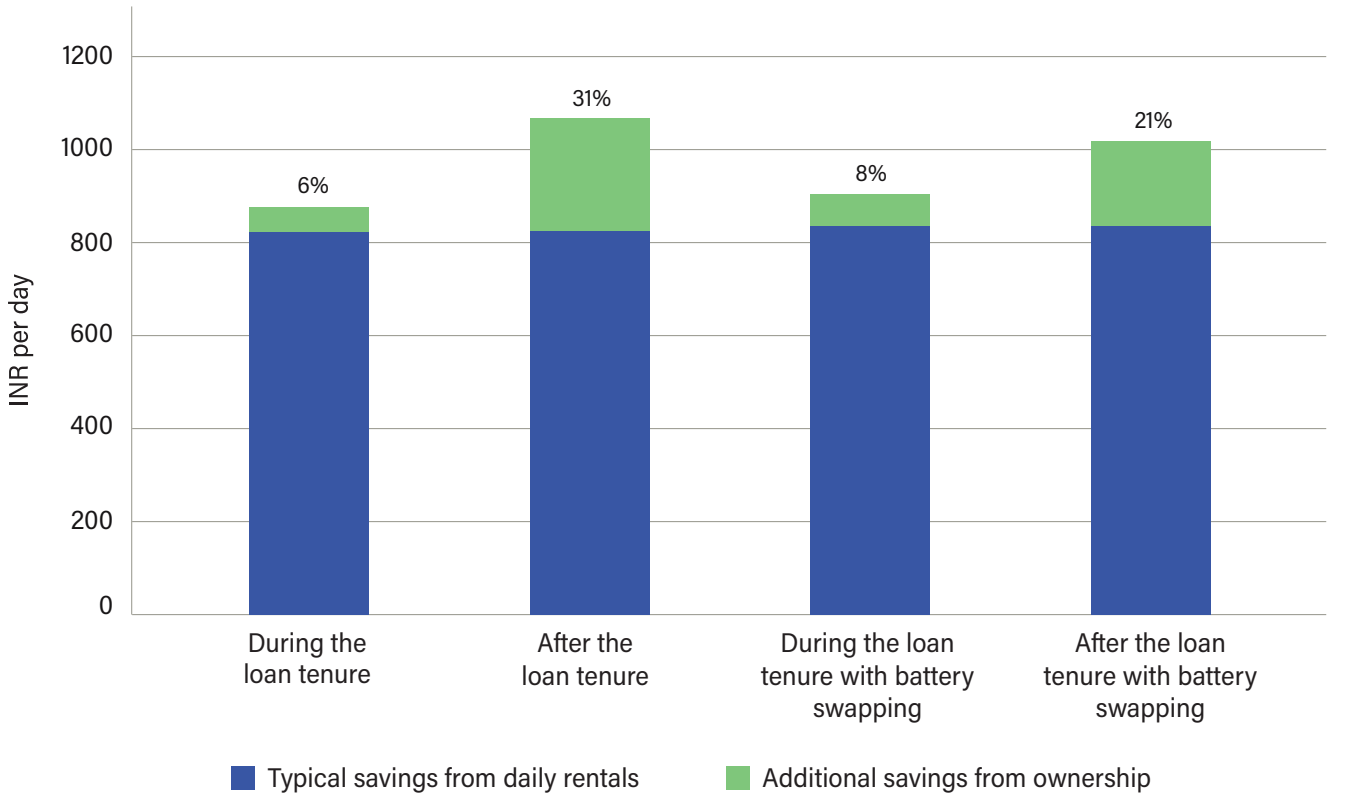
Most auto-rickshaw drivers in India rent their vehicles, either due to a lack of awareness of, or access to affordable financing. However, studies have shown that ownership of ICE or e-autos offers increased savings and higher incomes to drivers as compared to renting (CiSTUP 2012). Loan instruments providing 100 percent debt financing at lower interest rates have the potential to add 6 percent to daily driver incomes during the loan tenure and 31percent afterwards (Singh and Jena 2018). Over the lifetime of the vehicle, it is estimated that additional savings of INR 150,000 (USD 1,808) can be realised (EV Reporter 2020).

The transition to e-autos offers an opportunity to enable the shift from renting to ownership for auto drivers, consequently improving their quality of life. However, banks rarely offer auto-rickshaw loans due to the borrower's lack of credit history, unstable income, lack of collateral, and overall high perceived default risks in the sector. In addition, long and complicated loan application processes and documentation requirements cause inconvenience for autorickshaw drivers to access financing for electric auto-rickshaws.

Where formal loans are offered, financing institutions present high interest rates, low loan-to-value-ratio (LTVR), short repayment periods or strict collection mechanism (demanding daily or weekly payments), all of which are unfavourable for borrowers. Reported experiences of auto-rickshaw dealers indicate that only 6-10 percent of enquiries translate into loans (EV Reporter 2020), while remaining buyers tend to borrow from NBFCs or informal sources like moneylenders that provide more expensive credit.

With e-autos being more expensive than ICE auto-rickshaws, e-auto loans will typically have higher downpayment costs and increased monthly payments for drivers. Moreover, discussions with industry players suggest that formal financing for e-3Ws tends to be more expensive

FIGURE 17 | Additional driver savings from auto-rickshaw ownership



Source: Singh and Jena 2018

	Interest rate	Loan-to-value ratio	Loan tenure
ICE 3W	10-15%	80-90%	36 months
Electric 3W	>20%	<80%	<36 months

Source: Discussions with industry stakeholders

than for ICE 3Ws, with a LTVR of less than 80 percent and interest rates of more than 20 percent. In comparison, ICE 3Ws have an LTVR of 80-90 percent and interest rates of 10-15 percent. This is due to the absence of a secondary market leading to unknown resale and residual values and technological risks associated with the nascent e-auto sector. With appropriate support and simplified loan application processes, e-auto financing can emerge as a creditworthy sector with fewer risks and higher business volumes. Government- and private sector-led mechanisms to offer more affordable and innovative financing products can enable greater uptake of e-autos, with both environmental and socio-economic benefits to stakeholders. It can also increase availability of affordable, formal financing for e-auto drivers to provide a sustainable pathway to vehicle ownership.

4.2 Government-led financing for e-autos

States and local authorities aiming to support the electrification of auto-rickshaw fleets must ensure the availability of financing for an inclusive transition that benefits drivers. Local authorities can leverage central and state government financing schemes and set up institutional structures and partnerships to unlock more sources of affordable financing for e-auto loans. Additionally, governments can establish dedicated platforms to provide information, assistance, and resources to help drivers navigate the financing process. Governments can also enable access to concessional lending for women, to facilitate their entry into the e-auto workforce.

BOX L: POLICY SUPPORT BY THE CENTRAL GOVERNMENT

The central government offers various schemes for the benefit of small businesses that can be leveraged to enhance liquidity in the e-auto lending sector and reduce potential losses to lenders. One such scheme for micro-credit access is the Micro Units Development and Refinance Agency Ltd. (MUDRA) scheme ensuring quick and collateral-free micro loans of up to INR 10 lakhs (USD 12,170) for small businesses and individuals, including for e-rickshaws (PMMY 2023). This can be expanded to include e-autos. MUDRA loans are also backed by a credit guarantee fund for participating financial institutions, which in turn expands access to credit for under-funded stakeholder groups.

Similarly, the inclusion of electric mobility as a priority lending sector can incentivise banks to increase lending to the sector (Kant et al. 2021).

This section highlights some government schemes and partnerships that states and cities are deploying for e-3W financing.

4.2.1 Interest rate subvention schemes

State governments can promote financing through affordable financing schemes and interest rate subventions, which subsidise the market interest rate with the balance being borne by the government. These schemes have proven to improve the affordability of loans in agriculture and Micro, Small & Medium Enterprises (MSME) sectors (RBI 2023; 2021), and can be extended to EVs such as e-autos deployed in commercial segments.

The Kerala Financial Corporation (KFC), a public sector undertaking, offers affordable EV loans (including e-autos) with a maximum LTVR of 80 percent of the vehicle cost (including the cost of a charger), and with a tenure of up to 5 years. The interest rate of the EV loan is 7 percent, after accounting for the 3 percent interest subvention from the state government. Requirements for application include meeting a minimum credit score and confirmation that the applicant's total deductions from the salary including the equated monthly instalment (EMI) of the proposed loan, shall not exceed 80 percent of the gross salary (KFC 2023).

The Delhi government also offers a 5 percent interest rate subvention on EV loans, for which it has partnered with Convergence Energy Services Limited (CESL), a government-owned entity under the Ministry of Power (MoP). CESL empanels eligible financial institutions which provide EV loans with a minimum 80 percent LTVR and maximum 20 percent interest rate for receiving the interest subvention. With the subvention, empanelled financial institutions are expected to provide loans with a maximum interest rate of 15 percent (Millenium Post 2022). While this interest rate is higher than that offered by KFC, the Delhi government scheme ensures a higher volume of financing, delivered through multiple financial institutions at below-market interest rates.

4.2.2 Bulk procurement schemes

Bulk procurement schemes help reduce capital costs of EVs through economies of scale. EV demand is aggregated, and bids are invited from OEMs for a large number of vehicles, which results in a lower price per vehicle than through standard retail channels. CESL led a successful bulk procurement tender for 5,450 e-bus operations through a 'Grand Challenge', which resulted in the price discovery of a competitive bid rate, by aggregating demand from various state transport undertakings (STUs). The per km operational cost of e-buses for STUs in Delhi, Kolkata, Hyderabad, Bengaluru, and Surat reduced substantially (ranging from 15-48 percent) as compared to the previous years (Pati 2022). Similarly, bulk procurement may also be used to aggregate e-auto demand across different cities.

CESL has floated a tender to procure 100,000 e-3Ws (including e-autos), which will subsequently be available for lease or outright purchase to interested entities (CESL 2021). CESL proposed to collaborate with NBFCs who can buy the e-3Ws through aggregated purchases and lease them out to state service providers or auto drivers (Sen Gupta 2021). Participating in this public call, TWU (Three Wheels United), a community partner, and NBFC signed an MoU with CESL to procure 70,000 e-3Ws in 5 years to deploy across the country, starting with Bengaluru and Delhi (Financial Express 2022b).

Cities can work with agencies like CESL or set institutional intermediaries to aggregate e-3W demand and enable bulk procurement to reduce e-auto purchase costs for drivers.

4.2.3 Integration of social welfare schemes

The EV transition offers an opportunity to increase diversity and inclusion in the transport workforce. Access to e-auto ownership for women and other marginalised groups can be enabled through existing or new social welfare schemes, which offer subsidised access to vehicles for livelihood generation. In Kerala, the social justice department offers e-autos free of cost to those mothers who have children with serious learning disabilities like intellectual disability, cerebral palsy, autism, etc. identified under the National Trust Act (Saikiran 2021). Similarly, the local authority in Kevadia (Gujarat), the Statue of Unity Area Development and Tourism Governance Authority (SOUADTGA), collaborated with ETO Motors, a private e-3W operator, to deploy e-autos that were rented out to, and operated by, tribal women (The Machine Maker 2021). Bihar proposes a top-up subsidy of INR 8,000 (USD 96.5) on the purchase of e-autos (among other EVs) for consumers living below poverty line or belonging to reserved castes.

While they are not financing models, social welfare schemes typically linked with bank financing for beneficiaries, allow them to access loans with greater ease for their share of payments, where applicable.

4.2.4 Enabling partnerships and local interventions

Partnerships and institutional structures developed or supported by local authorities can help de-risk and unlock e-auto financing. Cities can collaborate with international financial institutions and multilateral development banks, and also engage with relevant stakeholders like auto-rickshaw unions to establish strategic partnerships and pilot demonstrations. These initiatives aim to showcase the feasibility and potential of e-auto operations to unlock financing from local financial institutions. Existing or new institutional structures, like co-operative societies, can act as intermediaries to provide required guarantees for financing.

The RAAHI (Rejuvenation of Auto-Rickshaw in Amritsar through Holistic Intervention) project, discussed in detail in Chapter 6, is an example of a pilot intervention for replacing diesel autos with e-autos, led by the smart city corporation in Amritsar through the creation of a new intermediary (The Tribune 2021). Another example is the 'Ernakulam Jilla Auto-rickshaw Drivers' Co-operative Society' (EJADCS), which was formed to support e-auto uptake in Kochi (The Hindu 2020a). These city-level initiatives have the potential to establish proof of concept for such institutions to support scaling of access to financing.

4.3 Private sector financing models

Apart from government-led initiatives, innovative private sector-led models have also shown promise in enabling access to e-auto financing. This section discusses various private sector models and partnerships that are actively financing e-3Ws across the country.

4.3.1 Innovative fin-tech solutions

Fin-tech companies are entering the e-3W financing space ahead of traditional financial institutions. Fin-tech solutions support expanded access to financing for e-3W ownership, irrespective of banking or credit history of consumers. Companies use digital technologies and a blend of cutting-edge tools like machine learning algorithms and psychometrics to govern their underwriting

decisions. Use of smartphones and IoT devices enable digital vehicle tracking and online EMI payments, thereby reducing default and recovery risks. RevFin is an example of a fin-tech company operating in the e-3W lending space, offering loans with LTVR of up to 90 percent of vehicle price and loan tenures of up to 36 months (ETAuto 2020).

4.3.2 Inclusive financing with community engagement

Financing providers and other e-3W ecosystem stakeholders are utilising community engagement to support positive loan repayment behaviours and enable collective accountability for successful vehicle financing and ownership. Their models involve trainings, campaigns, and social schemes to educate and build financial literacy among potential e-auto owners, and the development of peer networks to provide access to information and resources for new entrants. These measures may be integrated with other measures for scalability, such as institutional intermediaries for e-auto demand aggregation, or tech-based underwriting instruments to structure tailored repayment plans for unique earning profiles of customers (TWU 2023).

Based on industry conversations, one such model is operated by Three Wheels United (TWU), a community partner and NBFC, which offers loans at a 23 percent interest rate compared to the 30 percent rate offered by other NBFCs. Loans cover up to 100 percent of the vehicle cost for a tenure of up to 45 months. With less than 1 percent loan defaults, TWU also partners with public banks like the Pragati Gramin Bank and the Corporation Bank, and acts as a guarantor to access loan facilities at lower interest rates for drivers (UITP 2022).

SMV Green Solutions is an e-rickshaw distributor which partners with financial institutions like Avanti Finance and IndusInd Bank to provide loans to cycle rickshaw pullers to buy e-rickshaws. The company works closely with customers to ensure loan repayments and offers free or low-cost vehicle maintenance services over the loan period. SMV Green also launched a Vahini scheme for training women drivers and providing them access to finance for e-rickshaw ownership. To encourage women drivers and destigmatise the social norms against women transport workers, the company engages closely with communities and supports women in opening bank accounts for accessing loans. The enterprise has also won the international award for sustainable mobility awarded by the Ashden Foundation (Ashden 2019).

4.3.3 OEM-Financial Institution partnerships

At this early stage of development of the e-mobility sector, much of the uncertainty around EV financing is due to product risk, associated with the quality of EVs in the market and the availability of the aftermarket spares and maintenance support. EV manufacturers play an important role in de-risking the sector by ensuring the quality of products and the availability of spare parts for maintenance, and by supporting the creation of resale markets.

Many EV OEMs are providing schemes like vehicle and battery warranties, buyback guarantees and annual maintenance contract (AMC) packages to reduce risks associated with EV ownership. Companies may offer a buyback guarantee on their products to increase market confidence of resale value, as Ather Energy (an e-2W OEM) had done as a promotional offer. Social enterprises may partner with OEMs to combine scrapping incentives for old vehicles, which can be used by drivers as down payment for new e-autos, as TWU is doing with Mahindra & Mahindra (Business World 2020). In 2023, Lohum partnered with MG India and Mercedes-Benz Energy to provide second-life solutions to e-4W batteries (EV Reporter 2023). Similarly, such organisations or battery manufacturers can partner with e-3W OEMs and drive programmes for battery repurposing and recycling (Singh et al. 2022), to improve the scrap value of EV batteries. Such initiatives help build trust among consumers and financers and enable higher adoption of e-autos in the sector.

Further, OEMs are working with their own NBFCs or partnering with other financial institutions to enable access to finance. Kinetic Green, an e-3W manufacturer, has partnered with Ujjivan Small Finance Bank to provide loans for e-rickshaws (Iyer 2019) for a tenure of 12-48 months with 20-25 percent interest rates for up to 80 percent of the vehicle cost (Ujjivan SFB 2023). Captive NBFCs such as Bajaj Finance and Mahindra & Mahindra Financial Services provide specialised and subvention-linked products to electric two-wheeler products, which can be extended to finance potential e-auto models (Kant et al. 2021).

A three-way partnership amongst Terra Motors, Eqaro Guarantees and Prest Loans focuses on providing financing for e-3Ws loans to institutions and individuals (ETAuto 2021). In this model, Eqaro ensures a buyback agreement with the OEM and shares the asset risk and credit risk of the customer along with Prest Loans. Terra Motors offers product quality assurance and buyback guarantee for repossessed vehicles in case of default (NITI Aayog and BCG 2022). With this, the companies share the risk amongst partners and increase the financing available for e-3Ws.

4.4 Climate finance or green finance

Climate finance supports the activities of climate change adaptation and mitigation, providing concessional financing for environmentally sustainable projects that lower GHG emissions, such as clean transportation. Green finance, on the other hand, is a type of future-oriented finance associated with the development of financial products that simultaneously prioritise both environmental sustainability and economic growth (Noh 2019).

Climate finance is being leveraged for EV financing in India to promote more affordable credit for EVs and EV charging infrastructure. In May 2022, the Green Climate Fund (GCF) initiated the 'India e-mobility financing program', with a USD 1.5 billion fund to provide tailored leasing and financing solutions to EV owners and drivers (GCF 2022).

Development banks or multilateral agencies provide risk covers and offer loan guarantees in environmentally sustainable sectors such as renewable energy and electric mobility. One such hedging mechanism is the proposed EV Risk Sharing Program for EV retail loans, which is being set up by NITI Aayog, the World Bank, and Small Industries Development Bank of India, with a USD 1 billion fund, through which lending institutions can recoup their losses in case of defaults (Economic Times 2023a). Such programmes are especially impactful in de-risking new spheres like the e-mobility sector.

New green finance products are also being developed, which can be used to increase the flow of affordable financing to the e-mobility ecosystem. In 2022, the central government released a framework for sovereign green bonds, setting the obligations of the government as a green bond issuer (GoI 2022a). The framework was proposed to facilitate global and domestic investments in green projects in the country, including clean transportation strategies like promotion of public transport and supporting EVs through subsidies (WEF 2022). State governments can use these funds to support e-auto adoption, among other activities for e-mobility development. Additionally, the upcoming development of the carbon credits market in India, which is building on the country's existing Perform-Achieve-Trade (PAT) scheme that also includes the transport sector, can be used by local or state governments to accrue credits for clean transport fleets. The proceeds can be used to subsidise their adoption.

4.5 Alternate deployment models

Other market-driven deployment models for EVs can widen access to financing for e-autos. Vehicle leasing models and "battery-as-a-service" models have shown potential to grow in the sector, by reducing the costs of owning or operating EVs, especially for commercial use. State and local authorities can play a vital role in supporting these models by driving initiatives at the local level for individuals and fleet aggregators.

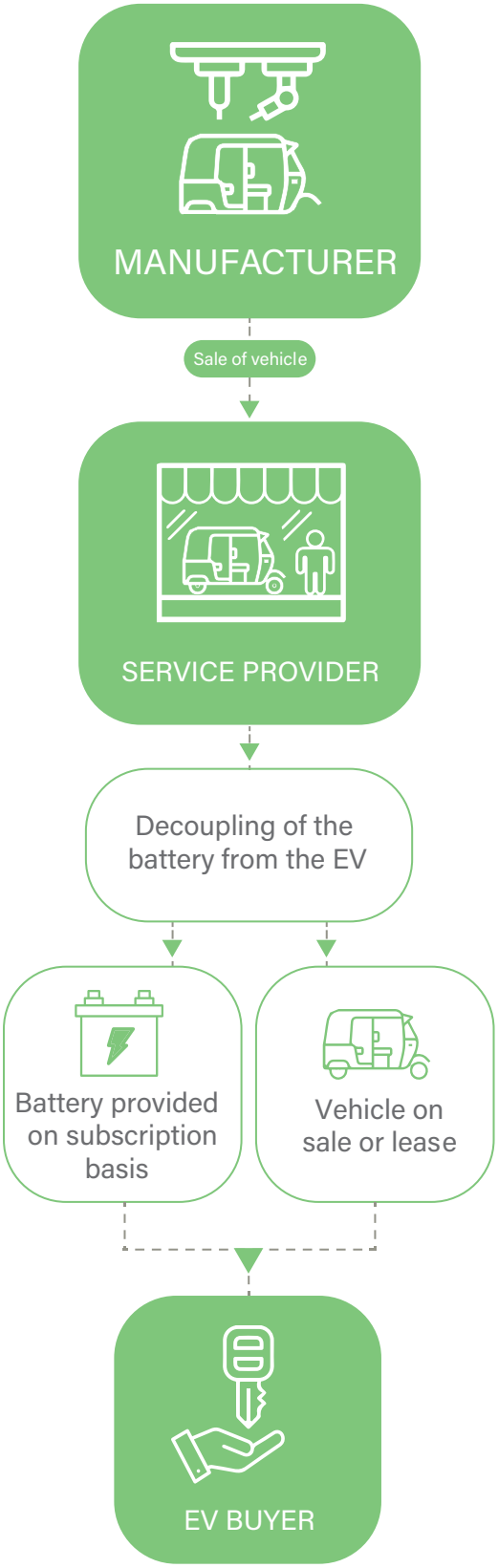
This section discusses the alternate deployment models and partnerships that can increase e-3W financing.

4.5.1 Vehicle leasing models

Vehicle leasing models enable e-auto drivers to pay a weekly or monthly fee for using the vehicle, typically including maintenance costs but excluding charging costs in the price. This allows fleet operators and individual drivers to try the new technology of e-autos without much risk, and without high upfront costs.

Leasing models can support rapid electrification of EV fleets, including e-autos, by supporting asset-light operations of high-utilisation EVs for fleet operators. In India, the 'e-lease' model by E-Trio was launched for cargo e-3Ws, with a down payment of INR 20,000 (USD 241) per vehicle followed by monthly instalments of INR 6,300 (USD 76) for 36 months. Fleet operators also have the option to include insurance, registrations, and other such charges into the plan for ease (News18 2021). Another model by Quiklyz, the leasing and subscription business vertical of Mahindra & Mahindra Financial Services Limited offers leasing or subscription of e-3Ws for a limited time period for commercial fleet operations for zero down payment (Livemint 2022) and INR 13,549 (USD 163) per month (NDTV 2022).

FIGURE 18 | Representation of BaaS model



Source: Saif 2021

For individuals, leasing may also offer a pathway to e-auto ownership through lease-to-own models. One example of this is the "PayGO" model, deployed by vehicle distributors or intermediary companies in sub-Saharan Africa for ICE vehicles and EVs. Customers make a down payment of up to 20 percent of the vehicle value and continue making daily, weekly, or monthly fee payments for a pre-decided period, after which they own the vehicle (Siemens Stiftung 2020). Maintenance costs may or may not be covered in this model, unlike in typical leasing models. While not prevalent in India, lease-to-own models can be offered to enable vehicle ownership for e-3Ws, in turn enabling better returns for drivers in the long run.

4.5.2 Battery-as-a-service Model

The battery-as-a-service (BaaS) model decouples the battery from the EV, allowing consumers to purchase an EV without paying for the battery, which accounts for 40 percent of the purchase cost. The battery, which may be fixed or swappable, is then provided to the consumer on lease or subscription basis, or a pay-as-you-go model (Saif 2021). This lowers the cost of the vehicle, enabling ease of adoption. It also makes EV financing easier, as the battery risk is decoupled from the EV and the loan amount is lower. Banks like Bank of India and Punjab National Bank also offer loans for battery replacement, which can be more easily enabled when battery is decoupled from the EV (PNB India 2022).

Battery swapping companies like Sun Mobility are at the forefront of the BaaS model, establishing a network of battery swapping stations for e-2Ws and e-3Ws. Battery swapping, in addition to reducing vehicle downtime, allows payments for batteries per swap or per unit, where the driver can pay according to the energy consumed. Others, like RACEnergy, are combining a battery swapping business model with EV retrofits, where e-autos retrofitted by the company subscribe to its battery swapping services. This allows companies to offer retrofits free of cost or at a subsidised rate and recover the cost of the retrofit kits through the battery swapping subscriptions.

5

Transition Pathways for Cities

The transition from ICE to e-autos requires a comprehensive approach. Various regulatory, financial, and infrastructural barriers continue to slow down the transition in this emerging sector. The previous chapters discuss planning for the roadmap for auto electrification, suggest policy and regulatory measures to support the transition, consider implementation models for charging infrastructure, and highlight various financing solutions for e-auto fleets.

An effective transition to e-autos requires a holistic approach with a mix of various strategies. Drawing on data from secondary literature and stakeholder interviews, this chapter highlights three cases of city-level initiatives for promoting e-auto uptake. The case discussions touch upon aspects of financial assistance for purchase of e-autos, institutional structures and multi-stakeholder partnerships for sectoral governance and reform, development of charging infrastructure, integration with public transit, and the creation of inclusive livelihood opportunities. Taken together, the case discussions are expected to illustrate potential implementation pathways for enabling the transition to e-autos and substantiate the planning and implementation roadmap laid out through the guidebook.

5.1 The RAAHI project

The Rejuvenation of Auto-rickshaws in Amritsar through Holistic Intervention (RAAHI) project aims at electrifying and reforming the passenger auto-rickshaw sector in Amritsar. The project is spearheaded by the Amritsar Smart City Limited (ASCL) under the Ministry of Housing and Urban Affairs' (MoHUA) City Investments to Innovate, Integrate and Sustain (CITIIS) program, with support from the Agence Française de Développement (AFD) and the European Union (EU). Funded through grants and low-interest loans, the initiative comprises of six interlinked components providing a holistic approach towards wider e-auto adoption (RAAHI 2021). The focus areas of the RAAHI initiative are:

5.1.1 Programme Structure and Incentives

With the primary objective of achieving better air quality by replacing existing diesel autorickshaws with e-autos, the RAAHI initiative also focuses on improved standard of living for auto-rickshaw owners and drivers.

Formation of co-operative society for drivers

The programme creates a formal institutional linkage between the Transport Department of Punjab and the auto-rickshaw drivers' unions, delivering the programme goals directly to auto-rickshaw drivers. A co-operative society is formed, which aims to organise the 15-20 auto-rickshaw unions operating in the city. With over 500 members as of August 2023, the co-operative society acts as the permanent body for delivering e-auto loans, welfare schemes and soft skills training to auto drivers and their families, and any other initiatives offered by local authorities for the auto-rickshaw sector.

Financial assistance for e-autos

Current lending practices in Punjab are tilted heavily towards unorganised financial lending models. With high rates of interest exceeding 25 percent per annum, the predatory pricing affects drivers' take-home incomes. The RAAHI programme is working with banks like the State Bank of India (SBI) and the Punjab Gramin Bank to provide loans up to INR 2.5 lakhs (USD 3,013), at an interest rate of 9.9 percent per annum for a maximum tenure of 4 years.

The programme also offers a subsidy of up to INR 1,25,000 (USD 1,506) per e-auto, which is directly reduced from the loan amount. In case of an outright purchase without a loan, the full subsidy is deposited to the e-auto owner's bank account. Piaggio and Mahindra, empanelled as e-auto OEMs in the programme, ensure scrapping through a certified scrapping agency, providing an additional scrapping subsidy of INR 15,000 (USD 181) to owners replacing their ICE auto-rickshaws. By reducing the effective cost of e-autos to about INR 1,40,000 (USD 1,687) making it equivalent to the cost of e-rickshaws, and by providing affordable financing, the programme aims to increase e-auto adoption with higher driver incomes. As of August 2023, the project had received 310 applications for e-autos and 210 e-autos have been delivered on a driver-cum-owner model in Amritsar (Pers. Comm. 2023d).

Development of charging infrastructure

The programme collaborates with EESL to install, maintain, and operate slow chargers for e-autos, through a revenue sharing model of INR 0.7 per unit of power sold. EESL has proposed to empanel companies to construct more than 80 charging points at 19 locations. This partnership improves the support ecosystem required for proliferation of e-autos in the city. However, due to various delays, no public chargers have been installed in the city, and the drivers are forced to charge their e-autos at their homes.

Inclusion of livelihood opportunities

The programme scope includes technical training of auto-rickshaw drivers to achieve high efficiency and maximum mileage from e-autos. It also includes the training of women family members of the drivers to promote livelihood opportunities for them. The partnering OEMs also train drivers on soft skills, which would improve user experience and could increase tourist footfall in the city.

5.1.2 Challenges to adoption

- As the project structure aims to replace ICE autos with e-autos, there has been resistance from ICE auto-rickshaw drivers to commit to the change. To improve the uptake, the transport and/or police department would need to implement strong enforcement drives where old ICE autos are seized.
- The project has been unable to include women drivers in the fleet due to traditional gender norms and the perception that the transport sector is male-dominated and unsafe for women. Initiatives for gender inclusion and women's livelihoods in the e-auto sector need to be supported by raising awareness and engaging communities, and by training women in driving and vehicle maintenance skills. There is also a need for ancillary support services for financial inclusion.
- As of August 2023, no chargers have been installed in the city due to a slow response from relevant CPOs to the city administration's tender call for the installation and operation of charging infrastructure. CESL and the authorities would need to expedite the empanellment and initiate installation of public charging infrastructure to improve adoption of e-autos.
- In case of loan defaults there is no guarantee fund mechanism for the bank to recover or reduce its losses. This has slowed down the institutionalisation of the low-interest e-auto financing initiative, as banks are risk averse and commercial EVs are a higher-risk sector. The growth of EV guarantee funds, such as those highlighted in Chapter 4 is expected to slowly improve the access and affordability of EV loans.

5.2 The Kochi e-auto project

Initiated in 2019, the project aims to facilitate first and last mile connectivity through improved intermediate public transport in the Greater Kochi area. Supported by Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ), the Kochi e-auto project was implemented under the Integrated Sustainable Urban Transport Systems for Smart Cities (SMART-SUT) scheme by the Kochi Municipal Corporation (KMC). The focus areas of the project are to:

5.2.1 Programme Structure and Incentives

The programme aims to support an institutional policy reform of the IPT sector, eliminate financial barriers to ownership-auto operations, and offer improved livelihood opportunities for auto-rickshaw drivers (especially women and those from economically weaker sections) in Kochi.

Formation of co-operative society for drivers

The Ernakulam Jilla Auto-rickshaw Drivers' Co-operative Society (EJADCS) was constituted under the programme, consisting of six major auto-rickshaw unions in the city. Its main function is to act as a support structure for the benefit of the drivers and to deliver standardised services to customers.

EJADCS aims to develop both organisational and individual capacities in the auto-rickshaw sector. The co-operative society acts a fleet owner and aggregator, owning the e-autos and leasing them to drivers who operate them on sharing basis along fixed routes not covered by bus or metro networks (The Hindu 2020b). This model allows the co-operative society to act as an intermediary, by providing an alternative deployment model for e-autos. This in turn benefits drivers with higher take-home incomes and minimises their exposure to technology risks. This is also more robust from a financing and operational perspective, as e-auto fleet utilisation can be maximised. As of May 2021, the society comprised nearly 3,000 of the total 15,000 drivers in Ernakulam district, including 10 women drivers (Swamy et al. 2021). However as of August 2023, there are no e-auto women drivers in the region as a result of dropouts.

Financial assistance for e-autos

The project supports the funding and procurement of a total of 100 e-autos, of which 80 are funded by GIZ and 20 are funded by UN-Habitat. Through the KMC, GIZ provided a seed fund of INR 45 lakhs (USD 54,237) amounting to 20 percent of the total e-auto cost, to the co-operative society for procuring and deploying e-autos in the city (The Hindu 2021b). The remaining amount was lent to EJADCS as SME loan from SBI at an interest rate of 12 percent. As of November 2022, the Kochi Municipal Corporation had handed over 30 of the 100 proposed e-autos to EJADCS (The New Indian Express 2022b). Apart from the fleet procured by the co-operative society, EJADCS will operate 200 e-autos to be procured by the Kochi Metro Rail Limited. This is an example of how partnerships between government agencies can help amplify impact through pooled resources.

FIGURE 19 | E-auto with swappable battery in Kochi

Credit: Pers. Comm. 2023

Development of charging infrastructure

The project approach towards implementation of charging infrastructure includes demand analysis and cost estimation for chargers (GIZ 2020). Based on an MoU with the KMC and support from the project grant, the Kerala State Electricity Board (KSEB) plans to erect, operate, and maintain charging stations at 15 locations (TOI 2022a). Through tenders invited by Kochi Metro Rail Limited (KMRL) (TOI 2022b), 15 charging stations have been inaugurated in Ernakulam (The New Indian Express 2022b).

Integration with public transit

The programme also targets provision of an e-auto feeder service to the city bus and metro networks from areas having limited accessibility. The rolled-out fleet of 30 e-autos and proposed fleet of 50 autos by October 2023, aim to provide enhanced first and last mile connectivity to transit networks with a ride booking app 'Auto Savari' (AuSa), having a pre-fixed fare and enabled with GPS and SOS facilities (The Hindu 2022b). Few of the 30 deployed e-autos are also being used for feeder service to cater to the newly launched Kochi Water Metro Services. In addition, KMRL envisions having at least 80 percent of the feeder service fleet to be e-autos and has procured an additional fleet of 75 e-autos to be deployed by August 2023 (Pers. Comm. 2023b).

Inclusion of livelihood opportunities

The programme prioritises women and financially disadvantaged persons in gaining access to livelihood opportunities in the EV sector. At least half of the 200 e-autos procured by KMRL were proposed to be operated by women drivers (The Hindu 2022a). The board members of EJDACS were also provided training on e-auto operations, managerial skillsets, charging infrastructure, and EV models for supporting an inclusive e-auto transition (GIZ 2020).

5.2.2 Challenges to adoption

- The co-operative society planned to deploy 100 e-autos in Elamkulam, Fort Kochi, and Kedavanthra by May 2022. However, only 30 were launched by November 2022. Various factors causing a delay in the implementation of such significant programmes could potentially hinder the adoption of electric vehicles by both individual citizens and commercial drivers in the city.
- With only 15 charging stations installed, the proposed e-auto metro feeder services lack a robust charging infrastructure network, which might slow down the demand for e-autos and impact efficient operations.
- Financing through banks for e-auto models with swappable batteries is a challenge, where the lenders seek special agreements to ensure smooth operations till loan tenure period. These hesitations need to be covered through robust implementation of battery swapping initiatives ensuring seamless operations.
- Half of the planned e-auto fleet was proposed to be operated by women drivers. However, there have been various challenges in retaining any women drivers on to the platform as of August 2023. The state government needs to partner with relevant driving institutions or local NGOs to onboard women drivers, and also provide additional retention and hand-holding support to minimise dropouts.

5.3 E-auto acceleration by the Delhi government

The Delhi government has actively promoted e-mobility in the national capital region, with multiple financial and non-financial incentives for EV adoption. With over 1.48 lakh EVs in the city (MoRTH 2023), Delhi aims to become the EV capital of the country. Notified in 2020, the Delhi EV policy aims to improve the local air quality by targeting a 25 percent EV market share of new vehicle registrations by 2024.

Among other initiatives, Delhi has implemented multiple measures for promoting e-3Ws, including e-autos. They include:

5.3.1 Incentives by the state

Purchase subsidies for e-autos, along with financial, regulatory, and infrastructure support measures create a strong ecosystem for market development of the e-auto sector in Delhi.

TABLE 8 | Comparison of on-road prices for auto-rickshaws by fuel type in Delhi

	COSTS (IN INR)	E-AUTO (SWAPPABLE)	E-AUTO (FIXED BATTERY)	CNG AUTO
A	Basic cost (inclusive of battery and charger)	2,47,000	3,53,026	2,35,000[b]
B	FAME-II subsidy[a]	42,000	69,000	0
C	Ex-showroom price with FAME subsidy (A-B)	2,05,000	2,84,026	2,35,000
D	Down payment (20% of C)	41,000	56,805	47,000
E	Purchase subsidy by Delhi government	30,000	30,000	0
F	Net loan amount (C-D-E)	1,34,000	1,97,221	1,88,000
G	Loan tenure	36 months	36 months	36 months
H	Loan interest rate	20%	20%	11%
I	Interest subvention by Delhi government	5%	5%	0%
J	Final interest rate (H-I)	15%	15%	11%
K	Total interest payable during loan tenure	33,225	48,102	33,576
L	Total amount payable (F+K)	1,67,225	2,45,323	2,21,576
M	Road tax per annum	230	230	305[c]
N	Registration charges	0	0	5700
O	Insurance	6000	8500	8000[d]
	Total price paid by beneficiary for the vehicle (D+L+M+N+O)	2,14,455	3,10,858	2,82,581

Notes: a. The considered subsidies for Piaggio L5M models are referred from the FAME website. b. The ex-showroom cost of CNG auto model is adopted for Bajaj Compact RE model from online websites. c. The road tax for CNG auto model is adopted from the Delhi Transport Department website. d. The insurance cost for the CNG auto model is adopted from online websites.

Sources: Delhi EV Cell 2023; Pers. Comm. c 2022; CarDekho 2023; MHI 2022b; Transport Department, Delhi 2023; Policymeter 2022

Purchase incentives for e-autos

Delhi offers various incentives for the purchase of e-autos. In addition to road tax and registration fee exemptions, the Delhi EV Policy offers purchase subsidies of INR 30,000 (USD 361.5) per vehicle. Further incentives are offered under FAME subsidy. Funding for the purchase incentives is provided from the Air Ambience Fund, raised through surcharges, such as road tax, pollution cess, congestion tax, and the environment compensation charge, on inefficient or polluting vehicles.

Additionally, Delhi offers an incentive of INR 7,500 (USD 90) for scrapping and de-registration of old ICE auto-rickshaws, which can further reduce the cost of an e-auto purchase.

Financing incentives for e-autos

Delhi offers a 5 percent interest subvention for loans or hire-purchase schemes for e-3Ws through CESL or banks, NBFCs or Micro Finance Institutions (MFIs) empanelled by CESL (The New Indian Express 2022a). Through this easy financing scheme, e-auto drivers are entitled to avail an additional benefit of INR 12,000-17,000 (USD 145-205). As shown in Table 8, these subsidies reduce the cost for e-auto with swappable battery to INR 2.14 lakh (USD 2,580), making it 24 percent lesser than an ICE auto and much more affordable for current and potential e-auto-drivers.

Permit incentives for e-autos

Delhi has had a permit cap of 1 lakh auto-rickshaws in the city. To promote e-autos, the state government rolled out 4,261 additional e-auto permits, of which 33 percent were reserved for women. The priority permits for e-autos incentivises their uptake over ICE auto-rickshaws. The Delhi EV policy also states that these permits can be owned and operated by fleet operators and aggregators, which can further accelerate e-auto uptake through the participation of EV fleet operators in the city.

FIGURE 20 | Launch of blue and lilac e-autos for men and women drivers in Delhi

Credit: Switch Delhi

Development of charging infrastructure

Delhi offers incentives for public and private charging infrastructure with an unspecified subsidy amount and concessional land access for public charging infrastructure, and a subsidy of INR 6,000 (USD 72) per charging point for private charging infrastructure. In 2021, the state set up a single-window facility for EV charger installations in private or semi-public spaces, enabling residents to choose, order, and pay for chargers from empanelled vendors using the DISCOM portal. As of October 2022, more than 1,000 charging points (59 percent by Resident Welfare Associations, 15 percent by offices, and 13 percent in parking areas) were installed in Delhi (India Today 2022).

For public charging infrastructure, the state nodal agency Delhi Transco Limited (DTL) floated a tender to deploy public charging and swapping stations across 100 land parcels aggregated from various land-owning agencies in Delhi. These initiatives are a part of Delhi's larger vision to install 18,000 public and semi-public EV charging points by 2024 (Delhi EV Cell 2022).

Inclusion of livelihood opportunities

Delhi is also integrating livelihood development initiatives for a more inclusive EV transition. The reservation of 33 percent of e-auto permits for women aims to leverage the EV transition to promote women's livelihoods in the male-dominated transport sector. The state also launched a training programme for EV mechanics by the Delhi Skill and Entrepreneurship University (DSEU) and Hero Electric, facilitated by WRI India, to ensure skill development in the EV workforce and provide job opportunities (DDC 2022).

E-auto feeder services to the metro

As part of a joint venture between the transport department and the Delhi Metro Rail Corporation (DMRC), the state allotted 1,299 of the 4,261 e-auto permits to the metro authority on a PPP model, to enhance last mile connectivity.

Operated by ETO Motors in collaboration with Sun Mobility, 86 e-autos provide last mile connectivity in the Dwarka and Azadpur areas of the city. Further, feeder services are planned to be scaled up to cater to other locations like Chhatarpur, Rohini, and the New Delhi Municipal Committee (NDMC) areas. The 36 e-autos operational in the Azadpur area are driven by an all-women staff, utilising the permits reserved for women (TOI 2023; The Print 2023).

5.3.2 Challenges to adoption

- The Delhi EV policy does not provide retrofitting incentives. Considering the high number of ICE auto-rickshaws and the poor air quality in the city, the government could consider retrofitting for a faster e-auto transition.
- Subsidies and other incentives are limited to residents of the state, and permit incentives are limited to those who have a Delhi-issued light motor vehicle driving license. This bars migrants and new entrants in the auto-rickshaw sector from benefitting from the incentives.
- Despite efforts by the Delhi government, the uptake of e-auto permits by women has been low. While a total of 1,466 permits have been reserved, only 823 women applied for the permits (Roy 2022). Gendered norms, social stigma, and concerns for personal safety prevent women from considering employment in the sector. Further, women have lower access to financing and are not included in peer networks of auto-rickshaw drivers. To address these barriers, an additional subsidy or financing incentive could be offered for women e-auto drivers. Local authorities could also work with women's groups that support sourcing and training of women drivers and promote social sensitisation through campaigns in low-income communities.


ELECTRIK

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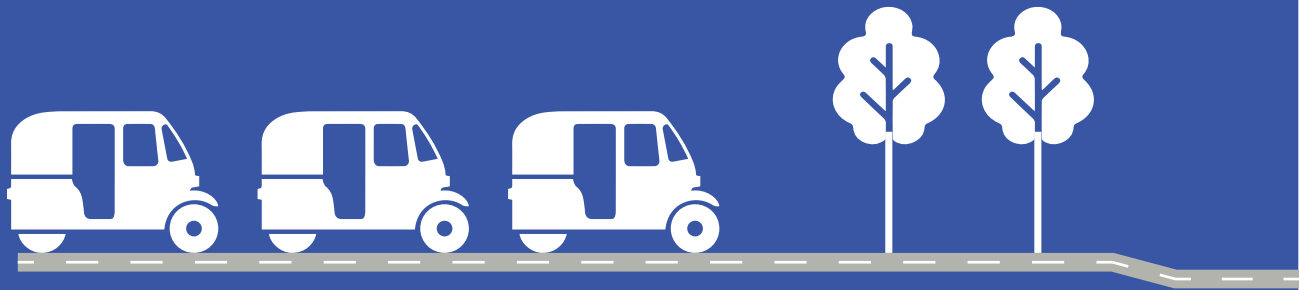
Conclusion

With a rapidly expanding transport sector contributing to a growing share of GHG emissions and urban air pollution in India, an accelerated shift to electric vehicles is critical to establish viable decarbonisation pathways (in concert with a growing share of renewables in the electricity grid) that decouple economic growth and carbon emissions. At the same time, it is important to ensure a just transition to clean transportation, with co-benefits such as clean air, livelihood opportunities, and improved transport services accruing to all members of the society, including women, low-income communities, and other marginalised groups.

In Indian cities, auto-rickshaws play a vital role in providing affordable shared mobility, accounting for up to 25 percent of urban motorised trips. They are also a preferred transport mode for women and other vulnerable groups with lower levels of vehicle ownership and varied travel patterns that are not catered to by public transport networks. However, the market share of e-autos remains small, at 6 percent of new vehicle registrations in FY2023. Considering the GHG emission impacts of auto-rickshaw fleets, as well as their utilisation by vulnerable users, an accelerated e-auto transition is expected to have significant environmental and socio-economic benefits.

The central and state governments have set ambitious targets towards the adoption of e-autos. The Government of India has committed to achieving 30 percent EV market share among new vehicle sales by 2030 and has projected a sectoral penetration rate of 80 percent for e-3Ws. Some state governments too have targets for e-autos, and various supply and demand side incentives for all EVs, with some specific incentives for e-3Ws. However, given the fragmented institutional governance framework for auto-rickshaw electrification, a programmatic approach is required to enable coordination between different government agencies, implement a holistic suite of measures for promoting a just e-auto transition, and overcome the barriers to e-auto adoption.

This guidebook, recognising the key role of state governments and local authorities in on-ground implementation of road transport transitions, aims to provide a detailed overview of the policy and regulatory levers that subnational governments can use to accelerate e-auto adoption. Key enabling parametres, such as the availability of accessible charging infrastructure and easy access to affordable financing, are also discussed in detail. Learnings from ongoing and successful programmes such as the RAAHI initiative, the Kochi e-auto project, and the Delhi government initiatives for e-autos, are analysed and offer best practices that can be adopted by other states and local governments looking to initiate their own auto-rickshaw electrification programmes.



Annexures

ANNEXURE A:
EXAMPLES OF E-AUTO (L5M) MODELS IN INDIA

MAHINDRA TREO

Kerb Weight	387 kg
Top Speed	55 kmph
Certified Range	141 km
Gradeability	12.7%
Battery Type	Lithium ion 48V
Battery Size	7.37 kW
Charging Type	Plug-in Charging
Charging Time	3h 50 min
Peak Power (kW)	8
Peak Torque (Nm)	42

Credit: Mahindra & Mahindra Ltd. (https://auto.mahindra.com/)

PIAGGIO E-APE CITY

Kerb Weight	389 kg
Top Speed	45 kmph
Certified Range	75 km
Gradeability	19%
Battery Type	Lithium ion 48V
Battery Size	4.5 kW
Charging Type	Battery Swapping
Charging Time	N/A
Peak Power (kW)	5.4
Peak Torque (Nm)	29

Credit: Piaggio (https://piaggio-cv.co.in/ape-e-city/)

BAJAJ RE E-TEC 9.0

Kerb Weight	NA
Top Speed	45 kmph
Certified Range	178 km
Gradeability	29%
Battery Type	Lithium ion - LFP
Battery Size	8.9 kW
Charging Type	Plug-in Charging
Charging Time	4 hours 30 minutes
Peak Power (kW)	4.5
Peak Torque (Nm)	36

Credit: Bajaj Auto (https://www.bajajauto.com/three-wheelers/ev-re/specifications)

Note: This is not meant to be an exhaustive list of electric auto-rickshaw models in India, but only aims to highlight the vehicle specifications of typical e-auto models.

ANNEXURE B:
CURRENT AND PROJECTED NUMBER OF E-3WS IN 2030

TABLE 9 | Number of passenger 3-wheelers registered from 2013-2023

FINANCIAL YEAR	NO. OF PASSENGER 3WS	ANNUAL GROWTH RATE
2013-14	2,97,472	-
2014-15	3,35,704	12.85%
2015-16	3,29,138	-1.96%
2016-17	3,30,869	0.53%
2017-18	4,01,912	21.47%
2018-19	4,70,343	17.03%
2019-20	4,69,340	-0.21%
2020- 21	1,15,818	-75.32%
2021-22	1,52,295	31.50%
2022-23	3,17,503	108.48%
(2013-14 to 2019-20)		8.28%

Source: MoRTH 2023

TABLE 10 | Projected number of e-autos in India by 2030

FINANCIAL YEAR	NO. OF PASSENGER 3WS	NO. OF E-AUTOS	EV PENETRATION
2022-23	3,17,503	15,247	4.8%
2023-24	3,43,807	35,075	10.2%
2024-25	3,72,289	58,083	15.6%
2025-26	4,03,132	84,663	21.0%
2026-27	4,36,529	1,15,248	26.4%
2027-28	4,72,693	1,50,320	31.8%
2028-29	5,11,854	1,90,412	37.2%
2029-30	5,54,258	2,36,116	42.6%
2030-31	6,00,176	2,88,085	48%

Note: Number of passenger 3Ws from 2023-24 to 2030-31 are projected using the AGR for 2013-14 to 2019-20 (using the pre-pandemic growth rate); Number of e-autos are projected considering the EV penetration rate of 48% projected as part of the Stated Policy Scenario by the International Energy Agency (IEA).

Source: IEA 2021b; 2021a.

ANNEXURE C:
LIST OF GOI INCENTIVES SUPPORTING AUTO-RICKSHAW ELECTRIFICATION

GOVERNMENT OF INDIA INCENTIVES FOR E-MOBILITY

National Electric Mobility Mission Plan

Launched in 2013 by the Department of Heavy Industry (DHI) as a roadmap for faster adoption and manufacturing of EVs.

FAME India Scheme

Budget outlay of INR 10,000 cr offered over 3 years, from 2019-2024, with INR 2,500 cr for demand incentives to support 5,00,000 e-3Ws and INR 1000 cr for deployment of charging station infrastructure.

PERMIT EXEMPTION

In 2018, MoRTH exempted electric vehicles from the requirement of passenger transport permits.

In 2020, MoRTH allowed the registration of EVs without batteries.

REGISTRATION FEE EXEMPTION

In 2021, MoRTH announced exemption of fee for new or renewed registrations for battery EVs.

In 2021, MoP launched the “Go-Electric" campaign to spread awareness on the benefits of electric mobility, with support from BEE.

In 2021, MoRTH announced financial incentives for replacement of old commercial vehicles having been on the raod for more than 15 years.

In 2022, battery swapping was prioritised as part of the FY 22-23 budget. NITI Aayog released a draft battery swapping policy to ensure interoperability and improving the battery swapping ecosystem.

ANNEXURE D: CHARGING DEMAND & CHARGER CALCULATIONS FOR HYDERABAD CITY

ELECTRIC VEHICLE SPECIFICATIONS AND CHARGING USE CASES			
Battery Capacity (kWh)[a]	7.4	**3W (L5M) ANNUAL GROWTH RATE**	**4.15%**
Range (km)[a]	130	Energy needs from home charging	25%
Energy consumption (kWh/km)	0.057	Energy needs from workplace charging (or charging hubs)	50%
Considered Mahindra Treo model		Energy needs from public charging[b]	50%

FORECASTING EV SALES AND ENERGY NEEDS										
	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Number of 3W	9,458	9,850	10,259	10,684	11,127	11,589	12,069	12,570	13,091	13,634
EV penetration rate (%)[c]	5%	8%	10%	12%	40%	45%	50%	55%	58%	60%
EV penetration rate	0.05	0.08	0.1	0.12	0.4	0.45	0.5	0.55	0.58	0.6
Number of electric 3W (registration) = Number of EVs * EV penetration rate	473	788	1,026	1,282	4,451	5,215	6,035	6,913	7,593	8,180
Number of electric 3W (on-road)[d]	473	1,261	2,287	3,569	8,020	13,235	19,269	26,183	33,775	41,956
Battery capacity (kWh)[e]	7.4	8.2	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
Energy consumption (kWh/km)[f]	0.057	0.057	0.056	0.055	0.055	0.055	0.055	0.054	0.054	0.054
Range (km) = Battery capacity/ Energy[g]	130	145	160	161	162	163	165	166	167	168

FORECASTING EV SALES AND ENERGY NEEDS (CONT'D)										
	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Daily driving needs (km)[h]	120	122	125	128	130	132	134	136	138	140
Daily energy needs (kWh) = Daily driving needs * Energy consumption per km	6.83	6.90	7.02	7.14	7.21	7.27	7.33	7.39	7.45	7.50
Total daily energy need = Daily energy need * Number of EVs (kWh)	3,230	8,700	16,060	25,496	57,803	96,211	1,41,248	1,93,471	2,51,522	3,14,795
Energy need from home charging per day (kWh)	808	2,175	4,015	6,374	14,451	24,053	35,312	48,368	62,881	78,699
Energy need from public charging per day (kWh)	1,615	4,350	8,030	12,748	28,902	48,106	70,624	96,736	1,25,761	1,57,398

ESTIMATING CHARGER REQUIREMENTS										
	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Charger utilisation rate[i]	15%	20%	25%	30%	35%	40%	45%	50%	55%	60%
No. of hours a charger will be utilised per day	3.6	4.8	6.0	7.2	8.4	9.6	10.8	12.0	13.2	14.4
C-rate of battery	0.5	0.5	0.55	0.55	0.6	0.6	0.65	0.65	0.7	0.7
Maximum power drawn by an e-3W (kW)[j]	3.7	4.1	5.0	5.0	5.4	5.4	5.9	5.9	6.3	6.3
Maximum power delivered by the charger (kW)	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
Power delivered per charger (kWh) per day	11.9	15.8	19.8	23.8	27.7	31.7	35.6	39.6	43.6	47.5
NUMBER OF PUBLIC CHARGERS NEEDED[k]	**136**	**275**	**406**	**537**	**1,043**	**1,518**	**1,982**	**2,443**	**2,887**	**3,312**

NOTES AND ASSUMPTIONS	
a. The battery capacity and range of Mahindra Treo model was considered for e-3Ws.	7.4 kWh 130 kms
b. The share of public charging for 3Ws is 50%, as certain users will charge at home or at charging hubs provided by fleet operators.	50%
c. The EV penetration rates considered here are from NITI Aayog, International Energy Agency (IEA), KPMG and Bloomberg New Energy Finance (BNEF) estimates.	For 2025 - 40% For 2030 - 60%
d. Phasing out of vehicles over a period of 10 years has not been considered here.	
e. Global trends indicate that the battery capacities are increasing across all EV segments. For e-3Ws, a net battery capacity of 9 kWh is forecasted by 2025, which is expected to hold steady at that capacity up to 2035 (Gode et al. 2021)	
f. Assumed a year-on-year decrease in energy consumption of 0.65% for e-3Ws (Gode et al. 2021).	
g. The estimated desired range for 3Ws is 150 km (Gode et al. 2021).	
h. With cities expanding, availability of better EV models and increasing e-commerce activity, the daily driving needs for 3Ws is also assumed to increase till 2030: 140 km.	
i. For charger utilisation rates, a 5% year-on-year increase was considered. The average utilisation by 2030 should be within 50-60%.	
j. Assuming that 7kW and 15kW chargers will be utilised, the maximum power draw considered is the lower limit of the vehicle battery capacity versus the charger capacity.	
k. Assuming that the 7kW chargers will be utilised.	

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Note:

a. Unless otherwise stated, all the interpretation and findings set forth in this guidebook are those of the authors and not of the organisations.

b. Currency conversion rate considered as of September 5, 2023: 1 USD = 83.243 INR