INDIAN INSTITUTE of MANAGEMENT AHMEDABAD

विद्याविनियोगाद्विकास:

Assessing the Tipping Point for EV Adoption in India

Analyzing trends, challenges, and opportunities



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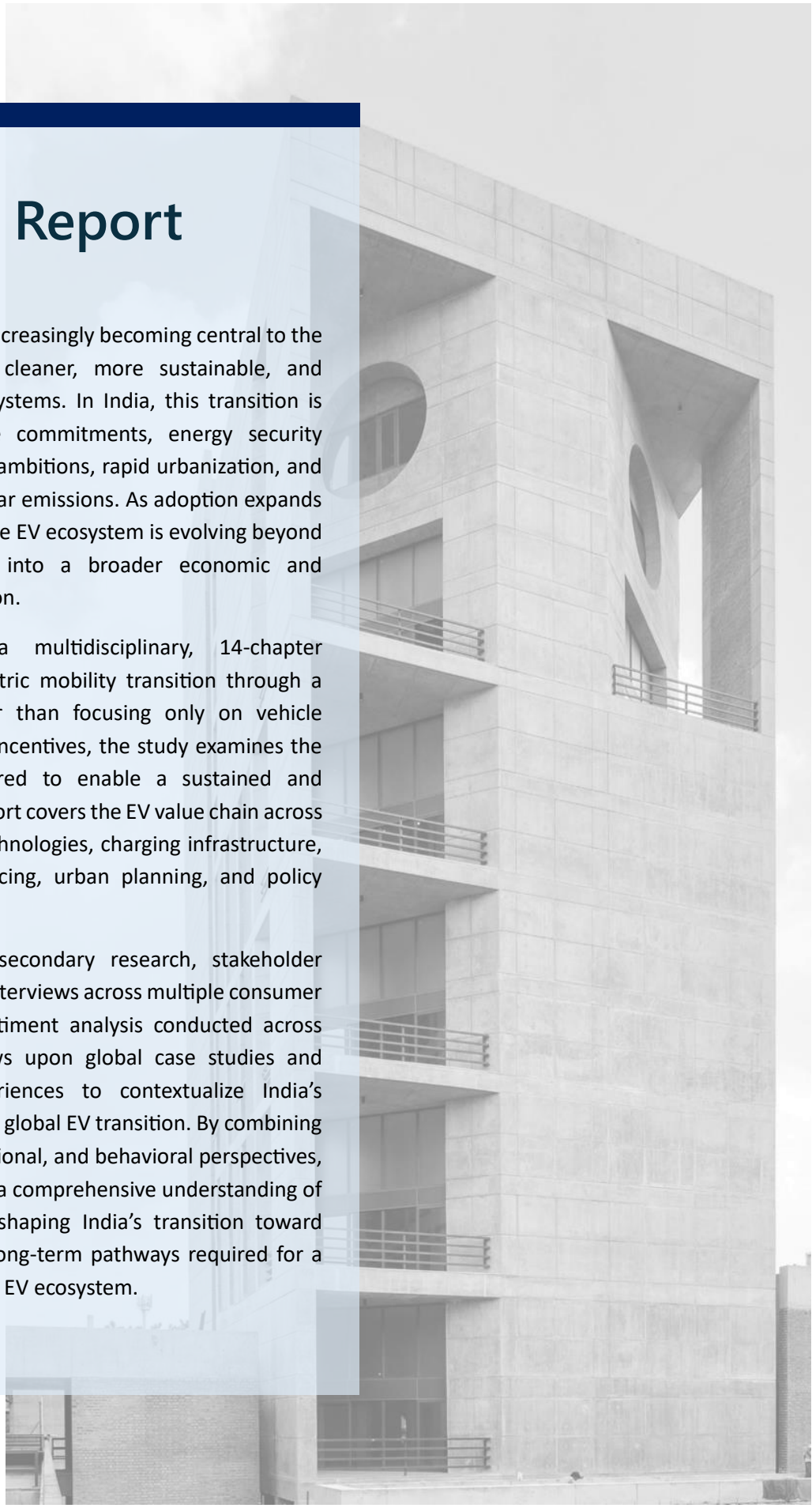
Cover image: Eco-friendly car charging — StockCake

About the Report

Electric vehicles (EVs) are increasingly becoming central to the global transition toward cleaner, more sustainable, and energy-efficient mobility systems. In India, this transition is being shaped by climate commitments, energy security concerns, industrial policy ambitions, rapid urbanization, and the need to reduce vehicular emissions. As adoption expands across vehicle segments, the EV ecosystem is evolving beyond a niche policy initiative into a broader economic and technological transformation.

This report presents a multidisciplinary, 14-chapter assessment of India's electric mobility transition through a systems-level lens. Rather than focusing only on vehicle adoption trends or policy incentives, the study examines the broader ecosystem required to enable a sustained and scalable transition. The report covers the EV value chain across manufacturing, battery technologies, charging infrastructure, consumer adoption, financing, urban planning, and policy frameworks.

The research integrates secondary research, stakeholder consultations, household interviews across multiple consumer segments, and digital sentiment analysis conducted across Indian cities. It also draws upon global case studies and comparative policy experiences to contextualize India's position within the broader global EV transition. By combining technical, financial, institutional, and behavioral perspectives, the report aims to provide a comprehensive understanding of the structural conditions shaping India's transition toward electric mobility and the long-term pathways required for a resilient and self-sustaining EV ecosystem.



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List of Acronyms

A

AAT: Advanced Automotive Technology

ACC: Advanced Chemistry Cell

AFIR: Alternative Fuels Infrastructure Regulation (European Union)

AIS: Automotive Industry Standard

AMC: Annual Maintenance Contract

ARAI: Automotive Research Association of India

ASDC: Automotive Skill Development Council

B

B2B: Business-to-Business

BaaS: Battery-as-a-Service

BEV: Battery Electric Vehicle

BIS: Bureau of Indian Standards

BMA: Bengaluru Metropolitan Area

BMS: Battery Management System

BMTC: Bangalore Metropolitan Transport Corporation

BOT: Build-Operate-Transfer

BRT: Bus Rapid Transit

C

CAN: Controller Area Network

CESL: Convergence Energy Services Limited

CMP: Comprehensive Mobility Plan

CPO: Charge Point Operator

CPCB: Central Pollution Control Board

D

DBL: Dedicated Bus Lane

DCR: Development Control Regulation

DDA: Delhi Development Authority

DEVI: Delhi Electric Vehicle Interconnector

DHI: Department of Heavy Industry

DISCOM: Electricity Distribution Company

DST: Department of Science and Technology

DVA: Domestic Value Addition

E

E2W / e-2W: Electric Two-Wheeler

E3W / e-3W: Electric Three-Wheeler

E4W / e-4W: Electric Four-Wheeler

EBA: European Battery Alliance

ECS: Equivalent Car Space

EESL: Energy Efficiency Services Limited

EMI: Equated Monthly Installment

EMPS: Electric Mobility Promotion Scheme

EPR: Extended Producer Responsibility

ESS: Energy Storage System

EV: Electric Vehicle

EV30@30: Global initiative for 30% EV sales by 2030

EVCI: Electric Vehicle Charging Infrastructure

EVRP: Electric Vehicle Routing Problem

EVSE: Electric Vehicle Supply Equipment

F

FAME: Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles

FOC: Field Oriented Control

G

GCC: Gross Cost Contract

GIZ: Deutsche Gesellschaft für Internationale Zusammenarbeit

GLA: Greater London Authority

GSDP: Gross State Domestic Product

GST: Goods and Services Tax

GVW: Gross Vehicle Weight

H

HCV: Heavy Commercial Vehicle

HMV: Heavy Motor Vehicle

HOV: High-Occupancy Vehicle

HRTC: Himachal Road Transport Corporation

I

ICE: Internal Combustion Engine

ICEV: Internal Combustion Engine Vehicle

ICCT: International Council on Clean Transportation

IEA: International Energy Agency

IEMI: India Electric Mobility Index

IIMA: Indian Institute of Management Ahmedabad

IoT: Internet of Things

IPT: Intermediate Public Transport

ISBT: Inter-State Bus Terminal

ITC: Input Tax Credit

ITDP: Institute for Transportation and Development Policy

J

JOGMEC: Japan Oil, Gas and Metals National Corporation

K

KABIL: Khanij Bidesh India Ltd

KSEB: Kerala State Electricity Board

KSRTC: Kerala State Road Transport Corporation

L

L5: Vehicle category for passenger three-wheelers

LCA: Life Cycle Assessment

LCV: Light Commercial Vehicle

LDA: Latent Dirichlet Allocation (Topic Modeling)

LEZ: Low Emission Zone

LFP: Lithium Iron Phosphate

LGV: Large Goods Vehicle

LTA: Land Transport Authority (Singapore)

LTO: Lithium Titanium Oxide

M

MBBL: Model Building Bye-laws

MCLP: Maximum Coverage Location Problem

MDB: Multilateral Development Bank

MeitY: Ministry of Electronics and Information Technology

MHI: Ministry of Heavy Industries

MoEFCC: Ministry of Environment, Forest and Climate Change

MoHUA: Ministry of Housing and Urban Affairs

MoP: Ministry of Power

MoRTH: Ministry of Road Transport and Highways

MPT: Material Possession Theory

MSRP: Manufacturer's Suggested Retail Price

MSRTC: Maharashtra State Road Transport Corporation

N

N1 / N2 / N3: Commercial vehicle categories (Light, Medium, Heavy)

NAB: National Automotive Board

NBEM: National Board for Electric Mobility

NBFC: Non-Banking Financial Company

NCEM: National Council for Electric Mobility

NCMM: National Critical Mineral Mission

NEBP: National Electric Bus Program

NEMMP: National Electric Mobility Mission Plan

NMC: Nickel Manganese Cobalt

NMT: Non-Motorized Transport

NPS: Net Promoter Score

NRDC: Natural Resources Defense Council

NSDC: National Skill Development Corporation (or Council)

O

OEM: Original Equipment Manufacturer

ONDC: Open Network for Digital Commerce

P

PCS: Public Charging Station

PHV: Private Hire Vehicle

PLI: Production Linked Incentive

PM e-DRIVE: Prime Minister's Electric Drive Revolution in Innovative Vehicle Enhancement

PMP: Phased Manufacturing Program

PMSM: Permanent Magnet Synchronous Motor

PPP: Public-Private Partnership

PRSF: Partial Risk Sharing Facility

PSL: Priority Sector Lending

PSM: Payment Security Mechanism

PSU: Public Sector Undertaking

PTA: Public Transport Authority

Q

QCA: Qualitative Comparative Analysis

QCI: Quality Council of India

R

R&D: Research and Development

RE: Renewable Energy

ROI: Return on Investment

RTO: Regional Transport Office

RVG: Residual Value Guarantee

RWA: Resident Welfare Association

RMI: Rocky Mountain Institute

S

SEZ: Special Economic Zone

SGST: State Goods and Services Tax

SOH / SoH: State-of-Health

SRTU: State Road Transport Undertaking

STU: State Transport Undertaking

T

TAFP: Technology Acquisition Fund Program

TAM: Technology Acceptance Model

TCO: Total Cost of Ownership

TEN-T: Trans-European Transport Network

TfL: Transport for London

TOD: Transit-Oriented Development

TPB: Theory of Planned Behavior

TPREL: Tata Power Renewable Energy Limited

TRL: Technology Readiness Level

U

ULB: Urban Local Body

UMTA: Unified Metropolitan Transport Authority

URDPFI: Urban and Regional Development Plan Formulation and Implementation

UITP: International Association of Public Transport

V

V-VMP: Voluntary Vehicle-Fleet Modernization Program (Scrapping Policy)

V2G: Vehicle-to-Grid

V2X: Vehicle-to-Everything

VADER: Valence Aware Dictionary and Sentiment Reasoner

VAT: Value Added Tax

VCU: Vehicle Control Unit

VGF: Viability Gap Funding

W

WSSTL: World Symposium on Sustainable Transport and Livability

WRI: World Resources Institute

Z

ZEV: Zero-Emission Vehicle

Executive Summary

India's electric vehicle (EV) transition has reached a critical inflection point, evolving from a policy-dependent niche into a market with growing structural momentum. While EV sales increased nearly tenfold between 2019 and 2024, reaching approximately 1.67 million units, the transition is now approaching an "execution ceiling." This report finds that the key constraint is no longer low consumer awareness, but a broader crisis of confidence surrounding the ownership lifecycle, charging reliability, resale value, and institutional coordination.

Despite high levels of awareness, a significant gap remains between consumer intent and actual adoption. Potential buyers continue to express concerns regarding battery life, resale value, and the repair ecosystem. At the same time, traditional range anxiety has increasingly evolved into "information anxiety," where consumers are less concerned about battery range itself and more concerned about locating reliable charging infrastructure and qualified service support. At the dealership level, EV adoption is further constrained by weak sales incentives, as EVs require longer customer engagement and generate lower service revenue than ICE vehicles.

The transition itself remains uneven across vehicle categories, creating a "two-speed" adoption pattern. Platform-driven two- and three-wheelers are approaching a self-sustaining tipping point due to favorable Total Cost of Ownership (TCO) economics and predictable operational duty cycles. In contrast, private four-wheelers continue to face slower adoption because of high upfront costs, limited affordable entry-level models, and financing concerns. Heavy-duty commercial vehicles face even greater barriers, with electric truck costs remaining significantly higher than alternatives.

India's ambition to emerge as a global EV manufacturing hub is also constrained by structural weaknesses across the value chain. The industry remains heavily dependent on imported lithium-ion cells and critical minerals. Simultaneously, several promising indigenous battery technologies, including Sodium-ion and Zinc-air chemistries, remain at Technology Readiness Level (TRL) 4–6, where commercialization risks are high, and policy incentives remain limited. Infrastructure deployment also suffers from execution gaps, with many publicly installed chargers remaining underutilized/non-functional due to siting models that fail to reflect actual mobility patterns and charging demand.

To move India toward a self-sustaining EV ecosystem, the report proposes a strategic shift from short-term adoption subsidies to long-term lifecycle security. This includes redirecting industrial support toward pre-commercial battery innovation, rationalizing GST structures across the EV value chain, embedding demand-driven charging infrastructure into statutory urban planning processes, and formalizing battery health certification systems to strengthen secondary EV markets. The report argues that institutional coordination is now one of the central binding constraints.

Ultimately, India's transition to electric mobility will depend on its ability to synchronize technical reliability, financial de-risking, urban planning, and industrial policy into a coherent execution architecture. By moving beyond fragmented pilots and isolated incentives toward a coordinated ecosystem approach, India can convert growing public optimism into a durable and self-sustaining mobility transition.

Chapter 1

Introduction: Assessment of the EV Tipping Point in India

Chapter Summary

Content:

1. Introduces the concept of an EV "tipping point" and frames the report around the question of when India's EV transition can become self-sustaining rather than subsidy led.
2. Sets out the report's scope across consumer adoption, commercial and public transport, supply-side constraints, charging infrastructure, and policy and industrial strategy.

Findings:

1. India's EV market has grown quickly, with sales rising from fewer than 170,000 units in 2019 to around 1.43 million units in 2024, but adoption remains uneven across vehicle segments and regions.
2. The market is still constrained by barriers like high upfront costs, weak charging density outside metros, and limited consumer awareness, which may delay a self-reinforcing adoption cycle.

Takeaways:

1. Reaching the tipping point will require coordinated action across policy, industry, infrastructure, and consumer-facing systems rather than isolated interventions.
2. The transition strategy must reflect India's actual market structure, including two-wheelers, three-wheelers, public transport, logistics, and uneven urban-rural adoption conditions.

1. Introduction

1.1. Achieving the 'Tipping Point' and what it means

The global automotive industry has been undergoing its most consequential transformation since the transition to oil-based motorized transport in the early 1900s (Hertzke, et al., 2025). At the center of this shift is the idea of a "tipping point"—a critical threshold at which incremental changes give way to rapid, self-reinforcing adoption (Lenton, 2013). In the context of Electric Vehicles (EVs), this marks the moment when uptake becomes self-sustaining, setting in motion an irreversible transition away from Internal Combustion Engine (ICE) vehicles as legacy production systems are phased out. This transition is driven by powerful feedback dynamics: as production scales, costs decline along the experience curve, improving affordability and accelerating adoption along a characteristic S-shaped trajectory (Mercure, et al., 2025).

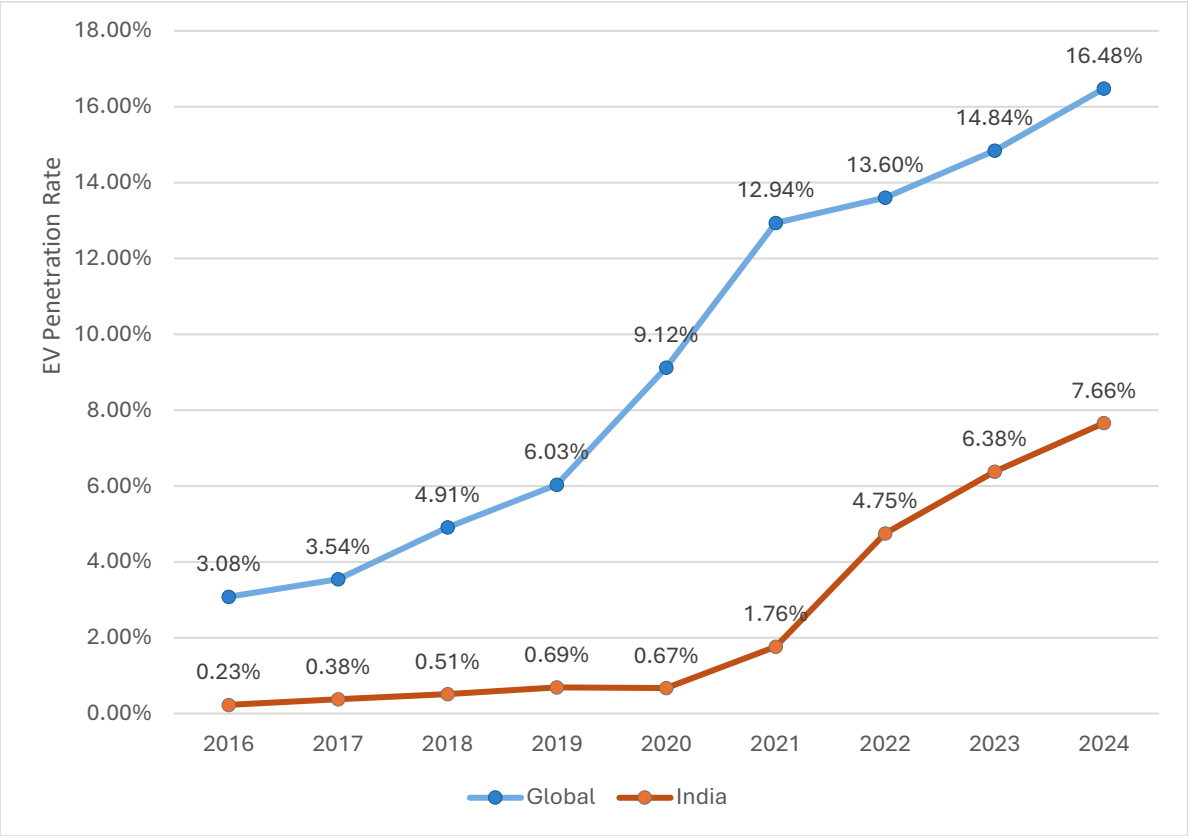
Building on this, the EV transition is not merely a technological substitution, but a system-level realignment shaped by global market spillovers, industrial scaling, and coordinated policy action. Lead markets such as China and the European Union have already crossed an initial threshold at which EVs are competitive on a total cost-of-ownership basis, generating scale and innovation that extend beyond their borders. India, as a large but relatively late-moving market, stands to benefit from these dynamics (Johnson, et al., 2023). Assessing its proximity to the tipping point, along with the barriers that may delay its onset, is therefore of strategic importance. Converging global cost trends and policy alignment could bring this forward by several years (Murphy, Lam, Mercure, & Sharpe, n.d.; Mercure et al., 2025). The implications extend beyond emissions reduction. A self-sustaining EV transition could deliver substantial economic benefits; for instance, it is estimated that India could save over INR 1 lakh crore (USD 14 billion) annually in crude oil imports if electric vehicles account for 30% of new vehicle sales by 2030 (Soman et al., 2020).

1.2. Global Progress

The global EV market has undergone a structural shift over the past decade, moving from a niche technology category to a mainstream automotive segment (Figure 1). Global EV penetration—measured as the share of new vehicle sales that are electric—rose from around 3% in 2016 to approximately 16.5% in 2024, with growth accelerating sharply after 2020 as production costs fell and model availability expanded. This trajectory reflects the combined effect of declining battery prices, increasingly stringent emissions regulations, and growing consumer familiarity with technology across a widening set of markets.

India's penetration trajectory, while below the global average, has followed a broadly similar pattern with a notable acceleration from 2021 onwards. EV penetration in India reached approximately 7.7% in 2024, up from under 1% in 2016. The gap between India and the global average reflects structural differences in market conditions, including lower average vehicle prices, consumer sensitivity to upfront costs, and a less developed charging network. However, the closing of this gap in recent years points to the improving competitiveness of EVs in the Indian market, particularly in the two- and three-wheeler segments that dominate domestic volumes.

Figure 1: EV Penetration Rate – Global & India

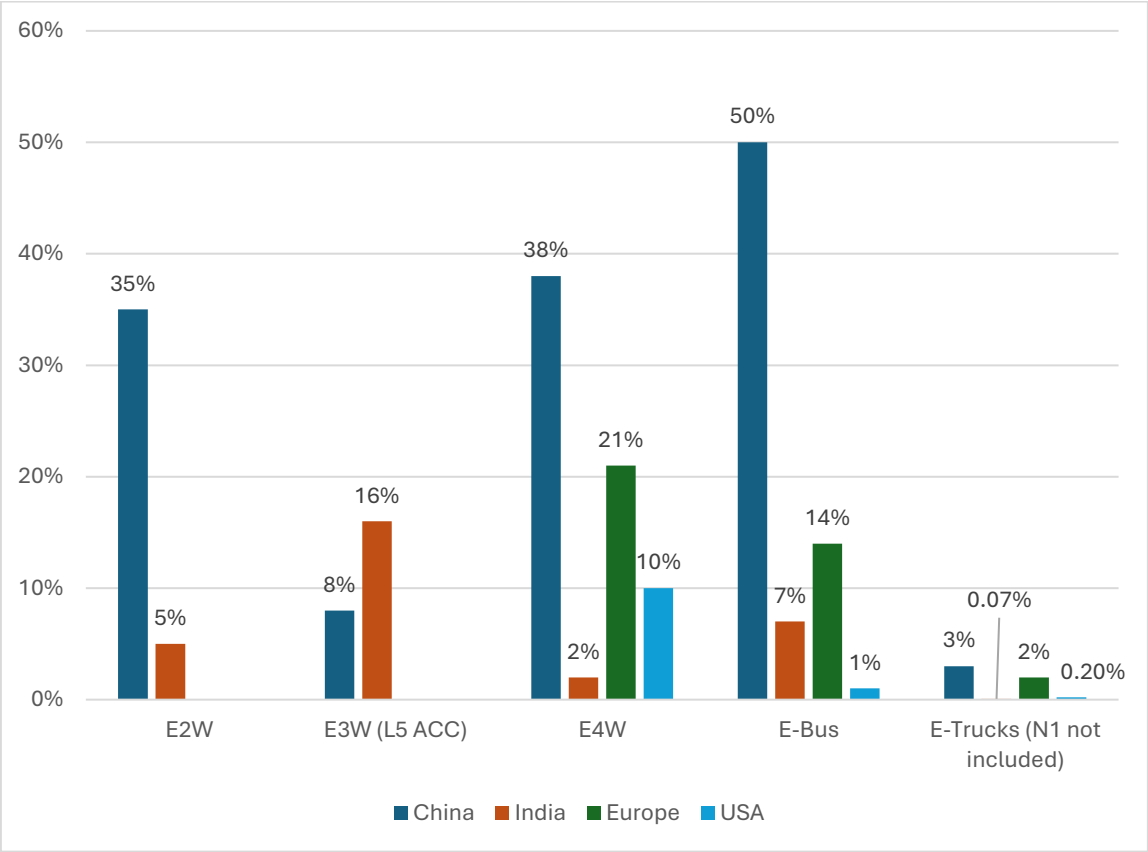


Source: 1) IEA Global EV Data Explorer for global data, 2) VAHAN Portal for India data (Accessed via Niti Aayog (Niti Aayog, 2025))

A closer look at penetration rates across vehicle segments and geographies reveals the uneven nature of the global transition (Figure 2). China stands out as the most advanced market across almost all vehicle types, with EV market share reaching 35% in two-wheelers, 38% in four-wheelers, and 50% in buses. Europe has made comparable inroads in the four-wheeler segment and shows meaningful penetration in two-wheelers and buses. The United States, by contrast, remains at an earlier stage, with limited penetration outside the passenger car category.

India's position in this comparative landscape is instructive. Its strongest performance is in the three-wheeler segment, where EV penetration has reached approximately 16%, reflecting the segment's suitability for electrification given predictable duty cycles and strong economics. Two-wheeler penetration stands at around 5%, while four-wheeler penetration remains below 2%. Notably, India shows a very low share in the bus segment, driven primarily by government-procured electric bus fleets under national procurement programs. Taken together, the data underline both India's genuine early-mover advantages in specific categories and the significant headroom that remains to close the gap with leading EV markets across the rest of the vehicle fleet.

Figure 2: EV penetration rate across China, India, Europe & US in different vehicle segments in 2023



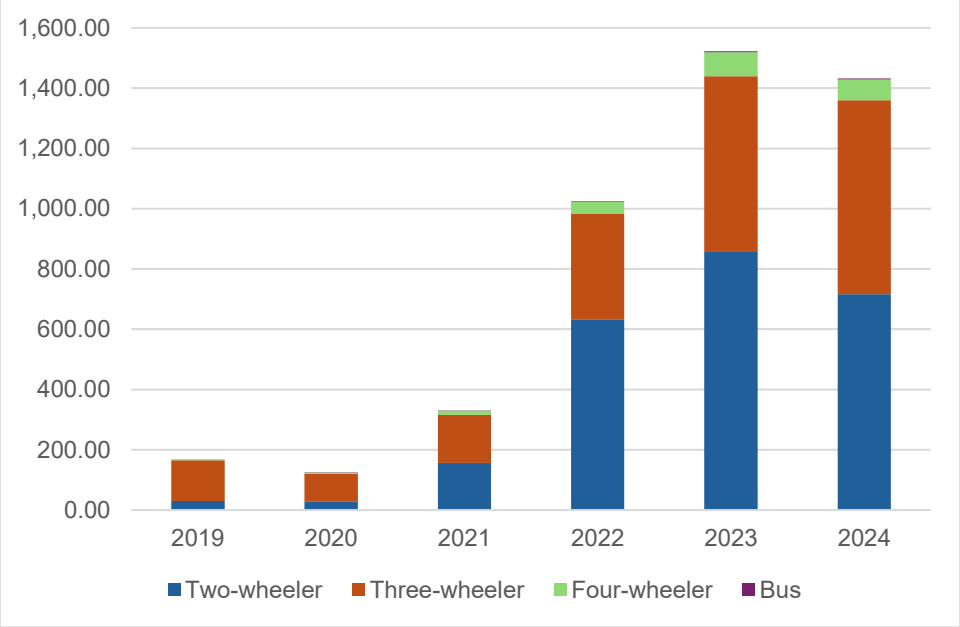
Source: 1) IEA Global EV Data Explorer for global data, 2) VAHAN Portal for India data (Accessed via Niti Aayog (Niti Aayog, 2025))

2. Background – Indian Scenario

India's electric vehicle (EV) market has undergone a remarkable transformation over the past few years, evolving from a nascent and largely policy-dependent segment into one of the fastest-growing EV markets among major economies. While the country still trails leading markets such as China and Norway in overall penetration, the pace and breadth of recent growth signal a market beginning to develop its own structural momentum.

Aggregate EV sales across all vehicle segments crossed 1.43 million units in 2024, up from fewer than 170,000 units in 2019, representing nearly a tenfold increase within five years (Figure 3). Crucially, this growth has not been uniform across segments. Two-wheelers and three-wheelers have led the transition, driven by compelling total cost-of-ownership economics, concentrated urban use patterns, and relatively lower upfront price gaps compared with their ICE counterparts. Four-wheelers, by contrast, have grown sharply in percentage terms, but from a low base, reflecting persistent affordability and charging anxiety barriers in the passenger car segment.

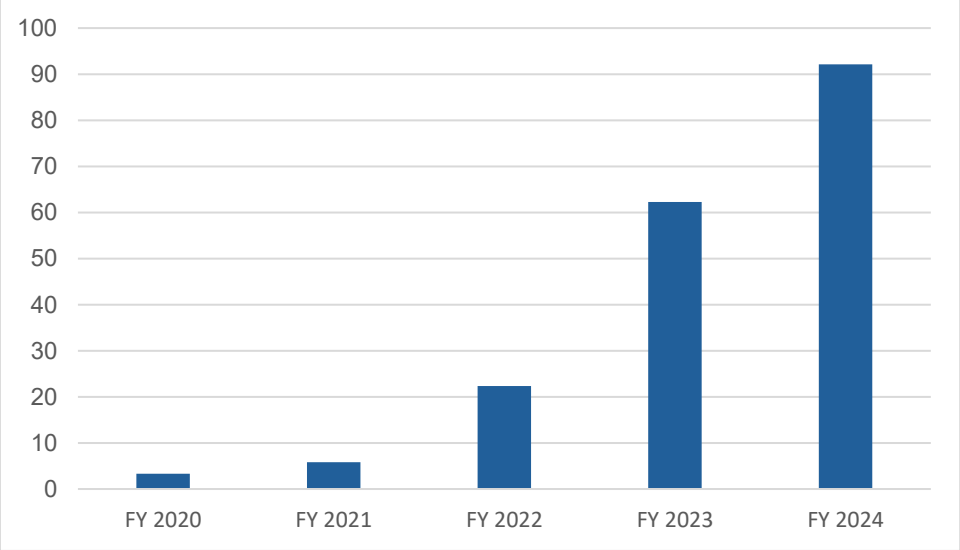
Figure 3: EV Sales in India by Vehicle Type (2019–2024, in 1000 units)



Source: Ministry of Road Transport and Highways, accessed via Statista.

The supply side has closely tracked this demand trajectory (Figure 4). Domestic production of electric passenger vehicles grew from approximately 3,300 units in FY 2020 to over 92,000 units in FY 2024—a nearly 28-fold increase in just four years (figure 3). This expansion reflects a decisive shift by major OEMs from imported, limited-volume offerings to locally assembled platforms designed for Indian roads and pricing conditions. The consolidation of production volumes has begun to unlock manufacturing economies of scale, placing cost-competitive models within reach of a broader consumer base.

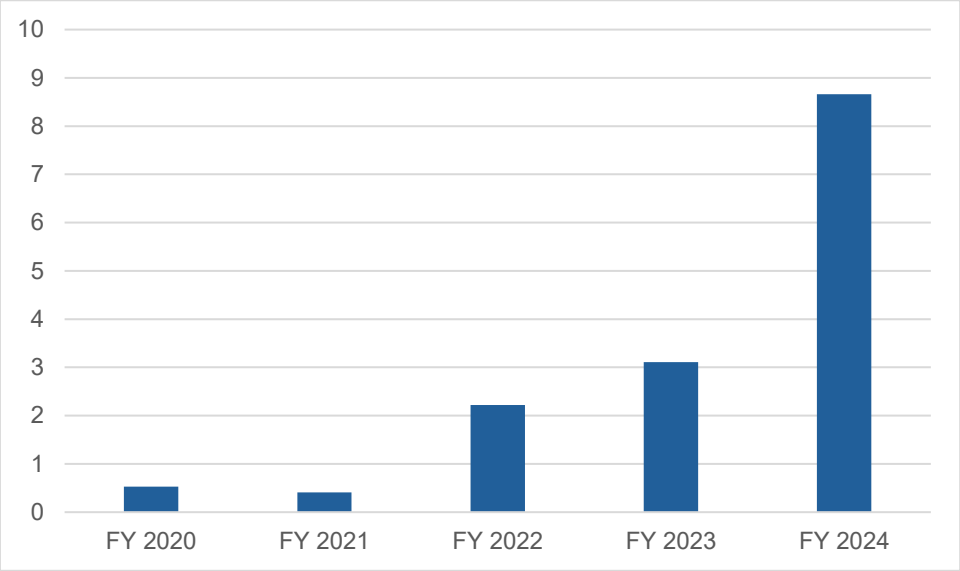
Figure 4: Production of Electric Passenger Vehicles in India (FY 2020–2024, in 1000 units)



Source: SIAM India; Ministry of Heavy Industries; Ministry of Road Transport and Highways (India), accessed via Statista.

The commercial vehicle segment tells a parallel story of accelerating momentum (Figure 5), albeit from an even smaller base. Production of electric commercial vehicles—spanning light goods vehicles, cargo three-wheelers, and medium-duty trucks—reached approximately 8,660 units in FY 2024, compared with just 530 units in FY 2020. While this represents exceptional growth, commercial EVs still account for only a small fraction of total commercial vehicle production. The segment is, however, increasingly attractive to fleet operators given the predictability of depot-to-depot routes and the strong fuel-cost-savings argument for high-utilization vehicles. E-commerce logistics, last-mile delivery, and urban freight corridors are emerging as priority use cases that could meaningfully accelerate this transition in the latter half of this decade.

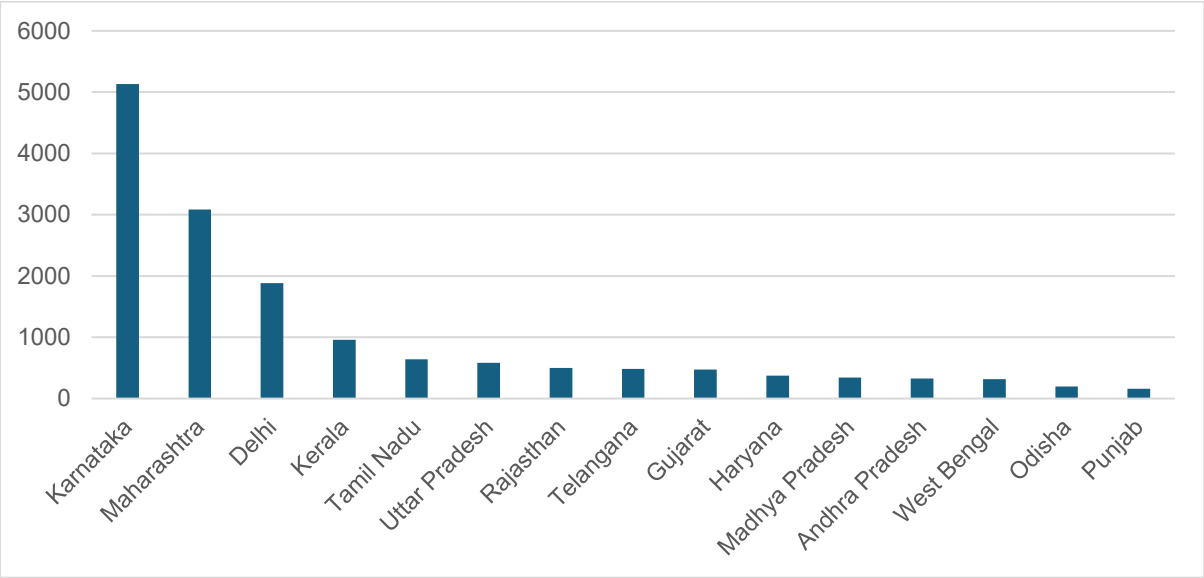
Figure 5: Production of Electric Commercial Vehicles in India (FY 2020–2024, in 1000 units)



Source: Ministry of Road Transport and Highways (India); SIAM India; Ministry of Heavy Industries, accessed via Statista.

Alongside vehicle sales, the buildout of public charging infrastructure has been a critical enabler and a persistent bottleneck in India's EV transition. As of March 2024, India had over 16,000 operational public EV charging stations, concentrated heavily in a small number of states (Figure 6). Karnataka led nationally with over 5,130 stations, followed by Maharashtra and Delhi (Ministry of Heavy Industries, 2024). This geographic skew reflects the uneven distribution of EV adoption, with the early transition remaining urban and metro-centric, while tier-2 cities and rural areas remain significantly underserved. Between FY22 and early FY25, the number of public charging stations in India increased from approximately 5,000 to over 26,000, representing a growth rate of nearly 70% in just three years (Times of India, 2025). While this marks significant progress, it still translates to an EV-to-charger ratio of 1:235, compared with the global benchmark of one charger for every six to twenty EVs (Times of India, 2025). The gap highlights that while infrastructure deployment is improving, the charging network is still not of the density or reliability required to support mass adoption, particularly in the passenger vehicle segment.

Figure 6: Operational Public EV Charging Stations by State, India (as of March 2024)



Source: Ministry of Heavy Industries, accessed via Statista.

Taken together, these data points sketch a market at an inflection point. Strong volumetric growth across vehicle segments, rapid domestic production scale-up, and expanding—even if unevenly distributed—charging infrastructure indicate that India's EV transition has moved past its pilot phase. Yet the market remains fragile in key respects: high upfront vehicle costs, inadequate charging density outside metros, and limited consumer awareness continue to constrain the pace of adoption. This challenge becomes even more pressing considering India's national 30@30 target, which aims to have electric vehicles account for 30 percent of total vehicle adoption by 2030. With EV penetration reaching only 7.6 percent in 2024, the gap between current progress and the 2030 ambition underscores the need for a significant acceleration in adoption over the coming years (Niti Aayog, 2025). Whether this acceleration materializes depends on the market's ability to cross the EV tipping point, the stage at which adoption becomes self-reinforcing through improving economics, infrastructure availability, consumer confidence, and ecosystem readiness. Understanding what drives or delays this transition is therefore critical. The rest of the report examines these dimensions in detail, drawing on primary and secondary research, stakeholder engagement, and comparative analysis to identify the pathways that could accelerate India's progress toward an EV tipping point within this decade.

3. Objectives and Scope of the Report

3.1. Objective

The primary objective of this research is to analyze the systemic conditions required for India to reach an EV adoption tipping point, defined as the threshold at which the transition becomes self-sustaining and electric vehicles irreversibly displace internal combustion engine (ICE) vehicles. While the current transition has been largely driven by a regulatory push, this report seeks to identify the execution

architecture needed to shift the market toward a consumer pull phase across personal mobility, public and shared transport, and logistics operations.

To operationalize this objective, the report addresses six core research questions:

1. Consumer dynamics: What factors enable or constrain EV purchase and usage decisions in the passenger vehicle segment across diverse urban contexts in India?

2. Commercial and public transit: What structural and operational challenges are faced by commercial fleets, city logistics, and public transport systems?

3. Ecosystem interventions: What supply chain, infrastructure, planning, and policy measures are required to accelerate adoption across commercial, mass, and shared mobility segments?

4. Supply-side obstacles: What are the key bottlenecks within the EV supply ecosystem, including constraints arising from trade and industrial policy?

5. Strategic pathways: Which combinations of technology options, business models, and policy instruments can enable India to reach the tipping point?

6. Policy activation: What targeted policy actions are required to activate these pathways and sustain a market-led transition?

3.2. Scope

This report presents a multi-dimensional assessment of India's EV ecosystem, drawing on primary consumer surveys across eight major cities, large-scale digital sentiment analysis, and extensive stakeholder consultations.

The scope includes:

1. Vehicle segments: Although most segments are touched upon across the report, the study mainly addresses 3 verticals: passenger vehicles (2w and 4w), urban logistics (parcel/food/grocery delivery), and mass transport (bus).

2. The value chain: An end-to-end assessment of the battery economy, from upstream mineral security and cell research and development to midstream assembly, downstream charging infrastructure, and secondary markets.

3. Pillars of transition: Evaluation of four interdependent subsystems shaping EV adoption:

    - Policy and governance: Review of national schemes and fiscal structures, including demand incentives, supply-side incentives/mandates, and tax design.
    - Industrial strategy: Assessment of OEM approaches to technology ownership, localization of critical components, and supply chain risk management.
    - Infrastructure readiness: Analysis of the availability, accessibility, and distribution of charging infrastructure, and its role in enabling reliable EV adoption across regions.

- The consumer journey: Examination of behavioral, informational, and lifecycle considerations influencing adoption across demographic groups.

4. Geographies:

- Primary consumer survey data was collected across eight major cities—Mumbai, Delhi, Bangalore, Hyderabad, Pune, Lucknow, Thiruvananthapuram, and Bhubaneshwar—to capture diverse urban adoption dynamics

- Representative Market Tiers: Deep-dive retail and dealer surveys were focused on Delhi, Ahmedabad, and Varanasi, representing three distinct market archetypes: a high-penetration mega-metro, a rapidly growing mid-sized metropolitan hub, and an emerging small-metro market

- The secondary research component draws on evidence from across India, including multiple states and cities, as well as relevant international case studies and global market comparisons.

3.3. Methodology

This report adopts a multidisciplinary, multimodal methodology to assess the systemic readiness of India's electric vehicle ecosystem. By combining policy analysis, value chain assessment, primary research, and stakeholder engagement, the study builds a comprehensive evidence base to evaluate India's proximity to an EV adoption tipping point. The methodology is structured chapter-wise, with each component designed to examine a critical dimension of the transition.

Chapter 2: India's EV Policy Landscape Review

This chapter is based on an extensive literature review of national and state-level policy frameworks, fiscal instruments, and institutional assessments. It traces the evolution from early market-seeding initiatives to more mature adoption frameworks. This analysis establishes the policy conditions that shape the pace and direction of the transition.

Chapter 3: Assessment of India's EV Value Chain

This chapter employs a systematic value chain analysis based on in-depth stakeholder interviews with policymakers, OEMs, and fleet operators, supplemented by targeted consumer interviews and a comprehensive review of secondary industry literature. It examines linkages across upstream, midstream, and downstream segments of the EV ecosystem

Chapter 4: India's EV Policies: Assessment and Future Directions

This chapter adopts a qualitative approach, drawing on expert interviews across government and industry, and situates India within a comparative global policy context. It evaluates the role of advanced policy instruments in shaping market outcomes and ensuring consistent supply-side momentum.

Chapter 5: India's OEM Strategies: Assessment and Future Directions

Focusing on technology and industrial strategy, this chapter synthesizes R&D roadmaps and expert inputs from battery developers, start-ups, and OEMs. It examines emerging chemistries, localization strategies, and critical innovation bottlenecks, highlighting the technological pathways necessary for long-term competitiveness.

Chapter 6: Consumers' Perception of EVs in India

This chapter employs a large-scale digital analysis of public discourse by examining YouTube video transcripts and Reddit content, supplemented by targeted survey inputs. Using analytical techniques, it captures prevailing narratives, concerns, and perceptions around EV adoption. The methodology is significant in uncovering unfiltered public sentiment and identifying trust gaps that influence consumer readiness for a broader market transition.

Chapter 7: Drivers of EV Adoption in India: Evidence from a Consumer Survey

This chapter analyses primary survey data collected across eight major Indian cities. Using structured questionnaires, it captures both behavioral and attitudinal dimensions of EV adoption and segments users across different stages of the ownership journey. The findings provide insight into demand-side barriers and adoption triggers.

Chapter 8: EV Dealership Capabilities and Consumer Ground Realities

Based on secondary research complemented by semi-structured interviews with dealership stakeholders, this chapter uses thematic analysis to examine retail-level dynamics. It highlights how dealer incentives, knowledge gaps, and customer engagement practices influence purchase decisions at the point of sale.

Chapter 9: India's E-Bus Transition: Opportunities and Challenges

This chapter combines technical, financial, and operational analysis with stakeholder consultations in the public transport sector. It evaluates cost structures and deployment challenges, positioning public transport as a key driver of demand aggregation and ecosystem stability.

Chapter 10: Electrifying Last-Mile Delivery Fleets in Urban India

Using a qualitative framework, this chapter analyses multiple logistics segments via secondary literature and targeted interviews to assess operational readiness and adoption barriers. It identifies varying demands across segments based on use cases and business models.

Chapter 11: Planning Cities for Convenient EV Charging

This chapter reviews national guidelines and city-level planning frameworks, supplemented by international case comparisons. It assesses how planning instruments integrate charging infrastructure and identifies gaps between policy intent and on-ground implementation.

Chapter 12: Insights from Stakeholder Consultations & External Engagements

Drawing on consultations with policymakers, industry leaders, and domain experts, this chapter synthesizes cross-cutting insights across the ecosystem. It provides a systems-level perspective on coordination challenges and institutional dynamics.

Chapter 13: Takeaways from the EV Stakeholder Workshops

This chapter is based on a multi-stakeholder workshop that brought together representatives from academia, government, and industry. It captures implementation-level insights, emerging business models, and practical constraints, translating analytical findings into actionable pathways.

Chapter 14: Summarizing Policy Pathways and Strategic Interventions

This chapter synthesizes the pathways identified across preceding chapters into a coherent framework to accelerate EV adoption toward a tipping point. It consolidates insights from policy, market dynamics, consumer behavior, and supply-side analysis to outline integrated strategies that enable a transition from a push-driven to a self-sustaining, market-led ecosystem.

Together, these methodological components provide a layered, integrated understanding of India's EV transition, enabling a rigorous assessment of the conditions needed to reach a self-sustaining tipping point.

4. Building Toward the EV Tipping Point

The chapters that follow, therefore, examine India's EV transition through a multidimensional lens, covering policy frameworks, industrial strategy, consumer adoption, infrastructure planning, market dynamics, and stakeholder experience. This structure is significant because reaching an EV tipping point is determined not by any single factor but by the interaction among technological readiness, market confidence, institutional coordination, and ecosystem maturity. By analyzing each of these dimensions individually and connecting them through an integrated systems perspective, the report builds a clearer understanding of the conditions under which India's EV transition can move from policy-supported growth to a self-sustaining, irreversible market shift.

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Credits

Sandip Chakrabarti: Conceptualization, Methodology, Resources, Supervision, Project administration, Funding acquisition, Writing - Review & Editing. **Anish Sugathan**: Conceptualization, Methodology, Resources, Supervision, Project administration, Funding acquisition. **Shreya Sinha**: Formal analysis, Investigation, Writing - Original Draft.

Chapter 2

India's EV Policy Landscape Review

Chapter Summary

Content:

1. Reviews India's shift from early EV adoption efforts to more mature policy frameworks, and examines how policies, institutions, and states are implementing them.
2. Synthesizes proven international policy levers, including mandates, infrastructure alignment, and zoning measures to contextualize and guide India's next transition phase

Findings:

1. Highlights that rapid policy expansion has led to varied outcomes, shaped by coordination challenges and fiscal structures across different segments of the value chain.
2. Observes that leading markets have successfully moved from a "regulatory push" to a "consumer pull" by deploying bundled policy packages rather than relying on isolated instruments

Takeaways:

1. Suggests a transition from broad purchase incentives toward stringent regulatory signals and concentrated geographical saturation programs to achieve long-term targets
2. Recommends drawing on globally tested strategies, such as corridor-based approaches and flexible financing models, to support a more resilient and domestically anchored EV ecosystem.

1. Introduction

India's EV transition has emerged as an important aspect of its national decarbonization strategy, with the potential to foster energy conservation, climate mitigation, and sustainable policymaking. Transport emissions account for approximately 13.5% of India's total energy-related carbon dioxide output, with a disproportionate share from urban centers and road transport (Dhar et al., 2017; Ouni et al., 2023). To mitigate this, the Government of India has implemented a series of national-level programs. In 2011, the government established the National Council for Electric Mobility (NCEM) to provide strategic recommendations for promoting EVs. Subsequently, the National Electric Mobility Mission Plan 2020 was launched in 2012, aiming to facilitate the adoption of hybrid and electric vehicles. The Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) scheme was introduced in 2015 to provide financial incentives to promote EV adoption. This scheme was expanded in 2019 to include the development of charging infrastructure.

Other initiatives include the Capital Goods Scheme (2016) and Production-Linked Incentive (PLI) schemes introduced in 2021, which focus on enhancing domestic manufacturing capabilities for automotive components and advanced battery storage systems. Amendments to motor vehicle rules and charging infrastructure guidelines in 2018 established a legal framework for retrofitting conventional vehicles and establishing EV charging stations.

In 2024, the Electric Mobility Promotion Scheme was launched to attract investments in EV manufacturing and bolster India's competitiveness in global markets. Most recently, the PM E-Drive scheme has been introduced as a continuation of these efforts, with a renewed focus on accelerating EV adoption and strengthening the supporting ecosystem; this scheme is discussed in detail in subsequent sections.

These policies underscore India's commitment to reducing carbon emissions, advancing sustainable transportation systems, and fostering domestic industrial growth.

1.1. National Policy Chronology and Major Programs

Table 1: National-level initiatives towards EV promotion up until PM e-DRIVE

Year	National-level initiatives towards EV adoption	Description
2011	National Council for Electric Mobility (NCEM)	The Government of India body to make recommendations for the promotion of EVs and their manufacturing. The establishment of NCEM created an institutional mechanism to guide India's EV transition by coordinating policy recommendations for electric mobility promotion and domestic manufacturing.

2012	National Automotive Board (NAB)	Served as the technical/operational counterpart to NCEM and later became the coordinating mechanism that helped translate electric-mobility intent into schemes such as FAME.
2012	National Mission for Electric Mobility (NMEM)	Established to enhance national energy security, reduce the environmental impact of vehicles, and strengthen India's domestic manufacturing capabilities in electric mobility.
2012	National Electric Mobility Mission Plan 2020	Approved in 2012 under NMEM, NEMMP 2020 laid out India's vision, targets, and a joint government–industry roadmap for promoting electric and hybrid vehicle technologies by 2020.
2014	Scheme for Enhancement of Competitiveness in the Indian Capital Goods Sector- Phase I	Developed domestic industrial and tooling capabilities through technology support, testing infrastructure, and academia–industry partnerships, creating a stronger foundation for EV manufacturing.
2015	Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India-FAME India	The Faster Adoption and Manufacturing of Electric Vehicles (FAME) scheme was launched in April 2015 under the National Electric Mobility Mission to encourage the purchase of electric and hybrid vehicles by providing financial support. Its first phase ran for four years until 2019.
2016	The Technology Platform for Electric Mobility (TPEM) is set up to support R&D consortia projects.	The Minister of State for Power, Coal, New and Renewable Energy, announced that the government of India aims to achieve 100% e-mobility by 2030. (The goal was later updated in 2018)
2016	Capital Goods scheme	The scheme aims to provide an enabling ecosystem for capital goods growth and ensure sustained incentives for domestic manufacturers to service domestic as well as export market demand, which matters for scaling EV component production and production equipment.
2016	National Capital Goods Policy 2016	• The policy envisages increasing production of capital goods from ~₹230,000 crore in 2014-15 to ₹750,000 crore in 2025 and raising direct and indirect employment from the current 8.4 million to ~30 million. • It envisages increasing exports from the current 27% to 40% of production, while increasing the share of domestic production in India's demand

		from 60% to 80%, thus making India a net exporter of capital goods. • The policy also aims to facilitate improvement in technology depth across sub-sectors, increase skill availability, ensure mandatory standards, and promote growth and capacity building of MSMEs.
2017	SAMARTH Udyog	To facilitate the creation of an ecosystem that enables the adoption of Industry 4.0 technologies across all Indian manufacturing companies by 2025, regardless of whether they are MNCs or large, medium, or small-scale enterprises.
2017	Planning Commission constituted a Working Group on Capital Goods and Engineering Sector for the 12th Five-Year Plan (2012-2017)	• Increase manufacturing sector growth to ~2–4% above GDP growth, making it the engine of economic growth, and raise its share to ~25% of overall GDP by 2025. • Increase job creation in the manufacturing sector to generate ~100 million additional jobs by 2025. • Increase "depth" in manufacturing, with a focus on higher levels of domestic value addition. • Enhance the global competitiveness of Indian manufacturing through appropriate policy support. • Ensure the sustainability of growth, particularly with respect to the environment.
2017	DHI extends FAME I for six months (4 times - till 2019)	Under this Program, 2.78 lakh EVs were funded with a cumulative demand reward of ₹343 Crore (approximately), and 465 buses were sanctioned to different cities/states.
2017	The National Board for Electric Mobility (NBEM) was constituted	• The Government of India constituted the National Board for Electric Mobility (NBEM) to provide strategic direction and inter-ministerial coordination for electric mobility in the country. • NBEM was mandated to align policies across ministries (Heavy Industries, Power, Transport, Urban Development, etc.) and to guide long-term planning for EV manufacturing, deployment, and infrastructure. • The Board also aimed to support early programmatic initiatives that later evolved into structured schemes such as FAME and phased manufacturing policies.

2017	CAFE Phase-1 introduced	• Applicable from FY 2017–18. • Set a fleet-average CO_2 emission target of below 130 g/km. • Established a fuel consumption target of less than 5.5 liters per 100 km, based on an assumed industry average vehicle weight of 1,037 kg. • Indirectly encouraged the adoption of EVs and hybrid vehicles by pushing automakers to reduce fleet-wide emissions and improve fuel efficiency.
2018	MoP amended goal to 30% e-mobility by 2030	• In 2018, the Ministry of Power (MoP) articulated India's aspirational target of achieving 30% electric vehicle penetration by 2030, signaling a long-term national commitment to e-mobility. • The announcement framed EVs as a critical lever for energy security, reduced oil imports, and emissions mitigation, rather than as a purely environmental intervention. • This target provided strategic signaling to states, utilities, and industry, influencing subsequent EV policies, charging-infrastructure planning, and utility-level preparedness.
2018	Amendments to the Electricity Act, 2003	Charging EVs is a service and does not require a license.
2018	Charging Infrastructure for Electric Vehicles Guidelines and Standards were notified.	The guidelines clarified that EV charging is a service (not the sale of electricity), removed licensing barriers, and defined norms for public charging stations, power tariffs, and technical standards. This notification created regulatory certainty for DISCOMs, private investors, and urban local bodies, forming the backbone for subsequent city-level EV charging and battery-swapping policies.
2019	Amendments to the Motor Vehicle Rules, 1989	For the promotion of electric vehicles, the Government has notified GSR 167(E) dated 1st March 2019 for conversion through retrofitment to pure electric and hybrid electric vehicles, and their compliance shall be as per AIS 123.
2019	Amendments made to the Model Building Bye-laws (MBBL) 2016 and Urban Regional Development Plans Formulation and Implementation (URDPFI) Guidelines 2014	Provisions for establishing Electric Vehicle Charging Infrastructure.

2019	FAME Phase II launched	The second phase (FAME II) is a 3-year subsidy program. It aims at supporting the electrification of public and shared transportation: around 7,000 electric and hybrid buses, 500,000 electric three-wheelers, 55,000 electric four-wheeler passenger cars, and 1 million electric two-wheelers. The Department of Heavy Industries also approved 2,636 EV charging stations.
2019	National Mission on Transformative Mobility and Battery Storage approved	The Union Cabinet approved the National Mission on Transformative Mobility and Battery Storage, chaired by NITI Aayog, to drive clean, sustainable mobility and localize electric vehicle (EV) production. This initiative includes a 5-year Phased Manufacturing Program (PMP) through 2024 to support large-scale, export-competitive Gigafactories for batteries and components.
2019	Revision to the "Charging Infrastructure for Electric Vehicles - Guidelines and Standards"	The Ministry of Power (MoP) issued revised guidelines and standards for charging electric vehicles, including a phased approach with measures such as the provision of one charging station per 3km x 3km grid in cities and every 25km on highways/roads.
2019	GST Concession Certificate for Persons with Disabilities	Not a core EV policy, but it is a mobility-related tax concession that can marginally affect the affordability of personal vehicles for eligible buyers.
2020	DHI revises the Phased Manufacturing Program (PMP) for xEV parts for eligibility under the FAME II scheme	• In 2020, the Department of Heavy Industry (DHI) revised the Phased Manufacturing Program (PMP) for xEV components to strengthen domestic value addition and localization under the FAME II scheme. • The revised PMP linked incentive eligibility to progressive localization of critical EV components such as motors, power electronics, battery packs, and control systems. • This move aimed to reduce import dependence, support domestic suppliers, and align demand-side subsidies with India’s broader Make in India and industrial-policy objectives.
2020	Amendment to the "Charging Infrastructure for Electric Vehicles - Guidelines and Standards"	Introduced tariff and service-related clarifications that lowered uncertainty around charging economics and EV operating costs.

2021	DHI Scheme for Industry associations and PSUs for undertaking promotional activities	Supported awareness-building around capital goods and government initiatives; indirectly useful for EV ecosystem communication and stakeholder engagement.
2021	Production Linked Incentive (PLI) Scheme for Automobile and Auto components (5 years - 2022-23 to 2027-28)	• To boost the manufacturing of Advanced Automotive Technology (AAT) Products • To facilitate and promote deep localization for AAT products and enable the creation of a domestic as well as a global supply chain.
2021	Production Linked Incentive (PLI) Scheme for National Program on Advanced Chemistry Cell (ACC) Battery Storage	• To strengthen the ecosystem for electric mobility and battery storage in the country. • The scheme includes an initial two-year gestation period from the Appointed Date (AD) (01.01.2023 to 31.12.2024), followed by a five-year performance period (01.01.2025 to 31.12.2029). • The scheme envisages enhancing India's manufacturing capabilities of Advanced Chemistry Cell (ACC) by setting up a Giga-scale ACC and battery manufacturing facilities in India with emphasis on maximum domestic value addition.
2022	Scheme for Enhancement of Competitiveness in the Indian Capital Goods Sector, Phase II	• The objective was to expand and enlarge the impact created by Phase I of the Capital Goods scheme. • Setting up of New Advanced Centers of Excellence and augmentation of Existing Centers of Excellence. • Setting up of Common Engineering Facility Centers (CEFCs) and augmentation of existing CEFCs. • Promotion of skilling in the Capital Goods Sector– creation of Qualification packages for skill levels 6 and above. • Augmentation of Existing Testing and Certification Centers. • Setting up of Industry Accelerators for Technology Development. • Identification of Technologies through Technology Innovation Portals. Deepened the industrial base through centers of excellence, engineering facilities, and skilling, which indirectly support EV manufacturing and test capability.

2022	Implementation of CAFE Phase-2	• Implemented from April 2022. • Tightened the fleet-average CO_2 emission target to below 113 g/km. • Reduced the fuel consumption target to less than 4.7 litres per 100 km, based on an assumed industry average vehicle weight of 1,082 kg. • Increased regulatory pressure on automakers to expand EV and hybrid offerings in order to meet stricter fleet emission standards.
2024	Scheme to Promote Manufacturing of Electric Passenger Cars in India	• This scheme was started to attract investments from global EV manufacturers and promote India as a manufacturing destination for e-vehicles. • The scheme also aims to put India on the global map for the manufacturing of EVs, generate employment, and achieve the goal of "Make in India".
2024	Ministry of Heavy Industries Electric Mobility Promotion Scheme	• Ministry of Heavy Industries, Government of India, has notified the Electric Mobility Promotion Scheme 2024 (EMPS 2024) with an outlay of Rs. 500 crore for a period of 4 months, w.e.f. 1st April 2024 till 31st July 2024 (later extended till 30th September). • The scheme is introduced for faster adoption of electric two-wheelers (e-2W) and electric three-wheelers (e-3W - including registered e-rickshaws & e-carts and L5) to provide further impetus to the green mobility and development of Electric Vehicle (EV) manufacturing eco-system in the country.
2024	E-Vehicle Policy: Scheme to promote India as a manufacturing destination so that e-vehicles (EV) with the latest technology can be manufactured in the country	• Minimum investment of ₹4,150 crore required, with no cap on maximum investment. • A three-year timeline for setting up manufacturing facilities in India and commencing commercial EV production; up to five years allowed to achieve 50% domestic value addition. • Companies setting up EV manufacturing facilities will allow limited imports of cars at a lower customs duty.

2024	Guidelines for Installation and Operation of Electric Vehicle Charging Infrastructure-2024	• Guidelines updated to provide greater clarity. • Updates earlier standards (e.g., one charging station in every 1 km × 1 km grid in urban areas, compared to the previous 3 km × 3 km; and one every 20 km on highways, expressways, and major roads, reduced from 25 km).
2024	PM Electric Drive Revolution in Innovative Vehicle Enhancement (PM E-DRIVE)	• A central initiative launched on October 1, 2024, with a total outlay of ₹10,900 crore. • It subsumed the Electric Mobility Promotion Scheme (EMPS) and focuses on accelerating adoption through demand-side incentives for e-2Ws, e-3Ws, e-buses, and e-trucks. • It also designates ₹2,000 crore specifically for the expansion of public charging infrastructure (72,300 stations) and introduces e-Vouchers via Aadhaar-based authentication for seamless incentive claims.

2. PM E-DRIVE Scheme: Policy Framework and Implementation

The PM Electric Drive Revolution in Innovative Vehicle Enhancement (PM E-DRIVE) scheme marks the latest phase in India's evolving EV policy architecture, consolidating and building upon earlier national-level interventions such as FAME. Notified on September 29, 2024, and effective from October 1, 2024, the scheme has an outlay of ₹10,900 crore. It aims to accelerate Electric Vehicle (EV) adoption, expand charging infrastructure nationwide, and strengthen the domestic EV manufacturing ecosystem (Government of India, 2025; Press Information Bureau, 2024).

2.1. Financial Scope and Program Extension

1. **Outlay and Initial Duration:** The scheme was launched on October 1, 2024, with a total financial outlay of ₹10,900 crore. It subsumed the Electric Mobility Promotion Scheme (EMPS) (Press Information Bureau, 2024; Pimpalkhare, 2025).

2. **Extension Rationale:** The government extended the scheme by two fiscal years, until 2027-28, because approximately half of the allocated funds remained unused. The scheme will cease once its full corpus is exhausted (Pimpalkhare, 2025; NITI Aayog, 2025a)

3. **Policy Role:** PM E-DRIVE serves as a crucial demand-side incentive mechanism, providing direct benefits to consumers to ease the upfront cost of EVs (Government of India, 2025; Press Information Bureau, 2024).

2.2. Key Components and Targeted Segments

The financial support is strategically allocated to different vehicle and infrastructure categories:

1. **E-Buses:** ₹4,391 crore is allocated for the procurement of 14,028 electric buses by public transport agencies. Demand aggregation for these buses will be managed in nine major cities (e.g., Delhi, Mumbai, Kolkata) (Press Information Bureau, 2024; Pimpalkhare, 2025). The extension is viewed as a positive step for the electric bus segment, giving state transport bodies a longer runway to plan deployments.

2. **Charging Infrastructure (PCS):** ₹2,000 crore is designated for setting up 72,300 Public Charging Stations (PCS). This includes 22,100 fast chargers for e-4Ws, 1,800 for e-buses, and 48,400 for e-2Ws/e-3Ws. Flexibility is provided to fund the establishment of charging infrastructure, potentially up to 100% of the project cost (Press Information Bureau, 2024).

3. **E-2W and E-3W Incentives:** The scheme aims to incentivize roughly 24.79 lakh e-2Ws and 3.2 lakh e-3Ws. However, incentives for electric two- and three-wheelers will be discontinued from the end of 2025-26 (Pimpalkhare, 2025).

4. **E-Trucks:** A fund of ₹500 crore has been set aside. Critically, incentives for e-trucks are conditional on the vehicle holding a scrapping certificate from an approved vehicle scrapping center (Press Information Bureau, 2024).

5. **Eligibility Criteria:** To qualify for incentives, EVs must be registered and equipped with advanced batteries. EVs purchased by government departments are not qualified for demand incentives (Government of India, 2025; Press Information Bureau, 2024).

2.3. Implementation Mechanism

The demand incentive is provided to buyers in the form of an upfront reduced purchase price, which the Ministry of Heavy Industries (MHI) then reimburses the Original Equipment Manufacturer (OEM). MHI utilizes e-Vouchers for customers, generated via e-KYC Aadhaar FACE authentication, which must be signed by both the buyer and the dealer to claim reimbursement (Press Information Bureau, 2024).

3. CAFE Norms

Corporate Average Fuel Efficiency (CAFE) norms are regulatory standards aimed at improving the average fuel efficiency of an automobile manufacturer's vehicle fleet. Introduced in India in 2017, the norms regulate the sales-weighted average emissions and fuel consumption of an automaker's entire fleet rather than individual vehicle models. They apply to passenger vehicles (M1 category) weighing below 3,500 kg, including petrol, diesel, LPG, CNG, hybrid, and electric vehicles.

India has implemented the norms in multiple phases (Saxena, 2026):

1. CAFE Phase I (2017–2022): Set a fleet-average target of 130 g/km of CO_2 based on an assumed industry average unladen weight of 1,037 kg.

2. CAFE Phase II (2022–2027): Tightened the target to 113 g/km of CO_2, based on an industry average weight of 1,082 kg.

3. Proposed CAFE Phase III (2027–2032): Draft norms propose progressively stricter targets, reducing fleet-average emissions from 88.37 g/km in 2027–28 to 71.47 g/km by 2031–32.

The framework follows a mass-based approach, where each manufacturer's target is adjusted according to the average kerb weight of its vehicle fleet.

3.1. Analysis of India's CAFE Norms: Performance Trends and Key Issues

An analysis of the first two phases of India's Corporate Average Fuel Efficiency (CAFE) norms highlights important trends in manufacturer compliance, increasing vehicle weights, and emerging structural concerns within the framework. While the norms have progressively tightened fuel-efficiency and emissions targets, their implementation has also revealed differing impacts across manufacturers and vehicle segments.

a. CAFE Phase I (2017–2022)

CAFE Phase I introduced a fleet-average target of 130 g/km of CO_2, based on an assumed industry-average vehicle weight of 1,037 kg. The phase was primarily aimed at institutionalizing fleet-level monitoring and improving overall fuel efficiency rather than driving major technological transitions (Saxena, 2026).

Compliance levels remained high during this period, with all passenger vehicle manufacturers meeting their respective targets. Mass-market manufacturers such as Maruti Suzuki, Hyundai Motor India, and Tata Motors generally recorded lower corporate-average CO_2 values due to their focus on lightweight, fuel-efficient models and incremental improvements in internal combustion engine (ICE) technology. In contrast, premium and utility-oriented manufacturers such as BMW, Mercedes-Benz, and Volvo Cars remained compliant through weight-adjusted targets despite having much higher absolute fleet emissions (Saxena, 2026; Barik, 2025).

However, experts suggest compliance was achieved largely through marginal efficiency gains in ICE technology and portfolio optimization rather than a significant shift toward electric vehicles (EVs) or low-carbon technologies. During the same period, the actual industry average vehicle weight increased from the 1,037 kg baseline to nearly 1,095 kg by FY 2021–22, which effectively reduced the stringency of the norms (Saxena, 2026).

b. CAFE Phase II (2022–Present)

Implemented in April 2022, CAFE Phase II tightened the fleet-average target to 113 g/km of CO_2, based on an assumed industry-average weight of 1,082 kg. These revised standards increased regulatory pressure on manufacturers and strengthened the role of EVs and hybrids through compliance mechanisms like super-credits (Saxena, 2026).

Unlike Phase I, compliance under Phase II has proven more challenging. Data for FY 2022–23 indicates that 8 out of 18 manufacturers failed to meet their targets. At the same time, average vehicle weights have continued to rise, reaching approximately 1,170 kg by 2023. This weight growth is driven by stricter safety requirements (such as mandatory airbags and BNCAP crash standards) and a growing consumer preference for utility vehicles (SUVs), which accounted for roughly 65% of total passenger vehicle sales by 2024–25 (Saxena, 2026).

c. Structural Concerns and Industry Debates

The proposed transition to CAFE Phase III (2027–2032) has intensified debate around the framework's design. A key point of contention is the mass-based methodology, which gives heavier vehicles relatively relaxed targets compared to lighter ones. This creates a "weight paradox" in which a lightweight car emitting 100 g/km might fail to meet its target, while a heavy SUV emitting 130 g/km might pass (Barik, 2025).

Manufacturer Debate: Maruti Suzuki has warned that draft Phase III targets are "unscientific" for small cars without a 3-gram relaxation, arguing that it could force the discontinuation of the most fuel-efficient petrol models. Conversely, SUV-focused firms like Tata Motors and Mahindra & Mahindra have opposed these weight-based carve-outs, arguing that manufacturers should instead rely on green technologies to meet targets (Saraiya, 2025).

Air Quality Misalignment: Experts note that while CAFE targets CO_2 for decarbonization, India's primary health concern is PM2.5 exposure. Current norms apply only to passenger cars, excluding two- and three-wheelers, which dominate urban mobility and contribute significantly to street-level pollution exposure (Lidhoo et al., 2026; Arun, 2026).

Testing Gaps: Compliance is currently based on the Modified Indian Driving Cycle (MIDC) conducted under laboratory conditions. These tests often fail to reflect real-world Indian conditions marked by heavy congestion, dust, idling, and extreme temperatures (Arun, 2026).

Proposed Way Forward: Industry stakeholders and researchers have proposed several reforms, including implementing a Zero Emission Vehicle (ZEV) credit trading scheme to reward over-achievers and incentivize innovation (Saxena, 2026), extending fuel efficiency norms to high-usage segments such as two-wheelers and commercial fleets (Saxena, 2026; Arun, 2026), and adopting piecewise or non-linear target structures to avoid disproportionately penalizing small, fuel-efficient vehicles (Saraiya, 2025; Barik, 2025).

3.2. Global Scenario of Fuel Efficiency and CO_2 Norms

Beyond India, Corporate Average Fuel Economy (CAFE) and CO_2 emission standards have become a central component of automotive regulation across major markets such as the United States, the European Union, China, Japan, and South Korea (Saxena, 2026). While the broader objective across jurisdictions is to improve fuel efficiency, reduce petroleum dependence, and mitigate climate change, regulatory frameworks differ significantly in terms of metrics, testing procedures, and compliance mechanisms.

Global regulatory systems can broadly be differentiated based on their measurement metrics and structural approaches:

Metric Variations: The United States and Japan primarily regulate fuel economy using metrics such as miles per gallon (mpg) or km/l, while the European Union, India, and South Korea focus on CO_2 emissions measured in g/km. China primarily uses fuel consumption metrics expressed in liters per 100 km (Saxena, 2026).

Structural Approaches: Most mature automotive markets avoid blanket exemptions for small cars and instead adopt footprint-based or weight-based methodologies to create differentiated targets across vehicle categories. Japan uses a weight-class-based "Top Runner" system, while the United States follows a footprint-based approach linked to vehicle size (Saxena, 2026).

Incentives for Innovation: Most major regulatory frameworks incorporate mechanisms such as super-credits or low-emission incentives to encourage the adoption of hybrid and electric vehicles (EVs) (Saxena, 2026).

3.2.1. Case Study: United States (CAFE Standards)

The United States introduced the world's first CAFE regulations in 1975 following the 1973 oil crisis, primarily to reduce petroleum consumption and improve energy security (Wang & Miao, 2020).

d. Regulatory Framework and Footprint-Based Targets

The framework is jointly administered by the National Highway Traffic Safety Administration and the Environmental Protection Agency. The National Highway Traffic Safety Administration (NHTSA) establishes and enforces fuel economy standards, while the Environmental Protection Agency (EPA) manages greenhouse gas (GHG) regulations and fuel economy calculations.

In 2012, the U.S. shifted from a uniform standard to a footprint-based system, in which compliance targets are determined by vehicle size. Smaller vehicles are assigned stricter efficiency targets, while larger vehicles are allowed relatively relaxed standards. This approach was intended to discourage manufacturers from downsizing vehicles solely to meet compliance requirements (Wang & Miao, 2020).

e. Policy Evolution

Following rapid tightening during the early decades of implementation, fuel economy standards remained relatively stagnant between 1990 and 2010 due to low fuel prices and limited political momentum. During this period, improvements in engine technology were often directed toward increasing vehicle size and horsepower rather than fleet efficiency.

The Barack Obama administration significantly strengthened standards, targeting a fleet-average fuel economy of nearly 49 mpg by 2025. However, the Donald Trump administration subsequently diluted these targets under the SAFE Vehicle Rule (2020), reducing the required annual improvement rate to 1.5% through 2026 (Wang & Miao, 2020).

f. Technological Impact

Research indicates that stringent CAFE regulations accelerated technological innovation in passenger vehicles, particularly through improvements in fuel injection systems, lightweight materials, and engine efficiency. However, the impact has been comparatively limited in the light-duty truck segment,

where consumer preference for larger and more powerful vehicles continues to dominate (Wang & Miao, 2020).

3.2.2. Case Study: European Union (CO_2 Fleet Standards)

The European Union established its CO_2 fleet standards framework in 2009, with a strong emphasis on decarbonization and long-term electrification. The EU framework is currently regarded as one of the most stringent automotive emission norms globally.

a. Regulatory Structure and Testing Framework

Unlike the U.S. footprint-based model, the EU follows a mass-based limit curve approach, in which each manufacturer's CO_2 target is adjusted based on the average mass of its fleet. Heavier vehicle fleets are therefore permitted higher emission limits (Fritz et al., 2019).

To address concerns regarding discrepancies between laboratory and real-world emissions, the EU transitioned from the New European Driving Cycle (NEDC) to the Worldwide Harmonized Light Vehicles Test Procedure (WLTP) in 2021, which provides more realistic testing conditions and emissions estimates (Saxena, 2026; Fritz et al., 2019)

b. Electrification Targets and Compliance Mechanisms

The EU has adopted an aggressive long-term decarbonization pathway, including a target of 0 g/km CO_2 emissions for all new passenger cars by 2035, effectively requiring a transition toward zero-emission vehicles (Saxena, 2026).

Studies suggest that achieving the EU's proposed 2030 fleet target of 59.4 g/km cannot be done solely through improvements in internal combustion engine technology. Instead, manufacturers are expected to require substantial shares of plug-in electric vehicles (PEVs) within their sales portfolios (Fritz et al., 2019),

To support this transition, the EU framework includes Zero and Low-Emission Vehicle (ZLEV) incentives, which reward manufacturers that exceed specified shares of low-emission vehicles by granting flexibility in overall fleet targets. The framework also permits pooling arrangements, allowing manufacturers to jointly meet fleet-average targets by combining high- and low-emission vehicle portfolios (Fritz et al., 2019).

3.3. Suggestions Emerging from Literature and Industry Discussions

A review of policy literature, industry consultations, and expert analyses highlights several suggestions for strengthening India's CAFE framework in future phases:

1. **Broadening applicability across vehicle segments:** Industry experts and regulators suggest that extending fuel efficiency norms beyond passenger cars to include two-wheelers, three-wheelers, and commercial fleets is essential, as these segments account for nearly 70–80% of vehicles and a substantial share of on-road emissions exposure. Relying solely on car-centric norms is considered insufficient to achieve India-scale air quality improvements (Lidhoo et al., 2026; Saxena, 2026)

2. **Adopting more representative testing procedures:** There is a strong proposal to transition from the laboratory-based Modified Indian Driving Cycle (MIDC) toward the Worldwide Harmonized Light Vehicles Test Procedure (WLTP) or real-world monitoring approaches (Arun, 2026; Saxena, 2026). Such methods, including onboard GPS monitoring similar to China's system, are better suited to capture actual Indian driving conditions characterized by heavy congestion, idling, dust, and extreme temperatures (Arun, 2026).

3. **Revisiting the target-setting methodology:** Manufacturers and analysts suggest exploring piecewise or non-linear target curves rather than the current linear mass-based approach (Barik, 2025). This change aims to resolve the "weight paradox," in which small, low-emission cars face disproportionately stringent targets compared to heavier SUVs that may pass due to weight-based relaxations (Saraiya, 2025).

4. **Updating weight baselines periodically:** Future CAFE phases should align target calculations with the actual current industry average unladen mass, which has increased from 1,037 kg in Phase I to approximately 1,170 kg currently. This structural weight growth, driven by safety mandates (such as BNCAP) and a shift toward SUVs, should be reflected in the regulatory baseline to maintain the framework's intended stringency (Saxena, 2026).

5. **Exploring market-based compliance mechanisms:** Stakeholders have proposed the implementation of a Zero Emission Vehicle (ZEV) credit trading system. This would allow manufacturers to overachieve their targets to trade credits with underachievers, providing flexibility while incentivizing investment in low-emission technologies (Saxena, 2026).

4. Fiscal and Tax Considerations

India's fiscal and taxation framework plays a central role in shaping relative price signals between Electric Vehicles (EVs) and Internal Combustion Engine (ICE) vehicles. The current Goods and Services Tax (GST) regime provides differentiated tax treatment across vehicle technologies and components, with explicit concessions for EVs. However, despite this favorable intent, inconsistencies within the tax structure and proposed GST rationalization measures pose challenges to sustaining EV adoption momentum.

4.1. Existing GST Framework for EVs and ICE Vehicles

Under the prevailing GST regime, electric vehicles are taxed at a concessional rate of 5%, while ICE vehicles are taxed at 28% GST, plus an additional compensation cess. This differential has been positioned as a clear fiscal signal supporting the long-term transition to electric mobility (Maini, 2025; Agarwal & Jain, 2025).

EV charging equipment is also taxed at 5% GST, aligning with the policy objective of supporting EV ecosystem development. However, other critical elements of the EV value chain are taxed differently. Standalone lithium-ion batteries attract an 18% GST, despite being a core component of EV systems (Maini, 2025; NITI Aayog, 2025a). Similarly, battery charging and swapping services are taxed at 18%, as they are currently classified under the "maintenance and repair" services category (Maini, 2025).

4.2. GST Structure Across the EV Value Chain

1. **EV Tax Advantage:** Electric vehicles benefit from a concessional 5% GST rate. In contrast, Internal Combustion Engine (ICE) vehicles are subject to a 28% levy plus applicable cess. The GST discount for EVs is noted as an important signal towards the long-term EV transition (Maini, 2025; Agarwal & Jain, 2025)

2. **Inverted Duty Structure:** The GST framework across EV components and services includes differentiated tax rates:

    a. EVs and chargers are taxed at 5%, while standalone lithium-ion batteries are taxed at 18%. (Maini, 2025; NITI Aayog, 2025a).

    b. Battery swapping and charging services are taxed at 18%, based on their classification as "maintenance and repair" services (Maini, 2025).

3. **Impact on Operators:** The 18% GST on charging and swapping services results in an estimated increase of around 13% in the cost of energy consumed. For instance, a driver with a monthly energy expenditure of ₹6,000 would incur an additional ₹780 attributable to GST (Maini, 2025). Furthermore, this may lead to the accumulation of unutilized Input Tax Credit (ITC) and a blockage of working capital for charging and swapping players.

4.3. GST Rationalization in the ICE Segment

The government is considering restructuring the GST framework, potentially eliminating the 28% slab.

1. **Proposed ICE Rate Cut:** If implemented, GST on most mainstream vehicles and auto components is expected to move to an 18% GST rate. Specifically, GST on small ICE cars could fall from 28% to 18%. Larger cars may move to a new 40% slab with the removal of the existing cess (Agarwal & Jain, 2025; Hindustan Times Auto, 2025).

2. **Threat to EV Momentum:** According to HSBC Investment Research, such revisions could result in price reductions of approximately 8% for small ICE vehicles. This may influence the relative price differential between ICE vehicles and EVs, which is a factor in consumer purchasing decisions (Maini, 2025; Hindustan Times Auto, 2025).

4.4. Existing Taxation Structure for ICE Vehicles

Available analyses show that the existing tax design for ICE vehicles fails to effectively serve environmental objectives:

1. **Basis of Taxation:** The GST Compensation Cess on ICE vehicles is determined by parameters such as vehicle length, engine capacity (cc), and fuel type, which are not directly linked to CO_2 emissions (Kohli, 2025).

2. **Alternative Approach:** Some analyses highlight the potential of a continuous emissions-linked tax function as a mechanism to align vehicle taxation more closely with fuel efficiency considerations during the transition period (Kohli, 2025).

4.5. Policy Prescriptions for Tax Alignment

Various analyses outline potential approaches to address tax differentials within the EV value chain:

1. **Tax Parity:** Some estimates indicate that aligning GST rates on standalone lithium-ion batteries, battery charging, and swapping services with the 5% rate applicable to EVs could influence adoption rates, with projections suggesting a potential increase of 15–20% (Maini, 2025; NITI Aayog, 2025a).

2. **Service Classification:** Discussions also include the classification of battery swapping and charging services, which are currently taxed under the 18% "maintenance and repair" category, with alternative categorizations (Maini, 2025).

3. **Preserve EV Advantage:** If GST rates for ICE vehicles are lowered to 18%, it will be necessary to ensure that the combined tax burden on EVs (including batteries and services) remains significantly lower to preserve the cost incentive for clean mobility (Agarwal & Jain, 2025; Hindustan Times Auto, 2025).

4. **Inter-Ministerial Coordination:** An inter-ministerial committee can help in speedily resolving critical inter-agency coordination issues, including skewed GST rates and DISCOM approvals (Government of India, 2025; NITI Aayog, 2025a; NITI Aayog, 2025b).

4.6. State-Level EV policies

While national policies provide the overarching framework for EV adoption, their on-ground implementation and outcomes are significantly shaped by state-level policy design and execution.

India's federal structure enables state governments to shape policies for elevating localized EV ecosystems. A literature review of state-level EV policies shows that more than 20 states have enacted dedicated EV policies since 2017. These policies differ in ambition, financial outlook, and execution capacity.

Tamil Nadu, Gujarat, and Maharashtra have focused more on attracting manufacturing investments, offering land at concessional rates, electricity duty waivers, and tax exemptions. For example, Tamil Nadu's policy targets 1.5 lakh EV jobs by 2030 and has onboarded Ola Electric and Ather as anchor investors.

State EV policies in India have evolved unevenly, reflecting divergent fiscal capacities, industrial priorities, urbanization levels, and political economy considerations. Early movers such as Karnataka and Andhra Pradesh initially framed EV policies primarily around manufacturing and export competitiveness, whereas later adopters, particularly Delhi and Maharashtra, placed stronger emphasis on urban deployment, fleet electrification, and charging infrastructure. This divergence has

resulted in a fragmented landscape where EV adoption outcomes vary significantly across states despite uniform national incentives.

Another defining feature of state EV policies is their instrumental heterogeneity. States deploy a mix of purchase incentives, tax exemptions, power-tariff concessions, land-use facilitation, and charging-infrastructure support. However, the relative balance between supply-side (manufacturing, R&D) and demand-side (fleet adoption, urban charging) measures differs sharply. In most cases, state policies prioritize industrial development objectives, while urban logistics, public transport electrification, and last-mile delivery fleets receive secondary or implicit attention.

Table 2: State-Level EV Policies (Select states)

State	Policy Name / Year	Primary Focus Areas	Key Instruments	Target Segments	Implementation Status & Relevance
Delhi	Delhi Electric Vehicle Policy, 2020 (Extended)	Demand acceleration, charging infrastructure, and last-mile electrification	Purchase incentives, charging-infrastructure support, battery-swapping enablement, scrappage incentives	e-2Ws, e-3Ws, e-buses, delivery fleets	One of India's most mature EV policy frameworks; strong focus on urban use-cases and public charging; instrumental in scaling e-rickshaws, delivery EVs, and e-bus deployment
Maharashtra	Maharashtra EV Policy, 2021	Manufacturing, private adoption, and charging infrastructure	Capital subsidies, tax exemptions, toll waivers, charging-station incentives	e-2Ws, e-3Ws, private e-buses, manufacturing units	Among the few states explicitly supporting private and commercial EV adoption**;** strong industrial alignment but uneven urban deployment
Telangana	Telangana Electric Vehicle & Energy Storage Policy, 2022	Manufacturing ecosystem, R&D, urban adoption	Land incentives, SGST reimbursements, and charging-infrastructure facilitation	EV manufacturers, fleet operators, urban users	Focused on ecosystem development; early-stage urban logistics electrification, with scope for stronger demand-side incentives

Gujarat	Gujarat EV Policy (2021).	EV adoption, charging rollout, and industrial promotion	Purchase subsidies, charging-station support, and manufacturing incentives	e-2Ws, e-3Ws, e-buses, industrial fleets	Strong alignment with public transport electrification (e-buses); charging deployment aided by ULB land availability
Tamil Nadu	Tamil Nadu EV Policy, 2019 (Revised)	EV manufacturing, export competitiveness, and charging	Capital subsidies, land allotment, and power-tariff concessions	OEMs, suppliers, urban fleets	Manufacturing-oriented policy; urban logistics and last-mile electrification are emerging but not yet central.
Karnataka	Karnataka EV & Energy Storage Policy, 2017	Early EV ecosystem development, innovation	R&D incentives, manufacturing support, pilot projects	Start-ups, OEMs, early adopters	First mover among states; strong start-up ecosystem, but slower scale-up of urban freight electrification
Uttar Pradesh	Uttar Pradesh EV Manufacturing & Mobility Policy, 2022	Large-scale manufacturing, fleet adoption	Capital subsidies, interest subsidies, and charging-infra incentives	OEMs, logistics fleets, e-buses	Policy ambition is high; execution capacity and urban charging remain key constraints.
Kerala	Kerala EV Policy, 2023	Public transport electrification, sustainability	Public procurement, charging-infra facilitation	e-buses, public fleets	Strong push in public transport (e-buses); limited private-sector logistics adoption
Rajasthan	Rajasthan EV Policy, 2021	Manufacturing + adoption	Fiscal incentives, power-tariff support	Manufacturer, consumers	Manufacturing-centric; urban EV demand remains limited
Andhra Pradesh	Andhra Pradesh EV Policy, 2018	Manufacturing hub creation	Land, capital subsidies, export focus	OEMs, suppliers	Policy emphasis on exports and manufacturing; weaker integration with urban logistics needs

5. India's Policy Priorities and Progress

This section introduces an additional lens to examine India's evolving EV policy landscape, drawing on two recent documents: NITI Aayog's assessment of India's electric mobility transition - "Unlocking a

$200 billion opportunity: Electric vehicles in India" (Niti Aayog, 2025a) and the India Electric Mobility Index (IEMI) 2024 (Niti Aayog, 2025b). These documents offer indicative perspectives on how policy priorities are currently being framed within institutional and analytical discourse. They provide a useful basis for reflecting on how different dimensions of the EV ecosystem, ranging from adoption trends to state-level readiness, are interpreted in the Indian context.

5.1. NITI Aayog's Report on "Unlocking a $200 billion opportunity: Electric vehicles in India"

5.1.1. Introduction

India has established a strategic commitment to electric mobility, targeting a 30% share of Electric Vehicles (EVs) in total annual sales by 2030. This ambition is based upon multi-dimensional national objectives, specifically seeking reduced dependence on imported fuel, increased integration of renewable energy sources through leveraging EV battery storage capacity, improved air quality, mitigation of Greenhouse Gas (GHG) emissions, and positioning India as a global leader in this evolving market.

While global EV sales expanded exponentially from 918,000 units in 2016 to 18.78 million in 2024, India's transition commenced slowly. By 2024, EV sales in India reached 2.08 million units, corresponding to an EV penetration rate of 7.66%. This trajectory indicates that while adoption is increasing, it remains significantly short of the 2030 national target, necessitating an accelerated growth of over 22% in market share within the next five years alone.

This report, published in August 2025 by NITI, adopts a diagnostic and consultative approach to assess the current state of India's electric mobility transition. It reviews the global and Indian EV landscape using secondary data, examines existing policies and programs, and situates these within the structural characteristics of India's transport system. A central methodological component is a series of multi-stakeholder consultations covering manufacturers, operators, financiers, utilities, and public agencies, used to surface on-ground constraints and implementation frictions, which are then synthesized into an analytical framework to guide future policy and institutional action.

5.1.2. Analysis of Current Status and Segmented Performance

Electrification progress in India shows heterogeneity across vehicle segments. Empirical evidence suggests India is performing better in the electric two-wheeler (e-2W) and electric three-wheeler (e-3W) categories and is identified as a global leader in the e-3W segment. Conversely, adoption in the electric car (e-4W) segment has been slow, and the transition of long-haul electric trucks has been nearly negligible when compared to the global scenario.

The lack of progress in heavy vehicles presents a critical policy challenge. Trucks and buses, despite constituting only 4% of the total vehicle fleet, are responsible for more than half of the CO2 and Particulate Matter (PM) emissions from road transport. Specifically, long-haul trucks (above 3.5-ton capacity) account for over 34% of the CO2 emissions from the transport sector, despite making up only 3% of the vehicle fleet. Data for 2024 illustrate this gap: out of 834,578 trucks sold, only 6,220 were

electric, and a minimal 280 of these were heavy-duty, long-haul trucks (above 3.5 tons). This minimal contribution highlights the necessity for targeted policy intervention in the commercial heavy-duty segment.

5.1.3. Structural Barriers

The EV transition in India faces several structural barriers identified by NITI Aayog's consultation committee. It is suggested that these challenges must be addressed within the framework of India's unique mobility context.

c. Key Challenges to Accelerated Adoption

1. **Financing Difficulties:** Financial institutions perceive high risk in lending for electric buses and trucks, largely because their upfront costs are two to three times higher than their Internal Combustion Engine (ICE) counterparts. This issue is exacerbated by the highly fragmented ownership structure, in which 80% of truck owners operate a fleet of fewer than five vehicles, limiting their ability to meet higher loan and equity requirements. Furthermore, the near absence of reliable e-Truck and e-Bus performance data impedes informed lending decisions.

2. **Charging Infrastructure Paradox:** The ecosystem is characterized by a dual challenge of inadequate charging facilities co-existing with the low utilization of existing public charging infrastructure. Public charging is substantially more expensive than home charging due to factors such as Charge Point Operator (CPO) margins, the lack of subsidies, and an 18% Goods and Services Tax (GST) liability. Operational hurdles include difficulties obtaining power supply connections and resistance from Resident Welfare Associations (RWAs) stemming from perceived safety risks.

3. **Awareness and Data Gaps:** Persistent public misconceptions regarding battery fire safety, degradation, range anxiety, and resale concerns continue to suppress buyer interest. Moreover, inadequate data maintenance hinders evidence-based policy design and monitoring.

d. Uniqueness of the Indian Context

Policymakers must focus on designing policies calibrated to reflect indigenous Indian conditions, differing from those in developed economies:

1. **Two-Wheeler Dominance:** Approximately 75% of the vehicle fleet consists of two-wheelers; consequently, measuring progress solely based on e-car adoption is inappropriate.

2. **Cost Sensitivity:** Indian consumers are highly cost-conscious. The high upfront cost of EVs is a significant deterrent, especially in a market dominated by lower-cost vehicles, with only ~2% of the fleet comprising cars priced above ₹10 lakhs

3. **Short Trip Lengths:** Travel distances are relatively small, with 54% of urban trips covering a 0–10 km range.

5.1.4. Strategic Solutions: Recommended Approaches and Actions

To achieve the desired pace of EV transition, NITI Aayog proposes a phased shift, focusing on the following core approaches.

a. Policy Shift: From Incentives to Mandates and Saturation

Current incentives (e.g., FAME subsidies) have been effective for initial market activation (7.6% penetration), but stronger regulatory signals are now required.

1. **Regulatory Push:** The approach must evolve from reliance on incentives to adopting progressively stringent mandates/disincentives. These mandates should initially target a limited subset of the vehicle fleet, such as public transport, paratransit, and urban freight, to signal direction without incurring strong backlash.

2. **Geographical Saturation:** Resources should be concentrated on saturation in limited geographies rather than a thin distribution across the country. This methodology facilitates scale-based learning, generates visible impact, and encourages replication. An immediate step is designing a saturation program to support five cities over five years for 100% adoption of e-Buses, e-Paratransit, and e-freight vehicles in urban areas.

b. Financing and Leasing Mechanisms

To overcome the barrier of high capital cost, particularly for commercial segments, two primary mechanisms are recommended:

1. **Blended Finance:** A pooled fund, drawing contributions from the public budget and multilateral development banks, should be designed and operationalized. This fund would provide lower-interest loans for e-buses and e-trucks, aiming to bring the cost of capital down to parity with diesel vehicle financing rates (10–12%).

2. **Shifting Capital to Operating Costs:** Mechanisms like Battery-as-a-Service (BaaS) and vehicle leasing (for trucks and buses) must be nurtured. Batteries account for up to 40% of an EV's capital cost. Decoupling this cost reduces the upfront equity burden for small owners. This framework requires concurrent support and establishment of a battery passport system to track battery performance, assess health, and ensure transparency for resale and recycling.

c. Infrastructure and Innovation

1. **Strategic Charging Deployment:** Charging infrastructure must be scaled strategically, guided by vehicle movement patterns, rather than relying on uniform distribution. Immediate action includes identifying 20 high-density corridors for e-Bus and e-Truck operations and commissioning studies to locate charging hubs based on existing halting patterns (e.g., within the 50 priority corridors). Coordination must be streamlined through establishing nodal agencies in each state, modeled on Singapore's EV. A crucial technological step is the development of a unified digital application to locate stations, book slots, and enable payments, enhancing user convenience.

2. **R&D Acceleration:** Dedicated R&D is necessary to reduce dependence on imported critical minerals (lithium, nickel, cobalt) and secure lower battery prices. This involves setting up an academia-industry-government partnership to accelerate research on new battery chemistries, such as sodium-based technologies.

5.2. Sub-National Performance Assessment: India Electric Mobility Index (IEMI) 2024

The India Electric Mobility Index (IEMI) 2024 provides a comparative and ongoing evaluation of electric mobility development across 28 states and eight Union Territories (UTs). The index framework comprises 16 indicators categorized into three themes, with outcome indicators accounting for 50% of the overall score:

1. **Transport Electrification Progress (50% weight):** Measures EV adoption and operational support.
2. **Charging Infrastructure Readiness (30% weight**): Evaluates charging network development and RE integration.
3. **EV Research and Innovation Status (20% weight):** Assesses R&D efforts, startups, and patents.

5.2.1. IEMI 2024 Scores and Thematic Leadership

Based on the IEMI scores, states are categorized into Frontrunners (65-99), Performers (50-64), and Aspirants (0-49).

Table 3: State-wise IEMI Scores 2024

Category	Leading States/UTs	Key Thematic Frontrunners (Score > 65)
Overall Frontrunners	Delhi, Maharashtra, Chandigarh	Transport Electrification: Chandigarh, Delhi, Maharashtra.
Overall Performers	Karnataka, Tamil Nadu, Haryana	Charging Readiness: Haryana, Karnataka, Ladakh, Himachal Pradesh.
		R&D/Innovation: Delhi, Tamil Nadu, Maharashtra, Karnataka, Haryana, Telangana.

5.2.2. Key Outcome Indicators

Analysis of specific outcome indicators reveals high-impact regional performance:

1. **Private EV Adoption:** Goa, Karnataka, Kerala, and Maharashtra are noted as Achievers or Frontrunners. Goa achieved a high private adoption rate of 15.4% in 2024.

2. **Commercial EV Adoption:** Assam, Chandigarh, Delhi, and Uttar Pradesh lead this indicator. Notably, Assam registered over 85% of three-wheelers as electric in 2024. Chandigarh led commercial EV adoption at 64.9%.

3. **EV-to-EV-Charger Ratio (Accessibility):** Himachal Pradesh, Ladakh, Manipur, and Meghalaya were scored highest, indicating better charging accessibility (fewer EVs per charger). Himachal Pradesh demonstrates the best ratio (39 EVs per charger).

4. **EV Startups:** Measured by startups per trillion INR of Gross State Domestic Product (GSDP), Haryana, Maharashtra, and Delhi lead. Maharashtra recorded the highest total number of registered EV startups (467) as of June 2025.

5.2.3. Immediate Next Steps for Policy Implementation

To effectively kickstart the accelerated adoption effort, five immediate actions were strategically recommended to align central and sub-national efforts:

1. Develop a clear policy, establishing targets and timelines for the transition to electric mobility.

2. Develop a clear program of increasingly stringent regulations that mandate the transition to EV within specified time frames.

3. Design a new saturation program targeting five cities for 100% electrification of e-Buses, e-Paratransit, and e-freight vehicles in urban areas.

4. Design and operationalize a blended fund to mitigate the cost of capital for e-Trucks and e-Buses.

5. Set up an inter-ministerial committee to speedily resolve critical inter-agency coordination issues, such as those related to DISCOM approvals, high fixed costs, and skewed GST rates.

Inference from both the reports:

Viewed through this lens, certain patterns in policy emphasis emerge. There is an observable focus on issues such as inter-agency coordination, infrastructure provisioning, and access to financing, particularly in segments where adoption has been slower. At the same time, variations in state-level performance, as highlighted by the IEMI, suggest that policy priorities may differ across contexts. Taken together, these documents point to a framing of India’s EV transition in which multiple levers like demand support, infrastructure, institutional capacity, and market design are considered in tandem, though their relative emphasis may continue to evolve over time.

6. Global Learnings

The global electric vehicle (EV) transition has been significantly accelerated by diverse policy frameworks that have moved markets from initial "regulatory pushes" to sustained "consumer pull" environments. According to the IEA, global electric car sales exceeded 17 million in 2024, with China leading at a 50% sales share, followed by Europe and the United States. (International Energy Agency, 2025)

a. Proven Global Policy Levers

Success in leading markets stems from a combination of fiscal incentives, stringent mandates, and infrastructure regulations (International Energy Agency, 2025).

- **Financial and Trade-In Incentives:** China's 2024 trade-in scheme, offering CNY 20,000 (~USD 2,750) to replace older vehicles with EVs, was a major driver; over one-third of the country's 11 million new EV sales benefited from this incentive.
- **Clean vehicle tax credit:** In the United States, the modified Clean Vehicle Tax Credit provided instant point-of-sale discounts of up to USD 7,500, while specific provisions for leased vehicles reclassified them as commercial to bypass local manufacturing requirements, doubling the share of leased EVs.
- **Regulatory Mandates and CO2 Standards:** Europe's transition is anchored in fleet-wide CO2 emission standards, which require a 15% reduction by 2025. Similarly, the United Kingdom's Vehicle Emissions Trading Scheme mandates a specific percentage of new registrations to be zero-emission each year (reaching 22% in 2024 and 28% in 2025).
- **Low Emission Zones (LEZs) and Commercial Policy:** European cities have successfully boosted electric Light Commercial Vehicle (LCV) adoption through LEZs. In the Netherlands, the introduction of LEZs and the removal of tax exemptions for ICE LCVs caused the electric sales share in that segment to leap to over 90% in early 2025.
- **Infrastructure Corridors:** The EU's Alternative Fuels Infrastructure Regulation (AFIR) mandates fast-charging stations (minimum 150 kW) every 60 km along the core TEN-T road network, ensuring highway coverage and reducing range anxiety for long-distance travel. (International Energy Agency, 2025)

b. Applicability for India's Policy Landscape

While India's PM E-DRIVE scheme focuses on E2/3Ws, buses, and trucks, several globally tested policies could contextualize and strengthen India's next phase.

- **Scrappage and Trade-In Integration:** Following China's model, India could enhance its national vehicle scrapping policy (V-VMP) by offering higher, tiered financial premiums specifically for replacing older ICE vehicles with electric models rather than new ICE alternatives.
- **Corridor-Based Charging Mandates:** Mirroring the EU's AFIR, India could adopt statutory requirements for fast-charging density along heavily used transport corridors to support the electrification of inter-city freight and passenger travel.
- **Urban Zoning Restrictions**: Establishing Low Emission Zones in high-pollution Tier-1 cities would provide the necessary "push" for logistics aggregators to transition their LCV fleets, moving beyond the current reliance on purchase subsidies.
- **Fiscal Agility for Leasing:** Adapting tax frameworks to treat "Battery-as-a-Service" and battery-leasing options more favorably could lower upfront costs, as seen in Vietnam, where battery leasing has made EVs price-competitive with conventional alternatives. (International Energy Agency, 2025)

7. Conclusion

This chapter provides a descriptive and exploratory account of India's EV policy landscape, tracing the evolution of national- and state-level schemes, regulatory changes, fiscal measures, and ecosystem support interventions. Across the materials reviewed, the policy trajectory appears to be shifting from initial market activation toward a broader mix of demand support, manufacturing promotion, and charging network expansion, with PM E-DRIVE representing the latest phase in this evolving architecture.

At the same time, the chapter also suggests that adoption outcomes remain uneven across vehicle segments and states. Read together, the documents examined here—along with the later NITI Aayog and IEMI materials—point toward a set of recurring policy priorities: stronger coordination, more predictable fiscal signals, improved infrastructure planning, better financing conditions, and more context-sensitive approaches across geographies and vehicle categories.

Viewed alongside the global context discussed in the chapter, India's experience appears broadly consistent with patterns observed elsewhere. International evidence suggests that EV transitions have typically been supported by combinations of policy instruments—spanning fiscal incentives, regulatory measures, infrastructure development, and industrial policy—rather than reliance on any single lever. At the same time, the global comparison highlights that the effectiveness of these approaches is shaped by local market conditions, institutional capacity, and the structure of the targeted vehicle segments.

Taken together, the chapter presents a policy landscape in which India's EV transition can be understood as evolving through the interaction of multiple policy levers. Rather than pointing to a single pathway, it suggests that the adoption trajectory will depend on how these elements are combined, adapted, and sequenced over time.

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Note: The documents reviewed (including GST slabs, policies, and guidelines) are based on information available online up to January 2025. There may have been subsequent updates, revisions, or discontinuation of some of these documents/schemes that may not be captured in this analysis.

Credits

Sandip Chakrabarti: Conceptualization, Methodology, Resources, Supervision, Project administration, Funding acquisition. **Anish Sugathan**: Conceptualization, Methodology, Resources, Supervision, Project administration, Funding acquisition. **Shreya Sinha**: Writing - Original Draft, Writing - Review & Editing. **Shriyash Puranik**: Validation, Formal analysis, Investigation, Data Curation, Writing - Original Draft. **Jesal Tejwani**: Validation, Formal analysis, Investigation. **Muskan Verma**: Validation, Formal analysis, Investigation, Data Curation, Writing - Original Draft. **Satya Andani:** Writing - Review & Editing.

Chapter 3

Assessment of India's EV Value Chain

Chapter Summary

Content:

1. Examines India's EV transition through a value-chain lens, covering OEM cost structures, B2B fleet demand, charging and battery-service models, domestic cell manufacturing and mineral security, and consumer-facing market dynamics.
2. Analyze how supply constraints, infrastructure readiness, industrial policy instruments, and confidence-based adoption barriers interact across upstream, midstream, and downstream segments.

Findings:

1. The EV transition is constrained by system-level misalignment: high battery-driven vehicle costs, import dependence, infrastructure gaps, financing frictions, and incomplete localization limit scale across segments.
2. Adoption is shaped not only by economics but by institutional credibility and ecosystem trust, including charger reliability, resale uncertainty, service access, and battery certification transparency.

Takeaways:

1. Accelerating scale requires coordinated sequencing across manufacturing incentives, aggregated demand creation, interoperable and audited charging infrastructure, and strengthened domestic R&D and skills capacity.
2. Moving from subsidy-led growth to durable market expansion depends on securing the full ownership lifecycle through localization, infrastructure reliability, and credible consumer safeguards.

1. Introduction

India's electric vehicle (EV) sector is currently undergoing a significant transition, moving from a relatively slow and limited phase of innovation to becoming a serious alternative to Internal Combustion Engine (ICE) vehicles. Anchored by India's 2070 net-zero commitment and a 30 percent EV penetration target for private passenger vehicles by 2030, the policy and industry focus has increasingly shifted toward building a "battery economy." However, this transition is complex. The battery alone accounts for approximately 30–40 percent of total vehicle cost, creating a substantial price premium over ICE vehicles and necessitating an examination of the entire EV value chain, from mineral extraction and cell manufacturing to vehicle assembly, infrastructure development, and final consumer adoption.

This chapter presents a systematic analysis of the EV value chain in India, drawing on over 25 stakeholder interviews and an extensive review of secondary literature to identify structural bottlenecks, cost drivers, and emerging opportunities.

The chapter is organized as follows. Section 2 examines supply-side constraints faced by Original Equipment Manufacturers (OEMs) in India, alongside the evolution of the policy landscape. Indian OEMs contend with elevated production costs, resulting in EVs typically being priced ₹4–5 lakh higher than comparable ICE vehicles. A key driver is the continued dependence on imported battery cells and critical components such as e-axles, with import reliance estimated at nearly 70 percent.

Section 3 shifts focus to the demand side, highlighting the Business-to-Business (B2B) segment (particularly logistics and fleet operators) as the early drivers of adoption. Despite higher upfront costs, EVs offer a strong operating cost advantage (approximately ₹0.6 per km compared to ₹2.5–3.0 per km for ICE vehicles). However, adoption remains constrained by capital expenditure requirements for charging hubs and operational inefficiencies arising from charging-related downtime.

Section 4 addresses the enabling infrastructure ecosystem, with particular emphasis on charging networks and battery solutions. Given projections indicating a requirement of approximately 1.32 million charging stations by 2030, this section evaluates how infrastructure gaps contribute to range anxiety and assesses emerging models such as Battery-as-a-Service (BaaS) and standardized battery swapping.

Section 5 moves upstream to examine the domestic battery cell manufacturing landscape. The analysis focuses on efforts to bridge technology and capability gaps through policy instruments such as the Production Linked Incentive for Advanced Chemistry Cells (PLI-ACC) scheme, and on strategies to secure critical minerals, including lithium, through international partnerships.

Finally, Section 6 completes the value chain analysis by examining the consumer journey. The findings suggest that, particularly among the aspirational middle class, adoption decisions are not driven solely by total cost of ownership calculations. Instead, purchase intent is shaped by an "architecture of trust," where dealer competence, peer influence, and visible infrastructure reliability play a decisive role in converting interest into adoption.

2. Original Equipment Manufacturing

2.1. Introduction

India's Electric Vehicle (EV) market is at a critical stage of expansion. Despite sustained government support for green mobility, large-scale adoption continues to face structural constraints. Original Equipment Manufacturers (OEMs) must contend with high production costs, limited charging infrastructure, an underdeveloped resale market, and continued import dependence across key components.

The most pressing challenge remains the price gap between EVs and Internal Combustion Engine (ICE) vehicles. This differential is driven primarily by high battery costs, continued reliance on imported cells, and limited domestic manufacturing depth. As a result, EVs remain less affordable for price-sensitive consumers, particularly in the mass-market segment.

Ambiguity surrounding EV resale values presents an additional obstacle. Unlike ICE vehicles, EVs have not yet completed a full lifecycle across multiple market segments in India, resulting in uncertain depreciation patterns. This uncertainty affects residual value estimation, increases financial institutions' perceived lending risk, and weakens consumer confidence in long-term asset values.

Infrastructure limitations further restrict adoption. Insufficient public charging networks and persistent range anxiety deter potential buyers, especially those requiring long-distance mobility. While projections suggest that India could have up to 50 million EVs on the road by 2030 (Jain et al., 2022), current charging infrastructure deployment remains inadequate to support this scale without substantial acceleration.

Moreover, continued reliance on imports of critical components, such as battery cells and e-axles, increases production costs and limits the competitive position of domestic OEMs relative to global manufacturers.

This section therefore examines the principal cost, infrastructure, and market-related constraints faced by OEMs and outlines potential policy interventions and industry strategies to support the sustainable growth of India's EV sector.

2.2. Three Key Challenges

a. Cost and Affordability Relative to ICE Vehicles

The most significant challenge facing OEMs is the price differential between EVs and Internal Combustion Engine (ICE) vehicles. EVs are typically priced ₹4–5 lakh higher than comparable ICE models. This gap is particularly restrictive in the sub-₹20 lakh segment, where affordability plays a decisive role in purchase decisions. Industry experts suggest that this gap is likely to reduce as battery costs decline, but at present, it remains a major deterrent (Philip, 2025).

A key driver of this cost disparity is dependence on imported components. India continues to import a large share of battery cells and e-axles (electric drive units), primarily from China and Europe. High import duties on these components further increase overall vehicle costs, making EVs less competitive

relative to ICE vehicles. The localization of e-axle manufacturing remains limited due to constraints, such as the lack of motor-grade steel production (Press Trust of India, 2024) and high-end semiconductor manufacturing capacity within the country (Koul, 2025).

An official from a leading EV OEM also noted that innovation and efficiency gains tend to accelerate once stable revenue generation models are established. According to this view, large-scale government procurement of EVs could create assured demand, triggering a virtuous cycle of production scale, innovation, and cost reduction. In addition, targeted subsidies and tax benefits for budget-friendly EVs could help address affordability concerns in the short term.

b. Charging Infrastructure Gaps and Range Anxiety

Range anxiety remains one of the most frequently cited concerns among potential EV buyers. For many consumers, especially inter-city travelers, a reliable driving range of 400–500 km is considered necessary for practical adoption.

According to a report by Forvis Mazars, India could have approximately 50 million EVs on the road by 2030. Supporting this scale would require around 1.32 million charging stations nationwide. This translates to the installation of nearly 400,000 chargers annually to meet projected demand (Forvis Mazars, 2024)

The Ministry of Housing and Urban Affairs has proposed that semi-public charging facilities account for 20 percent of vehicle-holding capacity (Ministry of Housing and Urban Affairs, 2019), along with corresponding enhancements in power load for such premises. Strengthening charging infrastructure in the following areas is critical:

1. Establishing a dependable and fast-charging network, particularly along highways, to support long-distance travel.

2. Standardization of EVSE and payment systems to ensure interoperability and ease of use.

3. Encouraging private-sector participation through Public–Private Partnerships (PPPs) to accelerate infrastructure deployment.

c. Resale Market and After-Sales Ecosystem

Uncertainty around resale value presents another major challenge. Unlike ICE vehicles, EVs in India have not yet completed a full ownership cycle across most segments. Rapid advancements in battery technology further complicate depreciation patterns, making it difficult to estimate long-term residual values.

As a result, limited data is available on vehicle health at resale and expected resale pricing. The absence of established residual-value benchmarks increases lenders' perceived risk and affects financing decisions across segments.

Developing a standardized residual value assessment framework could improve transparency and support informed purchasing decisions. Additional measures that could strengthen the resale ecosystem include:

1. Incentivizing OEMs to offer extended battery warranties (e.g., Mahindra's 15-year warranty model) to enhance consumer confidence.

2. Providing government trade-in incentives to replace older, high-emission vehicles with EVs.

3. Encouraging financial institutions to reduce down-payment requirements for EV purchases in the resale market.

2.3. Key Cost Drivers

2.3.1. Unit Cell Imports

a. Current State of EV Battery Cell Imports in India

Although India's Electric Vehicle (EV) market is expanding rapidly, the country remains heavily dependent on imported EV battery cells to meet rising demand. As of 2023, over 70 percent of EV battery cells imported into India originated from China, South Korea, and Japan (Koul, 2025).

According to projections by S&P Global Mobility, India's EV battery cell demand is expected to increase from 4 GWh in 2023 to approximately 139 GWh by 2035 (Das, 2024a). Despite this anticipated growth, domestic battery cell manufacturing remains in its early stages. Estimates suggest that local production may meet only about 13 percent of total demand by 2030, leaving most of the demand dependent on imports (Das, 2024a).

This high reliance exposes Indian OEMs to several risks, including geopolitical uncertainty, price volatility, and global supply chain disruptions. Additionally, the EV battery supply chain, comprising cell, module, and pack manufacturing, is fragmented, adding operational complexity and challenging the ability to ensure consistent battery availability for EV production (Carreon, 2023).

b. Potential Measures to Address Cell Import Dependency:

The following measures may be considered to address challenges related to battery cell imports:

- Partnerships with global mineral extraction leaders, including firms from Chile, Australia, and Argentina, to accelerate mining activities and build technical expertise.
- Creation of dedicated Special Economic Zones (SEZs) focused on refining raw lithium into battery-grade materials, supported by infrastructure assistance and tax incentives.
- Establishment of a Central Implementation Authority comprising representatives from key ministries (Heavy Industries, Power, Mines), state governments, and private-sector stakeholders to improve coordination, streamline policy execution, and accelerate ecosystem development.

2.3.2. eAxle Imports

An e-Axle is an integrated electric drive unit that combines key propulsion components—typically the inverter, electric motor, and gearbox—within a single axle assembly. It is central to the functioning of Battery Electric Vehicles (BEVs).

India continues to import a significant proportion of e-axles from countries such as China and those in Europe. High import duties on critical components increase the overall cost of EVs, reducing their competitiveness relative to ICE vehicles.

The localization of e-axle manufacturing remains constrained by the absence of motor-grade steel production and advanced semiconductor manufacturing in India. Limited domestic production of e-axles restricts the broader localization of EV drivetrains and powertrains, increasing dependence on foreign suppliers. In turn, the lack of a strong domestic supply chain hinders related ecosystem development, as large-scale deployment of charging infrastructure becomes difficult without sufficient EV penetration.

a. Potential Measures to Address e-Axle Import Dependency

The following measures may be considered:

- Expanding incentive structures similar to the Production-Linked Incentive (PLI) scheme for Advanced Chemistry Cells (ACC) to include e-Axles, power electronics, and rare-earth magnet manufacturing.
- Reducing import duties on e-axle components in the short term to improve cost competitiveness for Indian OEMs, alongside a phased transition toward local manufacturing.
- Providing PLI incentives to EV drivetrain manufacturers and encouraging firms such as Tata AutoComp, Sona Comstar, and Bharat Forge to invest in domestic e-axle production.
- Facilitating faster approvals for joint ventures between Indian companies and global technology leaders to accelerate localization of EV powertrains.

2.3.3. Lack of Global Integration

Global manufacturers such as Tesla and BYD are exploring entry and expansion in the Indian market (Carter, 2025). Domestic OEMs view this development both as competitive pressure and as an opportunity to strengthen the overall EV ecosystem.

The presence of established global players could accelerate the development of robust charging networks nationwide, indirectly supporting domestic manufacturers by creating a more conducive environment for EV adoption.

Under the Scheme to Promote Manufacturing of Electric Passenger Cars in 2024, customs duties for setting up manufacturing facilities have been reduced to 15 percent (Press Information Bureau, 2025c). However, these incentives do not extend to investments in charging infrastructure, which limits their broader ecosystem impact.

a. Potential Measures to Manage Global OEM Entry

The following measures may help manage the entry of global OEMs:

- Encouraging global players to establish local manufacturing facilities rather than relying on imports, thereby generating employment and strengthening domestic production.
- Promoting collaboration between domestic OEMs and foreign manufacturers through technology-sharing agreements to enhance India’s position as an EV manufacturing hub.

- Expanding the scope of existing incentive schemes to include charging infrastructure investments, encouraging manufacturers to invest not only in production facilities but also in nationwide charging networks.

2.3.4. Regulatory and Structural Gaps in Retrofitting

Retrofitting Internal Combustion Engine (ICE) vehicles into electric vehicles has been identified as a potential pathway to accelerate electrification without requiring large-scale vehicle replacement.

Several countries have adopted this approach:

- France: Legalized retrofitting of ICE vehicles to electric power in 2020, supported by subsidies, tax credits, and reduced registration fees (Sustainable Bus, 2020).
- Germany: Provides grants and subsidies for converting ICE vehicles to electric drivetrains, with support from local governments to meet environmental targets (Electrify, 2023).
- United Kingdom: Offers grants and tax exemptions for retrofitting older vehicles, particularly taxis and commercial vehicles, with discussions ongoing regarding formal national incentives (Carbon Action, 2017).

India has not yet implemented a comprehensive nationwide retrofitting program, but interest is increasing. Companies such as E-Trio are active in this space, and several states have supported retrofit solutions. The government has also indicated that regulatory frameworks to facilitate EV conversions, particularly for commercial vehicles, are under consideration.

Structured policy support around certified retrofit kits and financial incentives for conversion could help position retrofitting as a viable pathway within India's broader EV transition.

2.4. Conclusion

India's push toward electric mobility has made significant progress, yet multiple structural barriers continue to constrain large-scale EV adoption. High upfront vehicle costs, limited charging infrastructure, continued reliance on imported critical components, and consumer hesitation driven by concerns around range and resale value remain key obstacles.

Addressing these challenges requires a coordinated and sustained policy approach. Strengthening domestic manufacturing, particularly in battery cells and powertrain components, is essential to reduce cost pressures and import dependence. Parallel investments in charging infrastructure—supported through public–private partnerships—are necessary to improve range confidence and enable wider adoption. Targeted subsidies and fiscal incentives can help bridge affordability gaps, particularly in price-sensitive segments.

At the same time, fostering innovation in battery technology and expanding research and development efforts are critical to building long-term competitiveness. Policy support for retrofitting solutions, structured engagement with global OEMs, and improved inter-ministerial coordination can further strengthen the EV ecosystem.

With deliberate policy design, institutional coordination, and sustained industry participation, India has the potential to become a significant player in global electric mobility. By addressing current structural constraints while building domestic capability, the country can advance toward a cleaner and more resilient transportation system aligned with its environmental and economic objectives.

3. The B2B Segment

3.1. Introduction

Electric Vehicles (EVs) are among the fastest-growing segments of the global automotive industry, driven by international commitments to reduce carbon emissions and transition to cleaner mobility technologies. EVs and hybrids offer the potential to improve energy efficiency, enhance air quality, reduce congestion, and strengthen road safety.

Globally, the EV market continues to expand in alignment with long-term zero-emission targets for 2050. According to the International Energy Agency, more than 40 million electric cars are currently on the road worldwide, with 14 million sold in 2023 alone. These trends reflect a strong global momentum toward electrified mobility (International Energy Agency, 2024).

Within this broader transition, the Business-to-Business (B2B) segment plays a particularly important role in accelerating adoption, given its scale of operations and structured fleet management models.

3.2. Methodology

While EV adoption involves multiple stakeholders, including policymakers, OEMs, charging infrastructure providers, driver partners, and regulatory bodies, this study focuses specifically on the perspective of B2B users. The analysis examines commercial vehicle operators, logistics fleets, ride-hailing companies, and EV fleets deployed for public transportation. The objective is to understand the distinct preferences, operational challenges, and decision-making factors that influence EV adoption within these business segments.

The methodology combines secondary data analysis with primary research.

Secondary research includes:

- Review of EV market trends
- Analysis of government incentives and regulatory frameworks
- Assessment of infrastructure development
- Evaluation of market sentiment

The findings aim to inform targeted public policy recommendations related to incentives, infrastructure enhancements, and subsidies tailored to B2B requirements.

By examining the practical constraints and motivations of business customers, this research supports accelerated EV adoption in line with India's 30 percent adoption target by 2030, while also identifying pathways to improve operational efficiency within commercial fleets.

3.3. B2B EV Adoption: Customer Segmentation

The B2B EV market can be categorized into the following key segments, each with distinct operational characteristics, barriers, and evaluation metrics.

Segment	Examples	Key barriers	Metrics
Urban Last-Mile Delivery	Evify, Zomato, Swiggy, Zepto	Charging downtime, range anxiety, and lack of leasing options	Mileage, downtime, subsidy uptake
E-Commerce Delivery	Ekart, Jiomart, DTDC, Amazon Logistics	Inter-city range limitations, unclear ROI, and integration challenges	ROI comparisons, fuel savings, pilot data
Fleet & Ride-Hailing	My-Byk, BluSmart, Uber	Fast-charging dependency, insufficient incentives compared to private buyers, and driver retraining	Uptime, cost of ownership, range stats
Inter-City Logistics	Mahindra Logistics, Delhivery	Heavy-duty EV limitations, highway charging gaps, and ROI concerns	Payload range comparison, pilot outcomes, corridor readiness
EV Public Transportation	Govt/Corporate Fleets, EV Buses	Long charging cycles, unreliable maintenance, and subsidy dependency	Battery lifecycle, operational costs, depot charging stats

The segmentation highlights that EV adoption in the B2B market is driven primarily by operational efficiency and cost predictability. While last-mile operators focus on downtime and mileage, logistics and inter-city players prioritize clarity of ROI and charging reliability. The fleet and public transport segments evaluate uptime, lifecycle costs, and the feasibility of depot charging. These differences indicate that B2B adoption is shaped by route intensity, asset utilization, and capital recovery cycles, requiring segment-specific approaches rather than a uniform strategy.

3.4. Secondary Research

3.4.1. EV adoption in India

India is emerging as a significant player in the global Electric Vehicle (EV) transition. With an annual automobile production of approximately 28.4 million vehicles — including 4.9 million passenger vehicles and 21.46 million two-wheelers — India holds a strong manufacturing base. Additionally, automobile exports have reached 4.5 million vehicles, comprising 6.72 million passenger vehicles and 3.45 million two-wheelers (Press Information Bureau, 2025b).

The Government of India is actively promoting EV adoption to:

- Reduce dependence on crude oil imports and narrow the trade deficit
- Lower carbon emissions to meet climate commitments
- Address severe urban air pollution in metropolitan cities such as Delhi and Mumbai

Although India trails global leaders like Norway and China in overall EV penetration, it recorded a high EV growth rate in the first quarter of 2024. This growth has been supported by policy interventions such as FAME, PLI, and GST rationalization.

However, segment-wise adoption presents variation:

- The E-2W (Electric Two-Wheeler) segment has witnessed rapid adoption, primarily driven by retail customers.
- E-3W, E-4W, and E-Buses show comparatively slower adoption.
- These latter segments are predominantly driven by B2B customers, including fleet operators, logistics companies, delivery service providers, and public transport agencies. (Joshi, 2024)

This divergence highlights the need to specifically examine market dynamics and behavioral drivers influencing EV adoption among B2B customers in India, which forms the core focus of this research.

3.4.2. Government Incentives & Policies for B2B EV Adoption in India

The Government of India has introduced multiple schemes to accelerate EV penetration in the commercial and public transport sectors.

a. Production Linked Incentive (PLI) Scheme for EVs & Battery Manufacturing

The Government of India has introduced the PLI scheme to boost domestic EV and battery manufacturing by providing financial incentives to manufacturers. The various incentives are:

- The PLI AUTO Scheme has been aimed at promoting the manufacturing of Advanced Automotive Technology (AAT) Products with a total outlay of INR 25,938 crore for a period of 5 years (FY2022-23 to FY2026-27). This scheme will also help facilitate and promote deep localization of AAT products and enable the creation of domestic and global supply chains (Ministry of Heavy Industries, 2021)

- Production Linked Incentive (PLI) scheme for manufacturing of Advanced Chemistry Cell (ACC) has been started by the Government of India to reduce prices of battery, which is a critical component in EV manufacturing. The scheme will result in a drop in battery price, which will result in an overall reduction of cost in EVs, and shall promote faster adoption of EVs (Ministry of Heavy Industries, 2021).

The PLI scheme will help make EVs more affordable by reducing battery and vehicle costs. The scheme will further encourage fleet operators to shift from ICE to EVs, with better locally manufactured products suited for commercial use now available.

b. Faster Adoption and Manufacturing of Electric Vehicles (FAME-I & FAME-II)

The Government of India has introduced the FAME scheme to promote EV adoption by providing financial incentives for commercial and public transport fleets.

FAME-I (2015-2019): FAME India Phase I had four focus areas: technological development, demand generation, pilot projects, and charging infrastructure components. The phase was run until March 31, 2019, with a budget outlay of Rs 895 Cr.

Achievements under FAME-I include subsidies for approximately 2.8 lakh EVs, amounting to INR 360 crore; deployment of 425 electric and hybrid buses across various cities, supported by a government incentive of INR 280 crore; and subsidies of approximately INR 43 crore for 520 charging stations/infrastructure (Ministry of Heavy Industries, 2022).

FAME-II (2019 – 2024): The Government of India has allocated a budget of Rs 10,000 crores to support the electrification of public and shared transportation and aims to do so through demand incentives for Electric 2-Wheelers, 3-Wheelers, 4-Wheeler Passenger Cars, and Electric Buses. The scheme proposes establishing charging infrastructure, including subsidies for 2700 charging stations in cities and on highways. The details of the incentives for various vehicle types are provided below. (Kohli, 2024):

Vehicle segment	**No. of vehicles supported**	**Approx. size of battery**	**Total incentive (INR)**	**Max. ex-factory price to avail the incentive**
Electric 2W	10,00,000	2 kWh	20,000	1.5 lakhs
Electric 3W	5,00,000	5 kWh	50,000	5 lakhs
Electric 4W	35,000	15 kWh	1,50,000	15 lakhs
Electric Bus	7,090	250 kWh	50,00,000	2 Crores

c. State Level EV Incentives for Businesses:

Many states provide subsidies and tax benefits to individuals and businesses adopting EVs, including exemptions from registration and road taxes. State governments are also providing special benefits for EV manufacturing units and fleet operators; for example, Tamil Nadu has allocated land and other benefits for Vinfast to establish an EV manufacturing unit in the state (VinFast, 2025).

3.5. Porter's Five Forces Strategic Analysis Model

To provide a structured evaluation of the competitive landscape beyond individual cost metrics, this section applies Porter's Five Forces framework to assess the structural risks in India's EV sector. This approach enables a deeper understanding of the systemic power dynamics across five key forces: the threat of new entrants, the bargaining power of suppliers (particularly with respect to critical battery minerals), the bargaining power of buyers (such as high-volume fleet operators), the threat of substitutes, and the intensity of industry rivalry.

a. Threat of New Entrants (Moderate to High)

Barriers to Entry:

- High capital investment in manufacturing
- Requirement of charging infrastructure (e.g., dedicated networks built by fleet operators)
- Regulatory and certification compliance
- Established players with supply chain advantages

Opportunities for New Entrants:

- Government incentives under PLI and FAME are reducing the financial burden
- Policy push toward localization and domestic manufacturing
- Technological advancements in battery production
- Declining battery costs are improving commercial feasibility

b. Bargaining Power of Suppliers (Moderate to High)

Supplier power is primarily influenced by battery dependency and raw-material concentration.

Key Suppliers:

- The Battery is the most critical EV component, and the battery manufacturers play a vital role in the adoption of EVs.
- Secondly, the charging infrastructure providers play another critical role as they are also a larger part of the EV ecosystem.

Factors Increasing Supplier Power:

- Limited high-quality battery manufacturers
- R&D-intensive technology
- Dependence on scarce raw materials (lithium, nickel, cobalt)
- Concentration of manufacturing in China

Factors Reducing Supplier Power:

- Underutilization of the capacity of battery manufacturers in China, due to which the price of LFP batteries has dropped from USD 120$ in 2021-22 to USD 60$ in 2024-25 (McKerracher, 2024).
- Further, the Vertical integration by large players like Ola may reduce the supplier bargaining power.

c. Bargaining Power of Buyers (High)

Key Buyers:

- Fleet operators
- Logistics firms
- Taxi aggregators
- Corporate EV adopters

Factors Increasing Buyer Power

- Strong focus on Total Cost of Ownership (TCO)
- Availability of alternative fuel vehicles (ICE, hybrid, CNG)
- Large fleet purchase volumes

Factors Reducing Buyer Power

- Limited EV models in the commercial segment
- Dependence on available charging infrastructure

d. Threat of Substitutes (Moderate to High)

Key Substitutes:

- Internal Combustion Engine (ICE) vehicles, CNG-based vehicles, Hybrid vehicles, along with upcoming Hydrogen fuel cell vehicles offering a cleaner fuel solution.

Factors increasing Substitution Threat:

- Lower upfront cost of ICE/CNG vehicles
- Established refueling infrastructure
- Concerns regarding charging reliability and battery life

Factors Limiting Substitution:

- Rising fuel prices
- Environmental regulations
- Increasing registration costs for conventional vehicles
- Policy measures discouraging long-term ICE usage

e. Industry Rivalry (High)

The competitive landscape is intense, with both established OEMs and emerging EV-focused players.

Competitive Landscape:

- Established automakers expanding EV portfolios
- EV-focused startups increasing innovation pressure
- Expansion of manufacturing capacity in India

Competitive Strategies:

- Battery-as-a-Service (BaaS) models
- Flexible financing options
- Differentiation based on battery efficiency and range
- Investment in dedicated charging infrastructure

By applying this framework, the analysis identifies the major pressures shaping the attractiveness and long-term viability of the Indian EV market, including import dependencies and infrastructure-related entry barriers. Ultimately, the framework serves as a strategic lens for stakeholders to identify the key levers needed to move the sector from its current high-risk gestation phase to a stable, self-sustaining ecosystem.

3.6. Primary Data:

Interviews were conducted with three industry stakeholders to understand B2B EV adoption dynamics from both fleet operator and OEM perspectives:

Table 1: Respondents' Profile

Code	Role	Organisation Type	Region
P1.1	Senior Executive	Last-Mile EV Fleet Startup	Western India
P1.2	Founder-Leader	Electric Bicycle Platform	Multi-city (National)
P1.3	Mid-Senior Manager	Electric Two-Wheeler OEM	National

3.6.1. Major Trends

Taking the average responses of these people, the following results are obtained.

(1 – Least significant, 5 Most significant)

Table 2: Factors that influenced them to electrify their fleet

Factor	Average Score
Operational Cost Advantage	4.6
Demand from Clients	3.33
Clean/Green Image	3.33
Government Push	2

Inference: Operational cost advantage is the strongest driver of fleet electrification.

- EV running cost ≈ ₹0.5–0.6 per km
- ICE running cost ≈ ₹2.5–3 per km
- Lower maintenance due to fewer moving parts

Government push is perceived as the least significant factor, as incentives are viewed as more consumer-focused rather than business-oriented.

Table 3: Problems faced while entering the EV industry

Challenge	Average Score
High Initial Investment	4.3
Lack of Infrastructure	4.3
Difficulty in Raising Funds	3.6
Lack of Subsidies	3.33
Uncertainty about Battery Life	2.6

Inference: High initial investment is a major barrier due to:

- Charging hub setup (Hub & Spoke model)
- IoT systems and fleet management technology
- Vehicle acquisition costs

Lack of infrastructure (fast charging and swapping) creates operational hesitation and range anxiety.

Battery life uncertainty is comparatively less concerning, as LFP and NMC technologies are considered reliable (LFP ≈ 1000–1500 cycles).

Preference towards charging vs battery swapping

No clear preference emerged among the respondents for charging or battery swapping. While charging raises concerns regarding vehicle downtime and lost operational hours, battery swapping, though it reduces downtime, remains constrained by limited and inconsistent infrastructure availability. Overall, the primary bottleneck is the underdeveloped charging and swapping infrastructure.

3.7. Key insights From Interviews:

3.7.1. Last-Mile Electric Fleet Startup (P1.1)

a. Introduction

The case concerns a startup founded in 2021 in a Tier-2 city in western India, operating in last-mile logistics for groceries, food delivery, and e-commerce parcels. The company positions itself as a carbon-negative fleet operator.

It follows an integrated operational model, owning its vehicle fleet, rider workforce, and proprietary technology stack, including IoT-enabled vehicle monitoring and hub network management systems. Its client portfolio includes major e-commerce and food delivery platforms. The company has also partnered with a domestic electric two-wheeler manufacturer for vehicle procurement.

The current fleet comprises approximately 750+ electric two-wheelers, with plans to scale to around 5,000 vehicles by the end of FY25.

b. Operational Insights

The company initially experimented with electric three-wheelers for first-mile delivery operations. However, the model was found to be economically unviable due to relatively lower payouts and extended charging times (approximately 4–5 hours for an 80–120 km range). As a result, operations now focus primarily on electric two-wheelers.
Capital expenditure ownership is structured through a mix of financial and operational leasing arrangements. Over time, the company has been transitioning toward higher asset ownership. Break-even at the vehicle level is typically achieved within 1–2 years, after which revenue retention improves due to the absence of lease-sharing obligations.

c. Key Challenges and Observations

According to senior leadership, EV adoption in the logistics segment is primarily driven by commercial fleet operators. However, policy incentives and subsidies remain largely targeted at individual consumers rather than institutional fleet aggregators.

Operations in non-metro cities present distinct characteristics:

- Larger delivery radius due to low density

- Lower EV adoption among clients
- Limited charging infrastructure
- Higher supply–demand gap, increasing willingness to pay
- Lower real estate costs
- Availability of low-cost riders (delivery-based or salaried)

Infrastructure constraints remain significant. The absence of adequate fast-charging and battery-swapping facilities has required the company to develop and rely on its own normal-charging hubs.

Additionally, insurance coverage complications arise in battery-swapping models when there is a mismatch between battery identification numbers and chassis numbers.

Access to growth capital remains challenging for early-stage operators, owing to investor uncertainty regarding long-term EV market stability and policy continuity.

From a technological standpoint, Lithium Iron Phosphate (LFP) battery chemistry is preferred over Nickel Manganese Cobalt (NMC) due to superior lifecycle durability. A 3-kWh battery pack with standard Battery Management System (BMS) and Controller Area Network (CAN) integration typically delivers approximately 1,500 charge cycles under standard operating conditions.

Table 4: Estimated per-km operating cost of a 2-wheeler EV scooter across battery life stages

2-Wheeler EV running cost per km calculations				
	Values	Early Stage	Middle Stage	Last Stage
Fixed cost (Battery cost)				
Battery Cost (Rs)	35000			
Cycles (Nos.)	1500 (total)	500	500	500
Range per cycle (kms)		120	100	80
Total kilometers (kms)	150,000 (total)	60000	50000	40000
Fixed Cost per km (Rs /km)	0.23	0.23		
Variable cost (Charging)				
Cost per unit (Rs/Kwh)	10			
Total units for fully charging 3kwh battery	3	3	3	3
km per cycle		120	100	80
Variable Cost per km (Rs/km)		0.25	0.30	0.38
Total cost per km (Rs/km)		0.48	0.53	0.61

3.7.2. Urban Electric Bicycle Fleet Operator (P1.2)

a. Introduction:

This case examines a bicycle-sharing and rental enterprise founded in 2014 in a Tier-1 city in western India. The company operates a multi-city network across several Indian urban centers, managing a fleet of approximately 10,000 bicycles as of 2024, including both conventional and electric variants.

The company operates across three verticals:

1. Intracity Shared Mobility – Public bicycle-sharing systems implemented through B2G2C partnerships with state and municipal governments.
2. Campus Mobility Solutions – Dedicated mobility services for institutional campuses and large corporate establishments.
3. Cargo Mobility – Electric cycle solutions targeted at delivery riders.

In 2023, the company integrated electric bicycles into its operational fleet. Under the cargo vertical, it currently operates a B2C subscription-based model, serving individual delivery riders directly rather than partnering with food-delivery or ride-hailing aggregators. However, strategic collaborations with such platforms remain a potential future pathway.

Riders access vehicles through a structured subscription plan, while maintenance, servicing, and quality control are centrally managed by the company.

b. Limitations of Electric Scooters (Delivery Rider Perspective)

According to the senior leadership, delivery riders face several issues with electric scooters:

- Low Real-World Range: OEM-claimed ranges (150–200 km) are not consistently achieved under real operating conditions; practical range is often below 100 km, restricting daily delivery volume.
- Reduced Earning Potential: Lower effective range translates into fewer completed orders and constrained income generation.
- Low-Speed Vehicle Category Constraints: 25 km/h vehicles are operationally unsuitable for time-sensitive delivery segments such as food logistics.
- Fixed Battery Architecture: Non-detachable battery systems create charging challenges, particularly for riders without access to dedicated residential charging infrastructure.
- Inadequate Public Charging Ecosystem: Limited availability of reliable fast-charging infrastructure increases operational downtime.
- Downtime vs. Cost Savings Trade-off: Income foregone during charging downtime can outweigh operational savings from lower fuel costs.

c. Identified Market Gaps

Three distinct stakeholder gaps were observed:

- Delivery Riders: Face limitations in range, vehicle speed, and charging access, directly affecting earning capacity.
- Bicycle OEMs: Possess strong manufacturing capabilities but limited experience in fleet-based operational models; demand predictability and product–market alignment remain uncertain.
- Delivery Aggregators: Express intent to electrify fleets but encounter operational and infrastructure constraints; a substantial share of their delivery ecosystem remains dependent on ICE vehicles.

The company positions itself as an intermediary platform that aligns manufacturing capability, rider demand, and electrification objectives.

d. Why Electric cycles?

Electric bicycles were chosen because they address several operational bottlenecks:

- 1.5 kWh detachable battery reduces dependence on fixed charging infrastructure
- Approximate 130 km full-day range under typical operating conditions
- Lightweight structure (~35 kg) enables pedaling in case of battery depletion
- Lower regulatory compliance requirements compared to electric scooters
- Reduced manufacturing and homologation costs

e. Rider Economics

Electric bicycles provide a near-optimal earnings balance:

Table 5: Rider daily earnings comparison

Vehicle Type	Max. Earnings	Cost	Net Profit
Pedal Bicycle	Rs500 (@ 8hrs per day)	~0	500
Electric Bicycle	Rs1200 (@ 12hrs per day)	200	1000
ICE Scooter	Rs1600 (@ 14hrs per day)	500	1100

f. Ownership Model

For the initial 200 vehicles deployed under the cargo vertical:

- Capital expenditure (CapEx) was borne by OEM or franchise partners.
- Operational expenditure (OpEx), including labor management, maintenance, and technology integration, was handled by the enterprise.
- Revenue was shared between the operating company and OEM/franchise stakeholders under a predefined arrangement.

3.7.3. Electric Two-Wheeler OEM: New Product Development Strategy (P1.3)

Introduction

This case examines a legacy Indian two-wheeler manufacturer that entered the electric mobility

segment in early 2020 with its first mass-market electric scooter. The company established a dedicated EV production line at one of its southern India manufacturing facilities.

Since launch, production capacity has scaled to exceed 100,000 units annually, with additional capacity expansion planned to accommodate projected growth.

Key points:

- **Adoption Trajectory:** From the OEM perspective, EV market growth has progressed more gradually than initially anticipated. Achieving a 30% EV penetration target by 2030 is viewed as structurally challenging under current market conditions.
- **Battery Cost Structure:** Battery packs remain the single largest cost component, accounting for approximately 40% of total vehicle cost. Despite this, policy focus over the past five years has been more on demand-side incentives than on structural battery cost reduction through localization or upstream integration.
- **Warranty Strategy and Risk Mitigation:** To mitigate consumer concerns regarding battery longevity and replacement costs, the company offers battery warranties in the range of 30,000–50,000 km, depending on pack configuration and capacity.
- **Charging Infrastructure Constraints:** Public charging network expansion is perceived as insufficient relative to vehicle growth. This inadequacy continues to reinforce range anxiety, particularly for intercity or long-distance usage scenarios.

3.8. Recommendations

The following recommendations are derived from recurring themes across the primary interviews, supported by insights from the secondary research.

a. Subsidies

There is a need to rebalance subsidy allocation toward commercial EV operators. Currently, policy incentives are perceived to be more consumer-focused. Redirecting a greater share of subsidies to B2B operators can accelerate adoption, particularly since commercial fleets are driving large-scale electrification.

b. Charging Infrastructure

Expansion of charging infrastructure, particularly fast-charging and battery-swapping facilities, is critical to reducing range anxiety and operational downtime.

In addition, a proper audit mechanism should be implemented to verify the functionality of charging stations. Eliminating non-operational or “ghost” charging points would improve trust in the EV ecosystem and enhance reliability for fleet operators and riders.

c. Insurance Coverage for Swapped Batteries

Current insurance regulations do not adequately support battery-swapping models, particularly when there is a mismatch between the battery and chassis numbers. These regulatory gaps should be addressed to enable wider adoption of swapping models and reduce operators' risk exposure.

d. Center–State Policy Alignment

Policy inconsistencies across states increase operational costs for B2B EV adoption. For example, higher RTO fees in certain states make commercial EV deployment more expensive. A standardized regulatory framework or stricter harmonization between central and state policies would reduce uncertainty and cost disparities.

e. Battery Technology and Domestic Manufacturing

Given that batteries account for a significant portion of total vehicle cost, targeted investment in battery chemistry research and domestic cell manufacturing is essential. Public–Private Partnerships (PPPs) involving academic institutions and OEMs could support technological advancement, reduce import dependency, and lower long-term battery costs.

f. Promotion of Electric Cycles

Electric cycles are a viable, cost-effective mobility solution, particularly for last-mile delivery. Policy support in the form of improved road infrastructure and dedicated cycling lanes would enhance usability, reduce congestion, and improve rider experience.

4. Charging and Battery Infrastructure

4.1. Introduction

India is undergoing a shift towards electric mobility driven by the urgent need to reduce dependence on imported fossil fuels, address climate change, and mitigate air pollution. Electric Vehicles (EVs) provide a clean alternative by lowering emissions, reducing operational expenditure, and improving energy security. In response to the recognition of these advantages, India has set stringent EV adoption targets for 2030: 30% EV penetration in private passenger vehicles, 70% in commercial vehicles, 40% in buses, and 80% in three-wheelers and two-wheelers. (NITI Aayog, 2023).

Despite these ambitious goals, EV penetration in India remains relatively low due to numerous barriers, particularly the lack of a robust EV charging infrastructure. A low number of charging stations plays an important role in "range anxiety," deterring prospective buyers from switching to electric vehicles. The existing charging infrastructure in India is extremely fragmented, with low availability, low uptime, limited standardization, and significant regional differences, especially in rural and semi-urban areas.

From a policy perspective, the Indian government has launched various schemes and regulations, such as FAME-II, the Production-Linked Incentive (PLI) scheme, and the Battery Swapping Policy, to enhance EV adoption and infrastructure development. Different state governments have also launched their own customized EV policies to encourage adoption through incentives, rebates, and regulations.

On the corporate side, several local and foreign players have started venturing into India's EV space, drawn by its huge growth prospects. Investments are flowing into charging infrastructure, battery technology, and new business models, such as Battery-as-a-Service, subscription-based services, and battery-swapping solutions.

This section examines the current state of EV charging infrastructure in India, discusses the policy environment, and assesses the business prospects and economic implications of its development. In

addition, the report draws on global best practices and identifies key international standards and technologies. Finally, insights from industry players and sector experts have been incorporated to ensure a holistic perspective.

The rest of this section comprises secondary research, economic and business analysis, policy recommendations, and lessons learned from international EV adoption champions. The eventual aim of this study is to present concise, actionable recommendations for policymakers and industry stakeholders to work together effectively to help India achieve its ambitious 2030 EV adoption goals.

4.2. Objectives

The main aim of this research study is to analyze and propose effective strategies to accelerate the adoption of Electric Vehicles (EVs) in India, with specific emphasis on developing EV charging infrastructure through hybrid business and policy interventions. The study specifically aims to understand current hindrances, including poor infrastructure, fragmented policy implementation, and high expenditures, and to draw on best practices informed by global standards. In addition, it aims to provide unambiguous, actionable recommendations to foster public-private partnerships, streamline regulatory procedures, and leverage technological innovations in charging and battery management systems, enabling India to achieve its aggressive EV penetration targets by 2030.

4.3. Scope

The research approach taken for this project is extensive secondary research supplemented by expert interviews and stakeholder analysis. Secondary research entails a structured review of existing government policies, industry reports, and academic research on EV infrastructure and battery technologies, with a particular focus on evolving trends and best practices in global markets. Expert interviews with industry leaders, policymakers, and subject-matter experts yield qualitative evidence of real-world issues and opportunities within India's EV environment. In addition, comparative analysis and benchmarking of foreign case studies help determine effective approaches and potential pitfalls. Through the integration of secondary research, primary expert insights, and comparative benchmarking, strong, usable results for the overall project aims are guaranteed.

4.4. Current Policy Landscape for EV Adoption and Standardization

4.4.1. National-Level Policies and Programs

1. **Faster Adoption and Manufacturing of Electric Vehicles (FAME-II):** Introduced in 2019 with an outlay of INR 10,000 crore, this flagship policy promotes the adoption of EVs by supporting electric buses, three-wheelers, and commercial four-wheelers with subsidies. Despite the resources and motives, experts cite delays in releasing funds and complex procedures, advising the need for improved policy implementation efficiency (Ministry of Heavy Industries, 2019).

2. **Production-Linked Incentive (PLI) Scheme:** Allocated INR 18,100 crore, this scheme focuses on developing strong domestic manufacturing capabilities for EV battery and component

manufacturing, thereby decreasing India's reliance on foreign battery technology and making vehicle costs lower (Institute for Energy Economics and Financial Analysis [IEEFA], 2026).

3. **Battery Swapping Policy (NITI Aayog Draft, 2022):** Suggests that battery sizes should be standardized and that manufacturers must have interoperability. This policy focuses on Battery-as-a-Service (BaaS) to address high upfront investment and accelerate adoption, especially for fleet owners and commercial vehicles (NITI Aayog, 2022).

4. **Electric Vehicle Charging Infrastructure (EVCI) Guidelines, 2022:** Published by the Ministry of Power, the guidelines provide specific technical specifications, operational standards, and interoperability guidelines, making EV charging infrastructure mandatory in all new residential and commercial developments as part of building-level readiness (Ministry of Power, 2022).

5. **GST Concessions and Green Energy Open Access Regulations, 2022:** EVs have a GST of merely 5%, which is much lower than conventional vehicles, and charging infrastructure for EVs has lower tax rates, promoting investments. Green Energy Open Access Regulations promote the use of renewable energy for EV charging stations, promoting sustainability (NITI Aayog, 2023).

4.4.2. State-Level Prominent Policies and Programs

1. **Delhi EV Policy (2020):** Among the most forward-looking EV policies in India, with a goal of 25% EV penetration in new registrations by 2024. The policy offers significant purchase incentives, an interest subvention, and a road tax exemption, and promotes infrastructure development, especially battery swapping and the rollout of charging stations (Government of NCT of Delhi, 2020).

2. **Maharashtra EV Policy (2025)**: This policy aims to develop a strong EV ecosystem through financial subsidies for EV buyers and infrastructure developers. It stresses fleet electrification through targeted subsidies for charging infrastructure and requirements for fleet electrification for commercial fleets (MahaPreit, 2025).

3. **Karnataka EV Policy (2025):** Focuses on developing a strong EV ecosystem by promoting the setting up of charging stations, battery unit manufacturing, and EV tech startups. It encourages R&D through industry-academia collaborations and positions Karnataka as an EV innovation hub (Government of Karnataka, 2025).

4. **Tamil Nadu EV Policy (2019):** Targets large-scale EV manufacturing and infrastructure investment in the state. Provides specific fiscal incentives to multinational and domestic businesses setting up manufacturing and R&D facilities, greatly enhancing Tamil Nadu's position within India's EV sector (Government of Tamil Nadu, 2019).

In conclusion, effective implementation at both the national and state levels, with well-defined roles, incentives, and standardization, will be essential to achieving India's aggressive EV penetration targets by 2030. Ongoing refinement and consolidation of policies, along with proactive public-private partnerships and investment in technological innovation, will be instrumental in delivering India's vision for electric mobility.

4.5. Business and Economic Perspective on Charging Infrastructure

a. Investment Opportunities and Market Growth

The Indian EV charging infrastructure market offers significant investment opportunities, poised to grow considerably as vehicle adoption increases. Various companies, such as Tata Power, Hyundai Motors, and Hero MotoCorp, are strategically investing in developing countrywide charging networks. The increasing interest stems from India's ambition to significantly increase the number of public charging points installed by 2030, thereby greatly widening the market for infrastructure providers and investors (Tata Power, 2024; India Brand Equity Foundation, 2025).

b. Challenges for Infrastructure Expansion

Despite significant potential, several challenges limit private-sector entry. High up-front capital expenditures, long payback on investment, few standardized regulations, and dispersed state policies make investment unattractive. The availability of real estate in cities is another major impediment, necessitating policy measures to facilitate land allocation for infrastructure development (Ministry of Power, 2022).

c. Emerging Business Models

New business models such as subscription-based pricing, pay-as-you-go, and bundled battery-swapping services are on the rise to address consumer affordability and convenience. Firms like SUN Mobility and Ola Electric have implemented battery-swapping and leasing schemes, demonstrating effective business strategies that can accelerate EV adoption (NITI Aayog, 2022).

d. Economic Benefits and Employment Generation

The mass deployment of EV charging facilities has the potential to deliver significant economic gains, including job creation, reduced fuel imports, and improved energy efficiency. Industry estimates indicate that local manufacturing and servicing of EV equipment could create thousands of jobs across sectors, greatly enhancing the local economy and driving skill development (Niti Aayog, 2021).

4.6. Global EV Adoption Success Stories and Lessons for India

a. China

China is the world's largest EV market, and it has reached this position through robust top-down leadership and systematic planning. Aggressive EV sales targets were set by the Chinese government early on, supported by massive subsidies and regulatory policies. For most of the 2010s, Chinese consumers received generous buying incentives, and manufacturers were incentivized by a quota system (the New Energy Vehicle credit program) to make EVs or purchase credits. Equally significant, China heavily invested in local production of EV components, particularly batteries. Through policies such as "Made in China 2025" and large-scale R&D grants, China has taken over much of the EV battery supply chain – it has established dozens of lithium-ion cell gigafactories and procures major materials from domestic or captive mines. Such vertical integration has lowered costs. In terms of infrastructure, China has a very large network of charging stations. A key policy instrument has been the New Energy

Vehicle (NEV) mandate/credit system, which set credit targets for manufacturers and created compliance incentives to produce NEVs or purchase credits, similar in logic to ZEV-style programs (International Council on Clean Transportation, 2018). In parallel, China has invested heavily in charging infrastructure and standardization. By the end of 2022, China accounted for over half of the global stock of public slow chargers and had more than 1 million public slow charging points, reflecting a rapid scale-up in deployment (International Energy Agency, 2023). This large, visible public charging network has helped reduce range anxiety and normalize EV use, particularly in dense urban areas where home charging is limited (International Energy Agency, 2023). The mass availability of chargers (such as high-speed highway chargers and high-density urban networks) has eliminated a range of concerns for Chinese consumers. The policy has also pushed standardization – the government required common standards (such as the GB/T charging protocol) early on to make all EVs and chargers country-wide interoperable. In addition, China has a well-defined plan to phase out traditional gasoline cars over the next few decades, which indicates a long-term commitment.

Inference: The best practices India can learn from China are supply chain localization (encouraging local production of components and batteries) and extensive infrastructure investment before demand. An example from China is that a blend of consumer incentives, industrial support, and infrastructure development – sustained over many years – can establish a successful EV ecosystem. India, with analogous goals, can benefit from China's coordinated effort and robust government stimulus to overcome initial costs and infrastructure hurdles.

b. Norway

Norway is a frontrunner in EV adoption, often referred to as the globe's most electrified car market. Approximately 79.3% of new passenger vehicles sold in Norway in 2022 were fully electric (Norwegian EV Association, 2023). It was accomplished by a combination of strong incentives and friendly infrastructure. The government in Norway made the EVs economically viable by exempting them from most taxes – no VAT and no registration taxes, which are significantly high for regular cars in Norway. Therefore, an electric vehicle can be a few thousand euros less expensive than a similar petrol vehicle in Norway after incentives, the opposite of what is seen in most other countries. Furthermore, EV owners benefit from free or reduced road tolls, bus lane access in several cities, and lower parking charges, among other benefits. These user-specific advantages addressed the cost and convenience aspects squarely. In terms of infrastructure, even though Norway is geographically small, it has built an extensive charging grid, with most major roads featuring fast chargers and every city having at least one. Government grants funded the early deployment of charging points in less commercially attractive areas, providing full country coverage. By eliminating economic and practical barriers, Norway quickly gained mass acceptance – a positive feedback loop whereby large EV volumes now make it worthwhile for private firms to roll out even more chargers (Norwegian EV Association, 2023).

Inference: India can draw a few lessons from Norway, particularly the effect of well-designed fiscal incentives (such as tax holidays) to render EVs economically viable relative to internal combustion vehicles, and the importance of tangible non-monetary advantages (such as priority lane access or parking) to influence consumer behavior. Whereas India's financial position varies and depends on GST and road tolls, even halfway measures such as feebate schemes (charging polluting vehicles to subsidize EVs) can follow Norway's lead in tilting the balance in favor of EVs. Norway also emphasizes the importance of a strong charging infrastructure – customer confidence is supported by the

knowledge that chargers are never far away. Developing such a guarantee in India, particularly on highways and in smaller towns, will be critical as EV volumes increase.

c. United States

The U.S. strategy for promoting EVs has brought together infrastructure spending, consumer incentives, and industrial policy – particularly hastened in recent years. Under the Bipartisan Infrastructure Law, the NEVI Formula Program was launched in February 2022 and provides nearly $5 billion over five years to support state deployment of EV charging along designated corridors (Federal Highway Administration, 2022). In addition, U.S. federal rules for NEVI-funded stations set minimum standards for interoperability and user access (e.g., non-proprietary operation and open payment access), helping ensure a consistent national user experience (Federal Register, 2023; U.S. Department of Energy, 2024). This is driving all states to place fast chargers at intervals on interstate highways, plugging holes in the private charging network. For buyers, the U.S. has long offered federal tax credits for EV purchases (up to $7,500 per vehicle), and numerous states offer their rebates or sales tax exemptions. These incentives lower the effective purchase price of EVs. A significant recent driver has been the Inflation Reduction Act (IRA) of 2022, which features strong provisions to enhance local EV production. The IRA provides large production-linked tax credits to battery and EV manufacturers – for instance, an American battery plant can receive credits worth $35 per kWh of cell capacity produced, amounting to billions in support over a decade. This has already driven over $90 billion in announced investments for new EV and battery factories in the U.S. The IRA also overhauled the EV consumer tax credit to benefit North America-assembled cars with local batteries, thus encouraging manufacturers to develop supply chains in the country. The U.S. also promotes innovation across charging technology (through R&D grants on fast charging, smart grids, etc.).

Inference: The American experience highlights the value of combining demand-side and supply-side incentives. India's PLI schemes align with this approach, similar to the production-linked credits under the U.S. Inflation Reduction Act (IRA), and will require sustained policy support. U.S. research also emphasizes the role of public investment in developing charging infrastructure, particularly in locations where the business case is weak. This approach is relevant for India, where early-stage government investment can de-risk infrastructure deployment and enable greater private participation once EV adoption reaches scale.

In addition, the United States has prioritized standardization of charging infrastructure, with federal funding contingent on requirements such as the use of the Combined Charging System (CCS) and interoperable payment mechanisms. India is moving in a similar direction through its own regulatory framework. Overall, the U.S. experience underscores the importance of combining demand- and supply-side incentives, using public funding to de-risk early charging rollout where private returns are uncertain, and enforcing minimum standards for interoperability and payments (Federal Register, 2023; U.S. Department of the Treasury, 2024).

d. European Union

The EU has addressed transport electrification largely through regulation and climate policy. The EU has implemented stringent fleet-wide CO_2 emissions regulations for car manufacturers, effectively compelling them to sell an increasing proportion of EVs each year to avoid hefty fines. This led to a decision to prohibit the sale of new petrol and diesel cars from 2035, with all new cars thereafter having to be zero-emission. This strict deadline for the sale of combustion engines sends a powerful

market message to industry and consumers about the inevitability of EV dominance. European nations also use a combination of incentives (most, such as Germany, France, and the UK, have offered purchase subsidies or tax relief for EVs), but these are slowly being phased out as EVs move into the mainstream. The EU's policy focus has now shifted towards infrastructure expansion and the sustainability of the EV value chain. Under the EU Green Deal and related initiatives, member states are required to install charging points at frequent intervals along highways (as set out in the Alternative Fuels Infrastructure Directive/Regulation). For instance, the EU requires a fast charger every 60 km on the fundamental trans-European transport network. The EU has advanced electrification through binding regulation and infrastructure obligations. The Alternative Fuels Infrastructure Regulation (AFIR) (Regulation (EU) 2023/1804) sets mandatory deployment targets across member states and requires high-power charging availability on core TEN-T corridors (European Union, 2023; European Commission, 2023). Starting in 2025, AFIR requires fast-charging stations (≥150 kW) every 60 km along the core TEN-T road network for passenger cars, thereby strengthening corridor coverage and cross-border interoperability (European Union, 2023). The EU is also leading the way in battery recycling and sustainability law – forthcoming EU battery legislation will enforce a minimum recycled content in EV batteries, along with sourcing raw materials responsibly, to make the entire life cycle of EVs green (European Commission, 2023).

Inference: Recommended practices for India from the EU center on combining regulatory "sticks" with incentives ("carrots"). India could introduce phased-in fuel-economy or zero-emission vehicle (ZEV) standards for manufacturers, ensuring a steady pipeline of EV models, similar to the EU's CO_2 emission regulations. The EU's emphasis on grid integration of renewable energy and green charging—where an increasing share of public charging is powered by renewables—is also relevant for India's decarbonization objectives.

Finally, Europe illustrates the importance of policy consistency and long-term signaling. The announcement of a 2035 phase-out of internal combustion engine vehicles has helped align expectations across stakeholders on a shared transition timeline. India's existing targets (e.g., 30% electrification by 2030) are a strong starting point, but making select targets more binding or extending a clear post-2030 roadmap could further accelerate progress. Overall, the EU experience highlights the value of binding infrastructure obligations and long-horizon policy signals to coordinate investment across OEMs, utilities, and charging operators (European Union, 2023).

In general, international experiences identify a handful of shared concerns: deep incentives for demand (financial or otherwise) in the early market period (such as Norway, China), high public investment in charging facilities (China, US, EU) to supplement private action, domestic industry support to minimize costs (China, US), and definitive long-term signals or requirements (EU rules, China's and California's plans to phase out ICE vehicles) to keep the EV transition going. India, in its policy-making, can apply these concepts to its environment – for example, giving two- and three-wheelers preference for incentives (an area somewhat distinct to India's modal mix, but similar to the way China promoted two-wheeler electrification in previous years), making the electricity powering EVs cleaner at the same time (learning from the criticism that an EV is as clean as its fuel source), and promoting public-private partnerships for infrastructure as observed in several countries. By learning from what has succeeded elsewhere – and what not to do – India can ramp up its EV and charging infrastructure rollout cost-effectively and equitably.

4.7. Technology and Standardization Laws for EV Charging in India

a. Technical Standards for Charging Infrastructure

India has outlined detailed guidelines for Electric Vehicle Charging Infrastructure (EVCI), released by the Ministry of Power in 2022. These guidelines specify the technical standards for EV chargers, including charger types, power ratings, communication protocols, safety, and interoperability standards. Standards require the obligatory use of CCS (Combined Charging System) for DC fast charging and Type 2 connectors for slow and medium-speed AC charging. Moreover, India's Bureau of Indian Standards (BIS) requires adherence to stringent safety and operational requirements to ensure consumer safety and equipment compatibility. Standardized payment procedures and interoperability are promoted to enhance user convenience, aligning with international norms to minimize complexity and facilitate adoption (Ministry of Power, 2022).

b. Battery Standardization and Management

Battery standardization and technology are fundamental to the rapid growth of India's EV ecosystem. The 2022 draft Battery Swapping Policy presented by NITI Aayog focuses on developing standardized battery sizes, connector types, and interoperability across manufacturers. It promotes Battery-as-a-Service (BaaS) schemes, allowing users to exchange batteries promptly and efficiently, minimizing vehicle downtime by quite a margin. This is most advantageous for fleet and commercial vehicles, which are subject to greater utilization. Standardizing battery types and encouraging interoperability are likely to lower overall battery costs through economies of scale, simplify battery recycling, and make maintenance simpler (NITI Aayog, 2022).

c. Encouraging Next-Gen Battery Management Systems (BMS)

The development of Battery Management Systems (BMS) is important to maximize battery performance and lifespan. Enhanced BMS technologies offer real-time monitoring of battery health, capacity, charge cycles, and operational parameters, enhancing battery efficiency, safety, and lifecycle. Advanced battery management systems also enable predictive maintenance and optimized charging strategies, significantly extending battery life and lowering overall EV cost of ownership. The Indian EV policy has recognized these advantages, promoting investments in advanced battery technologies and their standardization. New standards are also being incorporated to improve the environment and recyclability of EV batteries (Frost & Sullivan, 2024; Das, 2024b).

d. Legal and Regulatory Framework for EV Standards

India's regulatory framework for EVs and charging infrastructure has developed rapidly in line with global best practices. Centralized standard-setting organizations such as the Bureau of Indian Standards (BIS) and the Automotive Research Association of India (ARAI) are responsible for establishing and implementing these standards. The government has also made it compulsory for EV makers and infrastructure providers to adhere to these standards, hugely improving consistency and reliability. Such standardization actions are essential to ensuring interoperability across the EV system, building consumer trust, and enabling faster infrastructure deployment (NITI Aayog, 2023).

e. Encouraging Renewable Integration and Smart Grids

For sustainability, the government encourages integrating renewable energy into the EV charging system. The Green Energy Open Access Rules, 2022, allow EV charging stations to use renewable energy through open access, thereby minimizing EV operations' carbon footprint. Also promoted are smart charging systems and Vehicle-to-Grid (V2G) technologies that enable EVs to store renewable energy and return surplus power to the grid during periods of high demand. These solutions not only have environmental benefits but also economic benefits, enhancing the resilience of the grid and providing EV owners with economic incentives (NITI Aayog, 2022).

f. Existing and Evolving Global Technology Standards

China, the USA, and the EU, where EV adoption is mature, have established technology standards and regulations that India can learn from. China's GB/T standard, Europe's CCS (Combined Charging System), and CHAdeMO (used mostly in Japan) are good examples of standardized charging approaches that have minimized customer inconvenience and facilitated faster adoption (Saraswathi & Ramachandran, 2024). India's standards today are well in line with CCS and CHAdeMO for DC fast charging and Type 2 AC chargers, keeping the nation ahead in global compatibility and export potential in the EV sector (Niti Aayog, 2021).

4.8. Insights From Stakeholders

The primary research involved identifying stakeholders who can accelerate EV adoption in India, including representatives from policy, business, and technology domains. While some inputs were highly targeted, others were more general and included broader suggestions that could support India’s goal of achieving carbon neutrality by 2070.

Table 6: Respondent's Profile

Code	Role	Organization Type	Region
P1.4	Senior Official	Ministry of Power	National
P1.5	Senior Officer (Technical Cadre)	Ministry of Power	National
P1.6	Product Manager	Electric Ride-Hailing & Fleet Electrification Platform	Multi-city
P1.7	General Manager	Major Indian Automotive OEM	National
P1.8	Former Mobility Sector Professional (R&D)	Automotive Manufacturing Sector	National
P1.2	Founder	Electric Bicycle & Micro-Mobility Enterprise	Multi-city

4.8.1. Expert Interviews:

a. Senior Official – Ministry of Power (P1.4):

Q.1 Who are the concerned parties involved in the EV charging ecosystem, and what clearances are required from them, if any?

- The Ministry of Power has appointed the Bureau of Energy Efficiency (BEE) as the nodal agency responsible for overseeing EV charging infrastructure development at the national level and addressing stakeholder concerns falling under its jurisdiction.

- Since electricity is a state subject under the Indian constitutional framework, approvals relating to land allotment and certain local clearances fall within the authority of respective state governments and local bodies. Accordingly, the central ministry does not directly grant permissions for land allocation for charging stations.
- OEMs or private charging service providers are generally required to coordinate with:
    - The Bureau of Energy Efficiency (national-level guidance and standards), and
    - The relevant state Electricity Distribution Companies (DISCOMs), which function as nodal agencies at the state level for electricity-related approvals and grid connectivity.
- For installations along national highways, clearances must be obtained from the Ministry of Road Transport and Highways (MoRTH).
- For installations on defense land, approvals are required from the Military Engineering Services (MES).
- A single-window clearance mechanism is currently under consideration to streamline the approval process across agencies. However, implementation timelines remain uncertain.

Q.2 Will the increase in charging stations place an additional burden on the grid and renewable energy systems? Is the existing infrastructure sufficient?

- India's electricity generation capacity is growing at approximately 5% CAGR and is currently adequate to meet overall demand, including emerging requirements from EV charging infrastructure. Given the current pace of charging-station deployment, achieving 30% EV penetration by 2030 appears attainable. At present, most charging demand is met through the grid, which remains the dominant and fastest-growing supply mode. However, the relatively low efficiency of renewable energy sources, such as solar (around 25% of installed capacity), limits generation potential, indicating that further progress in electricity decarbonization remains a focus.
- The electricity supply infrastructure may require targeted upgrades, including the expansion of transmission and distribution networks, particularly as charging stations extend into non-residential areas such as national and state highways. These requirements are considered addressable within ongoing infrastructure development efforts.
- Lastly, the carbon emission per unit travel in an EV that is charged using thermal power is presently more than the emissions of ICE vehicles. This can be addressed by increasing the share of renewable energy in the power mix or by managing emissions at thermal power plants, where interventions can be implemented more centrally.

Q.3 Is the concern of standardization being addressed by the government?

- The process of standardization falls under the ambit of the Bureau of Indian Standards (BIS). In the EV charging segment, standards for fast and slow charging have been established under Indian Standard IS: 17017, which support interoperability and facilitate broader adoption of EVs in India.

Q.4 How is the land allotment done for EV charging stations?

- Land allocation falls under the purview of the respective state, and it is normally done through a reverse bidding process where a pool of land is allocated to establish charging infrastructure. States may appoint nodal agencies for this purpose.

b. Senior Official – Ministry of Power (P1.5):

Q1. What are the biggest challenges on the policy side of things when EV charging is considered?

- The respondent noted that while demand-side schemes such as FAME have been introduced to support EV adoption, the process of fund allocation and disbursement involves multiple stakeholders, which can extend timelines before benefits reach end users.
- The respondent also highlighted the need for greater clarity on certain areas, such as the policy direction for private charging stations. Relevant information is distributed across multiple institutional levels, including municipal, state, and central authorities, as well as nodal agencies, requiring stakeholders to engage with several sources. This can pose a challenge, particularly for private players and startups entering the charging ecosystem, given the wide range of compliance requirements.
- Additionally, coordination between central and state authorities presents a challenge, as states issue differing sets of guidelines, some aligned with central policies and others not. This can become more complex where immediate priorities at the central and state levels differ.

c. Product Manager-Electric Ride-Hailing Company (P1.6)

Q.1 How is the location identified for setting up a charging station?

- The location of the charging station is dependent on a lot of factors:
  - If the charging station is to be established for its own fleet or for third parties as well.
  - The type of charging station that must be set up, i.e., fast charging station, slow charging station, or both.
  - If it is in a city, whether it has to be installed in a public/semi-public location or on a highway, it depends on the traffic density or peak hour traffic.

Q.2 What kind of compliance does a company looking to establish a charging station need to follow? Is there any suggestion that you may want to give to reduce the burden of compliance?

- The charger compliances are broadly divided into 3 categories, which are: operational compliances, which ensure the functionality of the setup; technical compliances, which set out the specifications of the station; connectivity of the charging station from server to charger, and other essentials; and testing compliance, which is done by checking the charging station on actual vehicles.
- Certain roles are also divided among various teams to make sure that they complete their respective requirements to complete the compliance checklist. Such as the infrastructure setup team that sets up and maintains the infrastructure as per the guidelines, particularly from the point of view of safety; and the charger functionality team that ensures charger heartbeat, i.e., this team ensures that the station remains functional by maintaining constant connectivity with it. (Charger heartbeat is a new concept & is currently in Delhi, Mumbai, and Bangalore for now)
- With respect to the reduction of compliance, the expert concerned believes that such compliance, stringent and complex as it may be, is essential as it is created with the idea of keeping safety standards in mind, and it need not be changed.

Q.3 How do we increase the charging station penetration in India, as it remains a concern for EV buyers?

- Multiple measures can be considered, including providing incentives to firms establishing or entering the charging infrastructure segment. These may include tax benefits, public–private partnerships, incentives on electricity pricing, and additional support for the use of renewable energy.

4.8.2. Customer Insights:

A few EV users were asked about the problems they encounter when trying to find a charging station during their journeys, especially on long routes. Here are a few concerns mentioned by them:

- Customers have raised concerns regarding charging stations being listed as functional despite being non-operational. This exacerbates the issue, as users may detour to such stations only to find them unusable. In such cases, the problem is compounded—not only is charging unavailable, but users may also be stranded off-route and forced to seek external assistance.

- Resolution of problems even after raising an immediate complaint takes months to get resolved despite multiple requests; this leads to inefficient charging stations on the ground even though we seem to be increasing the total charging capacity on paper, moreover, the credibility is also lost in the eyes of the user as they cannot rely on the information they get on applications that provide them with information on charging stations

- Charging stations face network problems when users attempt to connect to the network of the station to initiate the charging process and make payment.

- Support Staff at charging stations are either not available or are not well-equipped to handle customer queries and resolve technical difficulties.

Based on these difficulties, the next interviews were conducted keeping in mind the idea of finding a solution to such problems

d. General Manager – Major Automotive OEM (P1.7)

Q. What can be done, particularly from the range anxiety and resale value perspective, as battery charging and battery life are key components in the EV segment

- Support from the policy/government side
    - The major push received by the company occurred when the government placed a large procurement order (approximately 10,000 electric vehicles) in 2020. This demand anchor helped de-risk manufacturing decisions, encouraged the conversion of existing ICE platforms into electric variants, and signaled institutional confidence in the EV segment, thereby accelerating industry-wide momentum toward electrification.
    - Provision of land to OEMs for setting up special individual cell manufacturing units for batteries; this would act as an enabler for companies to focus on in-house production of batteries and reduce import dependence
    - Public support for R&D, particularly in areas such as battery cells and semiconductors. This includes developing frameworks that incorporate ground-level challenges and

address fundamental issues across the value chain, including supply chain constraints, charging infrastructure deployment, and scaling across OEMs.
    - Policy measures that facilitate collaboration between OEMs and startups in the charging ecosystem were also noted. Such approaches may support knowledge transfer and accelerate the deployment of charging infrastructure.
    - The introduction of structured frameworks, similar in intent to CSR mandates, was discussed to encourage OEMs to integrate EV-related objectives into their business targets.
    - Amendments to battery export-related regulations as a potential lever to support domestic production scale and influence cost structures.
- Steps that OEMs can take:
    - Attempt to reduce the weight of vehicles by using lighter metals, which would reduce the burden on the motor and would increase the range of the vehicle
    - Greater focus on in-house battery and cell optimization may support performance improvements and reduce external dependencies.
    - Retrofitting battery systems in existing vehicle models as a potential approach to manage costs.
    - Presently, warranty is given on batteries that are exposed to a maximum of 1 fast charging per month; this becomes a bottleneck in EV adoption. Adjustments to warranty terms or improved access to fast charging infrastructure are potential approaches in this context.
    - In the interim, where remote monitoring of charging infrastructure is still evolving, on-site operational support at charging stations may help address technical issues and improve uptime.

e. Former Automotive R&D Professional (P1.8)

Q. What major concerns do you believe exist in EV adoption, particularly from the battery and charging infrastructure standpoint?

- The Respondent highlighted the role of policy incentives to promote R&D in battery technology to reduce the dependency on Li-ion and move to options such as silicon carbide, graphene, or solid-state technologies, which will support domestic capability development.
- Serviceability of charging stations is a major concern. Charging stations may encounter operational issues post-deployment, and timely maintenance is important to minimize downtime and support user confidence in reliability.
- The respondent also noted the role of hybrid vehicles as a transitional pathway. Hybrid systems, which combine conventional fuels with electric propulsion, can offer improved fuel efficiency. Given that EV infrastructure, particularly for four-wheelers, continues to develop, policy support for hybrid adoption was discussed as a potential complementary approach in the broader transition toward lower-emission mobility.

f. Founder – Electric Bicycle and Micro-Mobility Enterprise (P1.2)

- It is evident that standardization plays a crucial role in pushing adoption; however, it can act as a disincentive to innovation. To ensure that innovation does not take a back seat while users

can still benefit from standardization, one potential solution is to introduce a battery-to-battery charging solution.

- This means that OEMs that wish to improve their battery optimization through innovation can do so by reinventing their batteries, which can be placed in half of the area where the battery is mounted in the vehicle. The other half can be used to accommodate standard batteries that fit all EVs, regardless of vehicle type or manufacturer.
- This can help in addressing the difficult problem of battery swapping. OEMs can sustain their innovation and continue to gain a competitive advantage while also benefiting from standardization.
- The removable regular batteries can act as a supplementary power source that charges the primary batteries, which power the EV. In this way, the problems of battery charging, ensuring quality, and the loss of innovation can be addressed.

4.9. Conclusion & Final Recommendation

Based on primary research and stakeholder inputs, the following measures emerge as potential approaches for the government and OEMs to accelerate EV adoption in India.

1. **Complexity in Regulatory Approvals:** This seems to be a prominent bottleneck for existing companies as well as for companies wishing to enter the EV charging space. The faster implementation of the Single-Window clearance system can improve the regulatory process by streamlining it and reducing administrative delays. Apart from this, state-level and center-level policies need to be more closely aligned to achieve uniformity across the country. This will make it easier for companies to establish stations as they will not have to go through multiple stages of compliance. This would encourage private sector investment.

2. **Serviceability of Charging Infrastructure:** There has been an increase in the rate of setting up charging infrastructure, but it is evident after inquiries from various stakeholders that these units are lacking timely service and maintenance. There is a need to implement real-time monitoring systems to track the functionality of the systems. Charging stations, especially heavily used ones, need to be manned until remote monitoring becomes reliable and trustworthy. If essential, prolonged outages may also be penalized; this will act as a nudge to keep the stations up and running.

3. **Ensuring Power Grid Capabilities:** The charging infrastructure would require a grid network that must be capable of handling the peak time energy requirements of freshly set up charging stations and also additional capabilities will have to be built keeping in mind the possibility of new charging stations coming up, this must at least be done in coherence with the target of 30% EVs by 2030. Merely producing more electricity will not solve the problem.

4. **Focus on Renewable Energy:** The burden of the increase in power demand is put mainly on conventional sources of energy, which are predominantly thermal. To achieve the carbon-neutrality target by 2070, greater focus is needed on renewable energy sources. One way to do it is to mandate that the charging station area, including any other businesses the station operators intend to open, install rooftop solar panels. Even if they generate only limited electricity, they will

still make a contribution and reduce the grid burden. The government can also implement an incentive policy in this regard, such as a tax-free setup for panels or a related subsidy.

5. **Support to Newcomers:** The government may provide certain benefits to OEMs that are willing to handhold startups that are interested in joining the EV charging space. This will attract more players and increase competition, ultimately benefiting end users by promoting innovation. It will also mean reduced burden on existing players to set up and maintain new and existing infrastructure

6. **Battery technology & innovation:** India is heavily dependent on imports for battery supply. If R&D in lithium-ion battery technology is strengthened, alongside research into next-generation alternatives such as graphene-based and solid-state batteries, import dependence can be reduced. This would enable domestic production to meet internal demand, lower overall battery system costs—which could translate into reduced end-user prices—and potentially position India as an exporter in advanced battery technologies over time.

7. **Battery Warranty:** Range anxiety remains one of the major concerns of EV users. That, coupled with a limit of only one fast-charging option per month to retain the battery warranty, further aggravates the trouble for the end user. This warranty issue needs to be addressed by either finding an alternate charging method for the battery, allowing multiple fast charges, or offering the option to swap the battery. Alternatively, OEMs can lease batteries; i.e., any EV buyer can use Battery-as-a-Service after buying an EV. This would remove the concern of battery warranty altogether. This should be a business-side initiative.

8. **Public-Private Partnerships:** It was observed that when the government placed a bulk order for EVs, it nudged the OEM to establish a separate team to work on the EV project, train them, set up the manufacturing line, and develop proficiency. This shows that government and business working in tandem can give a significant boost to EV adoption. For example, providing land, regulatory support, and financial incentives may help bridge the gaps OEMs may feel in the current market. They can also make EV-related developments part of their business targets, thereby encouraging them to bridge the supply-side gap.

9. **Maintaining Standardization with Innovation:** Standardization promotes mass adoption but can constrain innovation. To balance these objectives, one possible approach is to conceptually separate the energy storage system into two components. The primary battery pack would use OEM-specific technology to power the vehicle, while a secondary, standardized, and swappable battery module could serve as an auxiliary or range-extending unit, externally chargeable and used to recharge the main pack. This process will allow OEMs to continue innovating, helping them maintain their competitive advantage while remaining compatible with a standardized battery-swapping mechanism. Moreover, removable batteries can serve as an additional power reserve that can be charged without being detached from the vehicle. If this solution is implemented, we will be able to address concerns about battery swapping across different battery setups, charging availability, battery efficiency, and long-term sustainability in the EV ecosystem.

10. **Execution of plans:** Many frameworks fail to address the concerns that the frontline workforce experiences. To address this, frameworks, especially those pertaining to the policy side, should be

derived from the bottom up, with policymakers starting from grassroots-level problems and working their way backward to the top. This will maximize the purpose for which the framework was developed. The targets should remain top-down, but the solution should be bottom-up

11. **Integrating EV targets in Business:** OEMs can be given targets related to R&D, production, staff training, etc., where they will have to show performance figures relating to EVs. This would nudge them to make a minimum investment, such as in CSR activities. This will be a step towards the 30% EV penetration target by 2030 and the eventual phasing out of ICE vehicles.

12. **EV Battery Recycling Norms:** The EU's battery recycling norm mandates a minimum percentage of battery components to be recycled. India can establish a similar mandatory battery-recycling framework to encourage closed-loop battery supply chains, in which materials from old EV batteries are extracted and reused. This can help OEMs reduce costs and enhance sustainability.

5. Indian EV Battery Cell Manufacturing

5.1. Introduction

India has committed to achieving carbon neutrality by 2070 (Press Information Bureau, 2023). With renewable energy forming a central pillar of this transition, demand for energy storage systems has also increased (Press Information Bureau, 2024). In this context, the adoption of electric vehicles in India becomes imperative, given their role in integrating renewable energy and supporting decarbonization of the transport sector (Press Information Bureau, 2024; International Council on Clean Transportation, 2023).

Although an elegant solution to IC engine-powered vehicles, Electric Vehicles come with their own challenges. The lithium-ion battery contributes roughly 30-40% of the total cost of an electric vehicle, making it costlier than a comparable IC engine model of a vehicle on average (Cepnik & Linder, 2026). According to a consumer survey conducted in the United States, vehicle price emerged as one of the key considerations in new car purchases, with 43% of respondents identifying it as a holdback factor (Consumer Reports, 2020).

The Government of India has, over the years, introduced multiple missions, schemes, and subsidies to develop the EV battery industry in India (Press Information Bureau, 2023; 2024; 2025a).

5.2. Roadblocks

The challenges faced by the EV industry can be broadly categorized into two areas: one related to the energy density of Li-ion batteries, which directly affects vehicle range, and the other related to battery costs (Das, 2024a). Both challenges can be addressed, directly or indirectly, by developing a local Li-ion battery industry. A domestic battery industry will drive R&D investments to advance next-gen batteries with higher energy density, faster charging, and greater durability (Sivaram et al., 2024). Additionally, costs are expected to decline further due to a localized supply chain (KPMG, 2025).

The Li-ion battery value chain begins with the extraction of key minerals such as lithium, nickel, cobalt, and manganese. These raw materials are then processed to remove unwanted materials and refined to a purity level suitable for battery applications, producing battery-grade inputs. Manufacturers then use these materials to produce anode and cathode electrodes, which are assembled into battery cells that store energy. These battery cells are further combined into battery modules and packs that are ultimately integrated into electric vehicles (Carreon, 2023).

It is imperative to understand the challenges at each stage to comprehensively identify bottlenecks and develop strategies to improve efficiency, sustainability, and cost-effectiveness. Although other minerals are also important, this research primarily focuses on lithium, as it is the most critical element in lithium-ion batteries. Subsequent sections will highlight the challenges at various stages of Li-ion battery manufacturing.

5.2.1. Mining

Mining is the process of extracting minerals from natural deposits. Lithium used for battery production is generally extracted from hard rock minerals and brines (Saltworks Technologies, n.d.). Of the discovered lithium reserves, more than 80% are concentrated in four countries: Chile, Australia, Argentina, and China (U.S. Geological Survey, 2024).

In February 2023, the Geological Survey of India discovered 5.9 million tons of lithium in Jammu and Kashmir (Reuters, 2023a). However, the discovery received a lukewarm response from investors and mining agencies. The Indian government attempted to auction mining rights for the site again in 2024, but the auction was scrapped due to limited interest from mining agencies (Reuters, 2024a). The following challenges can be attributed to the mining stage of Lithium production in India:

1. Despite possessing mineral-bearing resources for several critical minerals, India has yet to confirm proven reserves that can be mined economically and sustainably. Limited domestic processing capacity for battery-grade materials further constrains self-sufficiency and leaves the country reliant on imports for several key inputs (KPMG, 2025).

2. India uses UNFC (United Nations Framework Classification) mineral reporting standards, which are less informative in terms of assessing the economic viability of reserves compared to CRIRSCO (Committee for Mineral Reserves International Reporting Standards). Hence, investors are skeptical about the feasibility and profitability of lithium mining projects (Walia, 2024).

5.2.2. Refining

Refining is the process of purifying naturally extracted lithium compounds to produce high-purity, battery-grade lithium compounds such as lithium hydroxide and lithium carbonate (Saltworks Technologies, n.d.). It is a complex, capital- and energy-intensive process that requires advanced processing technologies, specialized equipment, and strict environmental controls (Saltworks Technologies, n.d.). As of 2022, China held 8% of global lithium reserves and 72% of global refining capacity (Sharma, 2024). India is largely dependent on China to procure battery-grade lithium. A few of the key challenges in developing the lithium refining industry in India are listed below:

1. Limited domestic lithium reserves: With raw material uncertainty, lithium refining companies in India would face a significant challenge in securing a stable and cost-effective lithium supply (Jhunjhunwala, 2023).

2. High capital and operational costs: The upfront cost of setting up lithium refining infrastructure is significantly high. Additionally, since the lithium cell manufacturing industry is still in its nascent stage in India, demand is uncertain. Making such a large investment in an uncertain environment poses a significant risk.

3. Skill and technology gap: Lithium refining requires significant technological advancements and skill development. India currently lacks in-house expertise and largely depends on foreign nations for technology and specialized knowledge (Sarkar, 2026)

4. Competition from China: China has established a world dominance in lithium refining, making it hard for new entrants to compete on cost and efficiency (Sharma, 2024; Wald, 2024).

5.2.3. Battery Cell Manufacturing

The battery cell is the fundamental unit of a battery module or pack. Refined lithium, along with other minerals and components such as cobalt and nickel, is assembled to create a battery cell (McKinsey & Company, 2022; Metoree, 2026). Like lithium refining, cell manufacturing is also dominated by Chinese companies. In 2023, India's Lithium-ion cells and battery imports totaled around USD 3.06 billion (Goel et al., 2024). Indian manufacturers have begun investing in cell manufacturing, but they face multiple challenges. A few of the key challenges are listed below:

1. Import dependency for raw material: Since India does not have domestic lithium refining capacity, it remains dependent on countries such as China for the import of battery-grade lithium (Balazs & Hu, 2025).

2. High initial investment: To truly reap the benefits of low-cost production, cell manufacturing must be done at a large scale, requiring substantial initial investments (McKinsey & Company, 2022).

3. Limited technology transfer by the global giants: Most of the dominant battery manufacturers are based in China. The geopolitical situation between India and China limits technology exchange and Foreign Direct Investments (FDIs) (Wald, 2024).

4. Skill and technology gap: Lithium cell manufacturing is at a nascent stage in India, with limited foreign investments and a lack of indigenous expertise. Additionally, the shortage of domestic R&D centers for lithium-ion batteries further hinders innovation and increases reliance on foreign suppliers for critical technology and equipment (Sivaram et al., 2024).

5. Demand uncertainty: The demand for electric vehicles in India, especially in four-wheelers and commercial vehicle segments, remains uncertain due to several factors (International Council on Clean Transportation, 2023; McKinsey & Company, 2022). With such demand uncertainty, investment in a large-scale battery cell manufacturing plant is a risky proposition.

5.2.4. Battery Pack Manufacturing

Battery pack or module manufacturing involves assembling battery cells into modules to create a battery pack, which then can be installed in vehicles (Metoree, 2026). This part of the value chain is fairly developed in India. Many battery manufacturers, such as Amara Raja, Exide Industries, and Tata AutoComp, are active in this space and serve as the key suppliers to meet the existing demand of Li-ion batteries in India (Jhunjhunwala, 2023). However, battery cells, the fundamental units of a battery pack, are mostly imported from countries such as China, South Korea, and Japan (Wald, 2024; Sharma, 2024).

Summarizing the roadblocks in India's battery supply chain, the major hurdles lie in the mining, refining, and cell manufacturing stages (Jhunjhunwala, 2023; McKinsey & Company, 2022). The battery supply chain has been gradually developing, starting with end-use applications and extending to battery manufacturing (Jhunjhunwala, 2023). It is expected to grow further upstream as the demand for battery cells and packs increases (McKinsey & Company, 2022). However, the transition is slow at the moment due to the multiple challenges discussed in the above sections. Stimulus from the government, in the form of favorable policies and incentives, is required to catalyze the development of the battery value chain in India (Press Information Bureau, 2023; 2024; 2025a; 2025b).

5.3. Indian Policy Landscape

Over the years, the Indian government has introduced multiple policies and incentives to boost the adoption of electric vehicles in India. Some policies are directly targeted at the battery supply chain, while others indirectly support it by creating sustainable demand (Press Information Bureau, 2023; 2024; 2025a; 2025b). A few of the major policies and incentives are discussed in this section.

5.3.1. Production Linked Incentive (PLI) Scheme for Advanced Chemistry Cell (ACC) Battery Storage

The PLI-ACC scheme was launched in 2021 with an outlay of INR 18,100 crore to strengthen the battery cell manufacturing supply chain in India. It is a financial incentive scheme based on milestones related to battery performance, localization levels, and production volume. Under the scheme, the government targets to establish a production capacity of 50 GWh of ACC batteries. The incentives will assist the cell manufacturers in reducing the burden of the high initial investment required to set up cell manufacturing (Ministry of Heavy Industries, 2021a).

Under the program, bidders had to commit an investment of at least INR 225 crore per GWh to set up a battery cell manufacturing plant having a capacity of at least 5 GWh. The manufacturing facility must be set up within 2 years. Additionally, the beneficiary needs to commit to domestic value addition of at least 25% within 2 years and 60% within 5 years of the appointed date. The incentive is disbursed over 5 years after a 2-year gestation period (Ministry of Heavy Industries, 2021a).

As of February 2025, the government has agreements with three major battery cell manufacturers: Ola Electric Mobility (20 GWh), Reliance New Energy Solar (15 GWh), and Rajesh Exports (5 GWh). However, all three companies are behind schedule in achieving the first milestone of setting up

manufacturing units with the committed capacity. The delay is estimated to be due to supply chain issues (Agarwal, 2025).

5.3.2. Custom Exemption for Battery Materials

In the Union Budget 2025-26, the Indian government proposed exempting basic customs duties on critical materials required for Li-ion battery cell manufacturing in India. The machinery required for manufacturing is also covered under this exemption. Additionally, the customs relief applies to lithium-ion battery scrap, lead, zinc, cobalt powder, and 12 more critical minerals (The Economic Times, 2025; Chowdhury, 2025).

5.3.3. Relaxed FDI (Foreign Direct Investment) Norms

To make India a favorable destination for foreign investment, the government has eased FDI regulations, allowing up to 100% FDI in ACC battery manufacturing (Jhunjhunwala, 2023). In addition to investment, foreign companies bring much-needed technology and technical expertise to India, which are crucial for the growth of the Indian battery industry. Their presence can accelerate the localization of battery production.

5.3.4. Establishing control over lithium mining and refining

In 2024, the Ministry of Mines in India invested INR 200 crore in a lithium exploration project in Argentina. This project has been undertaken by a joint venture, Khanij Bidesh India Ltd. (KABIL), involving NALCO, MECL, and HCL (Press Information Bureau, 2024). In a similar exploration deal, India has announced a partnership with KABIL and CMO, Australia, for five target projects, two lithium and three cobalt (Press Information Bureau, 2023). All these projects aim to establish control over the supply of lithium and other critical materials (Jhunjhunwala, 2023).

In addition to foreign exploration, India is also expediting domestic mineral exploration. In January 2025, the Indian government approved the launch of the National Critical Mineral Mission (NCMM) with an expenditure of INR 16,300 crore and expected investment of INR 18,000 crore by PSUs. This mission aims to establish control over various stages of the critical minerals value chain, including exploration, mining, and processing (Press Information Bureau, 2025a). It is expected to support India's lithium battery industry by securing critical mineral supplies and enabling domestic refining.

5.3.5. Demand Side Incentives

Over the years, the Indian government has introduced various demand-side incentives to promote the sale of electric vehicles. Among these, FAME, which ended on 31 March 2024, was the most effective. Under FAME, the government offered subsidies on the final price of EVs to make them competitive with ICE vehicles. The scheme significantly accelerated the adoption of EVs, especially two- and three-wheelers (Ministry of Heavy Industries, 2019). Additionally, state governments also provided demand-side subsidies and road tax concessions to reduce the financial burden on EV customers. These incentives have helped create demand for electric vehicles and, consequently, EV batteries, which are crucial for sustaining the EV battery manufacturing industry.

Continuing in the same direction, the Indian government has launched a scheme titled 'PM Electric Drive Revolution in Innovative Vehicle Enhancement (PM E-DRIVE), which will be in effect from 01 October 2024. Under this scheme, EV customers will receive e-vouchers to avail the demand-side incentive. Total outlay of the scheme is INR 10,900 crore (Press Information Bureau, 2025b).

5.4. Global Benchmarking

Globally, several countries are pursuing the electrification of their vehicle fleets. Over the years, their respective governments have been introducing policies and incentives to stimulate the adoption of electric vehicles. These initiatives are discussed in the following sections.

5.4.1. Japan

Of the total globally installed lithium-ion battery cell manufacturing capacity, Japan had approximately 80 GWh by 2023, making it one of the key contenders in the EV race (Reuters, 2024). The Japanese government played a crucial role in this endeavor. It is strategically negotiating Foreign Trade Agreements (FTAs) and making investments to achieve its net-zero carbon-emission target. Some of these initiatives are discussed below.

1. Since the early 2010s, Japan has actively pursued overseas investments and partnerships to secure critical minerals required for lithium-ion battery manufacturing, particularly lithium, nickel, and cobalt. Through the Japan Oil, Gas and Metals National Corporation (JOGMEC), the country has supported projects in resource-rich regions such as Australia, Argentina, and Canada in collaboration with Japanese trading houses, including Toyota Tsusho, Mitsubishi, and Sumitomo. A notable example is the Olaroz lithium exploration project in Argentina, where Toyota Tsusho partnered with Australian mining company Orocobre with financial and strategic support from JOGMEC to secure long-term lithium supplies for Japan's battery industry. This reflects Japan's broader strategy of diversifying and strengthening mineral supply chains to support electric mobility and advanced battery production (JOGMEC, 2010; Toyota Tsuho Corporation, 2018).

2. Japan has treated critical minerals as an economic security issue since 2019, when it created an economic security section within its National Security Secretariat and later enacted the Economic Security Promotion Act in 2020. It has identified 35 minerals as critical and pursued a de-risking strategy to avoid strategic dependence on any single country (Sharma, 2026).

3. Japan's mineral security is managed through a dedicated institutional setup led by JOGMEC, which oversees policy implementation, supply diversification, overseas investment support, innovation in exploration and recycling, and stockpiling. Its mandate is supported by JBIC and JETRO, and until FY20, JOGMEC's budgets for exploration and asset acquisition investments, exploration loans, and debt guarantees were US$420 million, US$40 million, and US$140 million, respectively (Sharma, 2026).

4. Japan has also used targeted overseas investments to strengthen supply-chain resilience. In 2011, JOGMEC and Sojitz invested US$250 million in Lynas in Australia, securing nearly 8,500 tonnes of rare-earth products over ten years. This contributed to reducing Japan's dependence on China for

rare-earth imports from 90 percent to 58 percent, and later to 48.5 percent in 2018 (Sharma, 2026).

5. In 2024, JOGMEC has also partnered with Canada-based stakeholder Adventus Mining to cooperate in seeking out copper (for EV wiring) in southern Ecuador's Tres Picachos region (Hasegawa, 2024).

6. The New Energy and Industrial Technology Development Organization (NEDO), a Japanese government research and development agency operating under the Ministry of Economy, Trade and Industry (METI), announced in April 2022 an allocation of JPY 151 billion (approximately USD 1.2 billion) for the "Development of Next-Generation Storage Batteries and Next-Generation Motors" project under Japan's Green Innovation Fund. The initiative focuses on three key areas: research and development of high-performance storage batteries and materials; development of battery recycling technologies; and technologies to improve the efficiency and power density of mobility-related motor systems (Global Trade Alert, 2022).

7. In September 2024, Japan pledged approximately $2.4 billion for EV battery production, following a $1 billion pledge in subsidies for the same. This funding aims to help expand the country's annual production capacity from 80 GWh to 120 GWh. The government will support 12 projects related to storage batteries, as well as those involving battery components, materials, or production equipment. This backing includes support for investments by Toyota and Nissan Motor, along with joint projects led by Panasonic Holdings' energy unit in collaboration with automakers Subaru and Mazda Motor (Reuters, 2024)

5.4.2. USA

As the second-largest automobile market, the United States also does not want to be left behind in the race for electric vehicles as a renewable, clean energy source. In 2022, the U.S. introduced the Inflation Reduction Act to accelerate the development of EV battery technology and establish a domestic supply chain. In 2023, the U.S. reached 70 GWh of domestic battery cell manufacturing capacity (International Energy Agency, 2024), a significant figure given current EV demand Some of the key measures taken by the U.S. include:

1. In October 2022, the Department of Energy (DoE) announced a $2.8 billion grant to support 20 companies in domestically mining lithium, graphite, and nickel; building the first large-scale U.S. lithium processing facility; constructing facilities for cathode and other battery component production; and expanding battery recycling (Reuters, 2022).

2. The Inflation Reduction Act of 2022 includes supply-side incentives under the 45X tax credit, aimed at reducing the production costs of batteries and their components in the United States. Specifically, this provision allows the federal government to subsidize domestic battery cells at up to $35 per kWh and battery modules at up to $10 per kWh (or $45 for a battery module that does not use battery cells). (International Council on Clean Transportation, 2023; Atlas EV Hub, 2025).

3. The United States has used large-scale industrial incentives to accelerate domestic EV battery manufacturing and reduce dependence on external supply chains. Following the Inflation

Reduction Act (IRA), 17 new EV battery facilities were announced between 2020 and 2024, representing planned capital expenditure of nearly US$52 billion (Walton, 2023).

4. The IRA's Advanced Manufacturing Production Credit alone is estimated to provide incentives worth US$31 billion between 2022 and 2031, further encouraging battery manufacturing expansion. Major automakers including Ford, General Motors, Toyota, Honda, and Tesla have been linked to this first wave of battery capacity investments (Walton, 2023)

5. The U.S. government has also directly supported battery and critical mineral processing projects through the Department of Energy (DOE). In 2022, DOE selected 20 companies to receive a combined US$2.8 billion for battery manufacturing and mineral processing projects, followed by a US$2.5 billion loan to the General Motors–LG Energy joint venture for EV battery plants in Ohio, Tennessee, and Michigan. (Walton, 2023)

6. The U.S. Department of Energy (DOE), through its Loan Programs Office (LPO), has attracted 212 applications across its programs, totaling more than US$324.3 billion in requested loans and loan guarantees as of November 2024. (U.S. Department of Energy, 2024).

7. Under the Advanced Technology Vehicles Manufacturing (ATVM) Loan Program, DOE announced a US$7.54 billion loan to StarPlus Energy LLC, a joint venture between FCA US LLC and Samsung SDI, to finance up to two lithium-ion battery cell and module manufacturing plants in Kokomo, Indiana in 2024. At full capacity, the project is expected to produce about 67 GWh of batteries, enough to supply approximately 670,000 vehicles annually (U.S. Department of Energy, 2024).

5.4.3. Europe

In 2017, the European Battery Alliance (EBA) was launched to accelerate progress toward net-zero carbon emissions (European Commission, 2017). This alliance aims to unite various stakeholders, including industries, scientific communities, and state governments, to develop a robust, innovative, and sustainable battery value chain in Europe. The following are some key initiatives undertaken by the European Union:

1. First Important Projects of Common European Interest (IPCEI): Approved in 2019 by the European Union under the EBA, this initiative includes seven member states—Belgium, Finland, France, Germany, Italy, Poland, and Sweden (European Commission, 2019; IPCEI Batteries, n.d.). The goal is to invest €3.2 billion, with an additional €5 billion in private investments from all seven member states, to support research and innovation in four key areas:
    - Raw and Advanced materials
    - Cells & Modules
    - Battery Systems
    - Repurposing & Recycling

2. Second Important Projects of Common European Interest (IPCEI): Approved in 2021 by the European Union under the EBA, this initiative includes twelve member states—Belgium, Finland,

France, Germany, Italy, Poland, Sweden, Austria, Croatia, Greece, Slovakia, and Spain (European Commission, 2021; IPCEI Batteries). The goal is to invest €2.9 billion, with an additional €9 billion in private investments from these twelve countries. The primary objective remains the same: research and development across the entire battery value chain.

3. Battery 2030+, launched in 2020 under the EU's Horizon Europe program, supports research on next-generation battery technologies for electric mobility and energy storage. Under the BATT4EU Partnership, Horizon Europe has allocated up to €220 million for battery technology projects, of which more than €150 million has already been awarded through projects coordinated by the Battery 2030+ initiative (STREAMS, 2020).

4. Alliance for Batteries Technology, Training and Skills (ALBATTS) Project: With an outlay of about €4 million, this project aimed to identify the necessary competencies for battery manufacturing and the broader electromobility sector, as well as to design a relevant training program (Project Albatts, 2019).

5. DRIVES project: This was another project aimed at understanding and developing a blueprint for skill training across the entire value chain, from battery production to EV manufacturing. It had an outlay of €3.9 million for four years (DRIVES Project, 2019).

6. On March 5, 2025, the European Union announced to keep aside €18 billion to invest in the battery raw materials supply chain (Reuters, 2025a).

5.4.4. South Korea

South Korea is home to three key companies that play a highly significant role in commercializing electric vehicles today and are continuously striving to remain at the forefront of battery technology innovations: LG Energy Solution, Samsung SDI, and SK On. The Korean government is also proactively fueling the momentum created by these industry giants through various tax initiatives and strategic FTAs, ensuring access to the global supply chain. These efforts aim to strengthen not only the domestic market but also the export market. Here are some key initiatives:

1. In 2021, the Ministry of Trade, Industry, and Energy (MTIE) unveiled the K-Battery Blueprint, aimed at strengthening South Korea's leadership in battery technology. Under this roadmap, the country's battery manufacturers will be offered tax incentives, including up to a 50% tax deduction for R&D and a 20% tax deduction on facility investments (Soo & Jeong, 2021; Kang, 2021).

2. In May 2023, the South Korean government announced tax credits for companies building EV production facilities, offering a 15% tax credit for large and mid-sized companies and a 25% tax credit for small and mid-sized companies (Sarmmah, 2023).

3. In April 2023, the government announced plans to allocate 70% of the total annual R&D budget to 11 core areas, including secondary batteries. It is committed to investing $4.7 billion in projects across these key areas, with the investment distributed from 2023 to 2027 (Park, 2023)

4. According to Reuters, in April 2023, the government planned to jointly invest $15.1 billion with South Korea's top EV battery makers in R&D, aiming to become the first country to begin

commercial production of solid-state batteries. Around the same time, it also announced $5.3 billion in financial aid, in the form of loans and guarantees, to support companies investing in infrastructure in North America in response to the IRA (Reuters, 2023).

5.4.5. Industry Insights: Expert Perspectives

Most Indian battery manufacturers currently import battery cells, primarily from China, and assemble them into battery packs. However, these manufacturers are gradually moving upstream to produce battery cells domestically. Several companies have set up small-scale pilot manufacturing lines, some have entered technical partnerships with foreign firms, and some have already invested in large-scale manufacturing plants. Battery cell manufacturing is a capital-intensive process and requires high production volumes to achieve economies of scale. Hence, subsidies and incentives, particularly under the PLI -ACC scheme, are skewed towards large-scale manufacturers.

Industry experts acknowledge the technology and skill gap in India for battery cell manufacturing. India needs to promote foreign investment, preferably through joint ventures, to facilitate technology transfer. Such collaborations can help Indian manufacturers to access advanced cell chemistries, efficient production techniques, and best practices in quality control. Additionally, these partnerships will also help to boost the R&D capabilities of Indian manufacturers. Two recent developments in this space are expected to yield positive outcomes. In the first case, Indian Oil and Japan's Panasonic Energy have signed a binding term sheet to manufacture Li-ion cells in India. In the second case, JSW Energy is in discussions with LG Energy to form a joint venture in India.

Another expert also emphasized the need for a more skilled workforce. They compared the battery manufacturing setup of China with that in India and observed that the ratio of white-collar employees is higher in China than in India. It indicates that cell manufacturing requires a more skilled workforce than traditional manufacturing. To efficiently operate battery cell manufacturing facilities in India, significant skill upgradation is necessary.

Regarding the current policy landscape in the battery manufacturing industry, most experts supported the current policies, particularly the PLI scheme. However, they called for stronger initiatives to develop the charging infrastructure industry, as it remains a major roadblock to EV demand. Experts also recommended increased expenditure on Research and Development (R&D) related to EV batteries. This would not only foster the development of in-house expertise but also drive innovation. Currently, the incentives are largely focused on manufacturing. Introducing more incentives and grants through collaboration between academia and industry can help bridge the technology gap between India and other battery manufacturing nations worldwide.

Experts view Li-ion battery technology as a growing field over the next 5-10 years. Although alternative technologies, such as sodium-ion batteries, are in development, they are not yet commercially competitive with Li-ion batteries due to technical and economic factors. For instance, while sodium-ion batteries are cheaper than Li-ion batteries, their lower energy density makes them less competitive. According to the expert's opinion, given the prices of lithium already coming down due to over-supply by China, a situation is very likely that by the time sodium-ion batteries are ready for commercial rollout, lithium-ion batteries will become cheaper or at least comparable, taking away one of the main advantages offered by sodium-ion batteries. Experts dismissed any threat of technological

obsolescence and believe that investing in Li-ion battery technology is safe, provided there is sufficient market demand.

5.5. Recommendations

The Indian government has taken several steps to accelerate the development of the EV battery industry. These steps are primarily aimed at reducing the upfront investment required to set up large-scale battery manufacturing plants. While this remains a key focus area, other complementary initiatives can further enhance the impact. A few of these areas are discussed below:

1. **Focus on R&D**: R&D initiatives are crucial for developing in-house technology and capabilities. Battery cell manufacturing technology has been dominated by China, and given China's conservative approach to technology sharing, investing in R&D becomes imperative. Countries like China, Japan, and South Korea are working on not just one but multiple battery chemistries to develop the optimal one. There are already a bunch of battery chemistries available, some of which have been commercialized and others under R&D, for instance, lithium-ion, magnesium-zinc-calcium, lithium-sulfur, lithium-oxygen, and solid-state batteries. This makes it even more crucial for India to incentivize R&D. A few Indian early-stage companies and some large players have made significant investments in R&D within the battery manufacturing space. These companies require policy and financial support to sustain their R&D efforts and drive meaningful innovation. Academic institutes can play a pivotal role in driving research. However, to ensure academic research is evaluated through the lens of commercial viability, partnerships with private companies with R&D expertise can yield fruitful results. The government could consider directing grants toward partnerships between educational institutions and private companies.

2. **Bringing foreign technology**: The technology and skill gap is one of the major hurdles highlighted by all the industry experts. Countries like China, Japan, and South Korea are far ahead of India in battery cell manufacturing technologies. Leveraging the expertise of companies from these countries can help fast-track technological and skill development in India. These companies can be invited to set up their manufacturing units in India, preferably through JVs. Joint ventures can potentially facilitate the transfer of technology, skills, and efficient manufacturing practices. The government can make entry into the Indian market more attractive for such companies by offering tax rebates, a single window clearance system, low-cost loans, and other incentives.

3. **Strengthen hold over Lithium**: Lithium will continue to be a critical mineral for the EV battery industry. To reduce its import dependency on politically sensitive countries such as China, India must secure its lithium reserves and processing capacity. However, as of now, India has not discovered any major commercially viable lithium reserves domestically, making it imperative to explore overseas resources. One viable option is to establish lithium exploration partnerships with countries having abundant lithium reserves, such as Chile, Argentina, and Australia. In recent years, India has executed a few such partnerships; however, the scale and speed of such partnerships could be increased. This is because the process from exploration to actual lithium production takes between five and ten years. By the time these reserves become productive, India is expected to have a decent battery cell industry, allowing the country to shift its focus to localizing lithium refining as well.

4. **Development of the Energy Storage System (ESS) industry**: Lithium-ion batteries have diverse applications, including electric vehicles, mobile phones, electronic gadgets, and ESS. Among these, the ESS industry has the potential to generate significant demand for Li-ion batteries. ESS is used in grid stabilization, supporting renewable energy integration, and providing energy backup. As India advances towards achieving its sustainable development goals through renewable energy adoption, the ESS industry is expected to grow rapidly. Accelerating the development of this sector will create sustained demand for lithium-ion batteries, which, in turn, will support the viability of Li-ion battery cell manufacturing companies.

6. Consumer Journey Through Marketing, Dealer, and Advertising Aspects of an EV Product

6.1. Introduction

India's automobile industry is undergoing a drastic change as Electric Vehicles (EVs) are slowly moving from niche innovations for a few to mainstream competitors with traditional Internal Combustion Engine (ICE) cars. This shift is due to a multitude of factors, including rising concerns about the environment and climate change, increased government subsidies, and economic logic driven by rising fossil fuel prices. Combined, these factors place EVs at the center of the country's transition towards sustainable mobility.

Despite numerous initiatives and efforts by both the government and automakers, EV adoption has been slow. While two-wheeler EVs and commercial fleets have achieved some success, entering the private passenger car market has posed challenges. For the majority of households, purchasing an EV involves considerable hesitation, both because of practical barriers, such as charging infrastructure, upfront costs, and after-sales service, and psychological barriers such as trust, safety, and social influence.

This study answers the main question of what motivates or demotivates Indian consumers to adopt EVs. To answer this, we have mapped the whole consumer journey from initial awareness to post-purchase experiences. We combine this with detailed interviews across different customer segments and expert input to identify rational, cultural, emotional, and infrastructural factors that shape EV adoption in India.

6.2. Literature Review

6.2.1. Global Drivers of Adoption

a. Economic Savings and Total Cost of Ownership

Globally, one of the most compelling reasons to adopt Electric Vehicles (EVs) is the prospect of lower total cost of ownership (TCO). Compared to ICE vehicles, EVs tend to have lower running costs because electricity is much cheaper than petrol or diesel, and also because items that require maintenance on ICE vehicles - like clutch, oil changes, and exhaust systems - will not be needed for an EV. Research

indicates that financial savings are especially important to consumers in regions with high and volatile fuel prices, such as Europe (Javadnejad et al., 2023).

For commercial fleets and high-mileage user groups, the break-even point between the front-loaded costs of EVs and their operating costs is relatively short, providing an additional incentive to adopt EVs (Pamidimukkala et al., 2023). Experiences from Norway, China, and the United States show that when cost savings combine with subsidies, people switch to EVs much more widely (Javadnejad et al., 2023).

b. Environmental concerns and sustainability aspirations

Rising awareness of climate change and pollution has strengthened the environmental case for EVs. Many consumers see EVs as a personal way to contribute to a sustainable future, and this view aligns with the global push to reduce carbon emissions (Sidhpuria et al., 2020). In the EU, imposing emission targets has established standards that make choosing an EV not just a personal choice but a civic obligation. Young buyers often view EVs as aligned with their environmentally friendly values; research shows that both environmental concern and social responsibility influence their choice to own an EV. For most, owning an EV is both practical and a statement of identity as a responsible "green citizen" (Deka et al., 2023).

c. Lifestyle positioning and tech-forward identity

EVs will increasingly be marketed as lifestyle products in addition to cost and environmental goods. Companies like Tesla market EV ownership as an aspiration: a symbol of status relating to innovation and modernization. With more sophisticated technology, including autonomous driving and smartphone-integrated ecosystems, EVs are more than cars; they can be thought of as "gadgets on wheels." In the U.S., EVs are associated with "tech culture," while in China, they represent futuristic smart vehicles for the urban elite (Javadnejad et al., 2023). This lifestyle approach can supplement purchases based on informed cost-effectiveness and rational calculations and is especially relevant for rich and status-seeking consumers (Pamidimukkala et al., 2023).

6.2.2. Global Barriers

a. Range anxiety and charging infrastructure

The most frequently cited global barrier is range anxiety. While traditional Internal Combustion Engine (ICE) vehicles have ubiquitous refueling infrastructure, Electric Vehicles (EVs) rely on charging networks that are unevenly distributed. Also, long charging times, ranging from 30 minutes with fast charging to hours from home, add to consumer concerns. Research confirms that the lack of visible, convenient charging infrastructure contributes to reluctance to purchase EVs among early adopters and the late majority (He et al., 2020).

b. Battery degradation and replacement costs

Battery reliability is another significant challenge. Lithium-ion batteries are expected to lose approximately 15% to 25% of capacity over 6 to 8 years of use, effectively reducing driving range (Tarei et al., 2021). Consumer confidence is hampered by high battery replacement costs, which may account for 30 to 40% of expected car payments. Mitigating battery anxiety appears to be slowly eased by battery warranties and advances in vehicle technology (e.g., solid-state batteries); concerns about high

future repair costs are likely to be amplified in developing economies with active second-hand car markets (Pamidimukkala et al., 2023).

c. Uncertainty of resale value

Unlike ICE vehicles, EV resale values are unpredictable. Rapidly emerging technologies mean that older models will become obsolete more quickly, and used cars will face diminished demand as better-performing models emerge and marketplaces place greater weight on battery life (Tarei et al., 2021). Data from North America and Europe indicate that EVs depreciate more than ICE vehicles (CR Survey Research Department and Advocacy Division, 2020). A variety of buyback guarantees and certified pre-owned programs are in the testing phase, but consumers will remain uncertain about EV resale pricing until it becomes predictable (Pamidimukkala et al., 2023).

6.2.3. Indian Context

a. Government subsidies and Tax exemptions

India has identified EV adoption as a priority, along with energy security and sustainability. Programs such as FAME-II (Faster Adoption and Manufacturing of Hybrid & Electric Vehicles) and reductions in GST from 28% to 5% seem to reduce the cost difference compared to ICE vehicles (Sidhpuria et al., 2020). Tax breaks on EV loan interest (up to ₹1.5 lakh under Section 80EEB) further improve affordability. The distinction is that, while these policies have certainly improved urban adoption, EV adoption will vary across vehicle segments and geographies (Chhikara et al., 2021).

b. Adoption patterns: Two-wheelers and Fleet taxis

India's adoption path significantly differs from that of Western countries. Two-wheelers (motorcycles and scooters) and fleet taxis have their own unique and prominent place within the electric vehicle (EV) adoption path (Chhikara et al., 2021). This reflects India's special mobility ecosystem, where two-wheelers account for more than 70% of ownership. Fleet operators with some vehicle usage (and some economics from fuel savings) will almost always favor putting an electric vehicle into service. However, private vehicle adoption is largely confined to metropolitan areas such as Delhi, Bengaluru, and Mumbai, while uptake in rural settings is constrained by infrastructure challenges and a lack of awareness (Tarei et al., 2021).

c. State-level Policies and Regional incentives

Certain states, such as Delhi, Gujarat, and Himachal Pradesh, have comprehensive and targeted electric vehicle policies (including handout subsidies, road tax waivers, and requirements for a minimum density of charging stations) (Tarei et al., 2021). Delhi's 2020 EV policy even mandated that charging stations be within 3 km of each other, which created early visibility. However, these policies have shortcomings because the town-size gap often leads to delays in implementing infrastructure in smaller towns, even when they are included in policy announcements (Chhikara et al., 2021).

6.3. Adoption Through the Lens of Diffusion

Rogers' diffusion of innovation (García-Avilés, 2020) is helpful for understanding adoption patterns in India. Early adopters of electric vehicles tend to be wealthy, urban dwellers who are environmentally

conscious and understand EVs as symbols of development and technological progress (Deka et al., 2023). In other words, the novelty and signaling of a new lifestyle that comes with being an early adopter takes precedence over the functional risk of delayed charging or resale uncertainty. The early and late majority are still hesitant because they need to see the ecosystem mature to a point, and social proof of the decision to adopt. The literature provides evidence that peers, friends, neighbors, or colleagues who have adopted an EV reduce perceived risk, thereby enhancing diffusion (Tarei et al., 2021). Therefore, adoption clusters are more pronounced in metropolitan geographies where social history convergence, increased infrastructure development, and early adopters are present.

6.3.1. Gaps in Literature

a. Emotional and household-level decision making

Most existing literature concentrates on the barriers to EV adoption, such as economic and technical factors (e.g., TCO, range, infrastructure). However, in India, EV adoption is frequently a household-level decision, often driven by emotions, family hierarchies, and social signaling (Deka et al., 2023). Factors such as generational gaps in risk-taking propensity, family pride, or fear of unreliability, among others, can influence decisions, and these dynamics are often only partially captured empirically.

b. Dealer experiences and peer effects

Even in mixed-methods studies, dealers act as trust brokers; however, their influence is often underemphasized in the literature. Dealers' understanding of EV features and technologies, warranty coverage, charging behaviors, and their ability to engender trust in consumers can be a real barrier or enabler of adoption (Chhikara et al., 2021). Peer effects on EV adoption yielded similar findings; they are commonly acknowledged but have rarely been studied beyond anecdotal surveys. Qualitative research could focus on underlying experiences, particularly how peers influence EV adoption within households: whether they accelerate or delay decision-making, share usage experiences, confer social prestige, exert social pressure, or shape perceived group norms. It could also examine how collective, consensus-based decisions emerge within peer networks and how peers articulate and communicate barriers to adoption (Tarei et al., 2021).

6.4. Methodology

Our study took place in three phases:

1. **Preliminary secondary research**: We started with scanning the secondary research from the International Energy Agency (IEA) reports, NITI Aayog, and global and domestic leading automotive industry associations to develop some understanding of the trends globally and the policy landscape in India.

2. **Expert interviews**: Second, we engaged automotive professionals and academic frameworks to develop a segmentation framework for capturing the diversity of EV consumers in India.

3. **Consumer interviews**: Lastly, we conducted semi-structured interviews with adopters and non-adopters, distinguishing between affluent households, value-conscious households, and traditionalist households, for a total of ten unique semi-structured interviews.

6.4.1. Approach

The interviews were semi-structured, narrative-based, and designed to allow participants to reflect on their decision-making process on their own terms.

The guide considered the important decision-making stages: (1) Initial awareness; (2) Home discussions; (3) Purchase option evaluation; (4) Dealership experience; and (5) post-purchase satisfaction (in case of EV adoption).

This approach allowed us to review both rational considerations of EV purchase (cost, safety, and warranty conditions) and emotional considerations (pride of ownership, peer nudges, hesitations, and fears).

6.5. Personas & Segmentation

Drawing on expert interviews with professionals from the Indian automotive sector, including individuals with experience in research and development, new product development, and four-wheeler manufacturing, we developed a 3 × 3 segmentation matrix.

These specialists provided insights grounded in engineering expertise, product development strategies, and market strategies, with positive implications for understanding consumers' mindsets and barriers to adoption.

During our conversations, we very much put them at the top of their expertise by discussing buyer-emergent types, notions of affordability shaped by bias, how age and risk appetite influence decisions, and how adoption always unfolds on a moment-to-moment basis.

There was a unifying emphasis on psychographics (risk apostate tolerance, technology curiosity, the symbolic meaning of ownership) and the staged progression (exploration → deliberation → adoption), which shaped the packaging of the framework that emerged for classifying potential EV consumers by socio-demographic category (affluent, value-conscious, traditionalist) and level of consideration or adoption.

Table 7: Segmentation Matrix

Consumer Type	**Explorer**	**Deliberator**	**Adopter**
Affluent (Urban/Semi-Urban)	Tech-induced professionals are interested in EVs but are waiting for the ecosystem to mature and for EVs to prove themselves socially.	Actively comparing and sometimes getting test drives of EVs as options, despite believing EVs are convenient, practical, and reliable, they chose to abstain from buying.	Early adopters who perceive EVs as either a lifestyle enhancement or a status symbol, thereby influencing their social circles.

Value-Conscious (Mass-market households)	Some awareness/interest in EVs and are aware of the savings EVs could deliver; however, cautious due to the initial premium.	The buying decision is considered, but when they see more favorable economics and/or a clearer ecosystem, they may consider it, though skeptically.	Once they see that EVs will have long-term value, they will adopt.
Traditionalist (Risk-averse)	Skeptical about EVs generally but still curious, perhaps only exposed to EVs through media or relatives.	Thinking of buying EVs but currently anchored on ICE due to satisfying loyalty and practicality of comfort and reliability.	Late entrants adopt EVs slowly, and when they do, it is often for a single or limited use case, since they are still relying on their existing ICE vehicles.

6.5.1. Rationale for the framework:

1. **It moves beyond demographics to capture mindset and risk appetite.** Experts suggested that we could not explain EV adoption in India based solely on demographics. Two households with the same income and proximity to a charging location may act completely differently based on their willingness to adopt technology, their acceptance of risk, and any symbolism associated with ownership. The framework includes an assessment of attitudes and risk acceptance to highlight how adoption is driven as much by psychological factors as by affordability.

2. **Models' adoption as a staged progression.** Expert inputs emphasized that the adoption process is seldom as simple as moving from awareness to purchase. Adoption takes place over several steps - it starts with awareness and curiosity in the Explorer phase, moves to consideration in the Deliberator phase, where households carefully weigh the pros and cons, and then leads to engagement and participation in the Adopter phase. This staged model of adoption reflects the likely way households will examine new technologies, through interested contemplation and tentative justification, before arriving at a final decision.

3. **Provides a structured lens for mapping insights from our study.** By combining socio-economic types with adoption stages, the matrix creates nine archetypes that are both intuitive and analytically useful. This framework gives an organized way to place and understand consumer stories. Later, each interview will be matched to these archetypes to show how the theory connects with real experiences.

6.6. Findings from Consumer Interviews

a. Initial Awareness

The respondents' thinking about most aspects of EVs did not exist in a vacuum. Most households first become aware of EV ownership through a combination of mass media and social signals. While respondents used these mass communication sources to build a general understanding and become familiar with the product, they did not consider these sources sufficient to establish evidence of a viable EV. Rather, respondents' credibility was established through proximity: if a neighbor, co-worker, or family member purchased an EV, the notion of ownership moved from an abstract, innovative concept to a real, tangible action. This peer visibility made the difference between viewing EVs as "experimental" and seeing them as legitimate purchase options.

Overseas exposure also played a role in shaping perceptions. Respondents who had studied, lived, or traveled abroad frequently referred to the ease with which EVs operated in Singapore, Europe, or the Gulf states. For them, the presence of widespread charging infrastructure and seamless integration into daily life confirmed that EVs "worked." At the same time, this comparison created skepticism: several respondents questioned whether India's realities, such as traffic congestion, inconsistent electricity supply, and poor road conditions, would allow a comparable experience.

Within families, the first conversations about EVs were framed either as cost-saving opportunities or as environmentally responsible choices. But before long, they encountered resistance. The issues of range reliability, charging visibility, and, specifically, the unknown costs of battery replacements arose almost immediately. Rather than generating simple enthusiasm, having been made aware caused a more complex interplay between aspiration and anxiety. Households were attracted to the ideas of savings and modernity while retaining a sense of unease about uncertainty.

An additional nuance came from how respondents interpreted the "sustainability" narrative. For most, EVs symbolized personal contributions to a cleaner environment, with less smoke, less smell, and less noise. Yet one particularly well-versed respondent, who had been driving EVs for over a decade, pointed out that while EVs reduce tailpipe emissions, the environmental costs of battery production and disposal are considerable. They called it consumer greenwashing, i.e., something buyers can do so they feel good about themselves, not a systemic fix. What was interesting was that they still preferred EVs based on local harm-reduction benefits, emphasizing a reciprocal relationship in which personal experience and conscience shape EV adoption.

b. Household Decision-Making

The buying of a vehicle was usually thought of collectively as relational to family structures and cultural norms, but the extent and nature of input varied across segments. Younger, affluent buyers had more autonomy and were more likely to see themselves as futuristic decision-makers. Value-based and traditional households relied much more on elders or trusted family members. One very interesting example involved an uncle's recommendation, essentially closing the deal before the potential buyer even test-drove the car.

c. Several themes emerged from these discussions:

- Upfront cost as the primary hurdle: Across all household characteristics, EVs were viewed as considerably more expensive than their ICE counterparts. Although respondents recognized potential long-term savings in fuel and maintenance costs with an EV, the higher upfront cost served as a significant barrier, especially for cost-conscious households facing EMI obligations.

- Battery cost anxiety: Another highly mentioned concern was surrounding the question of what happens after the five-to-eight-year battery warranty. Consumers calculated that replacement could cost half the price of a premium EV, or nearly the full cost of a small EV like the Tata Tiago. For many, this made them wonder whether it would be more sensible to simply buy a new car at that stage. This was not framed as a rejection of EVs but as an unresolved uncertainty, a hesitation that colored otherwise positive deliberations.
- Resale value: Interestingly, although resale was an area respondents could consider, it was rarely an important factor. While resale concerns are major factors in the global literature, our respondents did not appear to be as concerned.
- Variety and choice: Many respondents expressed frustration that the number of models found in EV showrooms is fewer than the number of options for ICE, thus limiting their options in finding something that met their needs and budgets.
- Trust and hierarchy in decisions: Traditionalist households had a strong reliance on brand reputation (Tata, Mahindra) and the voices of trusted family members. Their emotional leaning carried more weight than spreadsheets and technical assessments.
- Gendered decision-making: The influence of gender appeared as a theme repeatedly. Men (fathers and sons) were almost always the final decision-makers. Women stressed safety, comfort, and practicality, but their voices rarely defined the conclusion. In one striking example, a respondent claimed that EVs were a “girls’ car,” because there is no engine noise, and thus, it made the car less masculine.

These comments illustrate how cultural associations of cars with power and prestige remain relevant, despite the changing consumer attitude.

For these reasons, household decision-making was rarely a simple exercise in weighing costs and benefits. Rather, it was a re-negotiation of affordability, trust, cultural identity, and reassurance.

d. Dealer Experiences

- The dealership was one of the most critical, yet inconsistent, touchpoints in the adoption journey.
- Positive encounter: In some cases, test drives effectively dispelled abstract fears. Respondents described the smoothness and quietness of the EV driving experience as reassuring. For first-time buyers, the act of driving the car was often more persuasive than any advertisement. It converted curiosity into genuine interest.
- Negative encounters: Dealers often fell far short, but a majority of the respondents from both the cost-conscious and traditionalist groups noted that sales staff would have difficulty clarifying basic questions around battery life, degradation, and the particulars of warranties. The technical illiteracy of the sales staff elicited some skepticism at a key moment.
- Selective messaging: Dealers often referenced lifestyle features, including sunroofs, visual displays, and voice control. Both subsidies and financing options were listed, but any “hard questions”, like post-warranty support, operational range during congested Indian traffic, or battery replacement costs, were largely avoided or answered vaguely. Consumers interpreted such avoidance as evasiveness, leaving unanswered queries that further embedded their skepticism.

- Variety gap: Showrooms typically showcased fewer EV models than ICE models, limiting choice while contributing to household perceptions of EVs as an incomplete market.

Overall, dealers were weak touchpoints, building trust with test drives in good cases, but often fueling skepticism with evasiveness or lack of knowledge.

e. Post-Adoption Experiences

Among adopters, experiences were largely positive but always tempered by caution.

- Satisfaction: Owners consistently highlighted the money saved on fuel, the low stress of city commute, and the quietness of the drive. One adopter described a 500 km trip without incident, which helped significantly build his confidence in the vehicle's integrity.
- Concerns that persisted: Even satisfied owners brought attention to the gap between the claimed range and the actual range. Most found themselves using either Eco mode or Eco+ in order to ensure they could drive longer distances, but that diminished the sense of freedom in driving. Battery degradation was also a persistent concern for some owners, despite warranties.
- Usage patterns: Almost all adopters restricted their EV use to urban commutes, retaining ICE vehicles for longer trips. This dual strategy reflected a transitional phase: EVs supplementing rather than replacing ICE cars.
- Service and repair anxieties: Owners also pointed to the absence of a distributed servicing ecosystem. Unlike ICE cars, which benefit from thousands of local mechanics and informal "workarounds," EVs were entirely dependent on authorized service centers. If parts were unavailable, there was no alternative. This created a perception of vulnerability and higher long-term dependency.
- Measured optimism: Adopters described their experiences as positive, but with a caveat. They appreciated the short-term savings and convenience factor but were not fully willing to adopt an all-EV lifestyle and depend on that as their only mode of transport.

6.7. Findings By Consumer Segments

6.7.1. Urban/ Semi-Urban Affluent Segment

- **Explorer**
    1. Attracted to EVs as lifestyle upgrades and technological statements.
    2. While overseas exposure to Singapore and Europe heightened confidence in EVs, the gaps in Indian infrastructure (charging visibility, poor road surfaces) created an obstacle.
    3. Masculine identity influenced perception: one respondent felt that the absence of engine sound made EVs seem "feminine" or a "girls' car," showing that cultural associations with power and status still shape affluent explorers.
- **Deliberator**
    1. Recognized both cost savings and greater environmental value, but abstained from purchasing EVs until infrastructure became visible and reliable without risk.

2. Strongly influenced by peers; observing friends and colleagues successfully using EVs helped validate their suitability and ultimately encouraged adoption.
3. Thought of EV adoption as "inevitable" but not practical as of now; chose to delay purchasing EVs until the warranties and resale ecosystems matured.

- **Adopter**
  1. Long-term adopters saw EVs as practical tools rather than status symbols.
  2. Environmentally sensitive yet realistic, one respondent rated EVs as "greenwashing at the consumer end" yet still preferred them based on several day-to-day benefits (for example, quiet and non-fumes).
  3. Expressed concern about a lack of servicing ecosystem and post-warranty costs, all while reporting satisfaction with use day-to-day.

6.7.2. Value Conscious Segment

- **Explorer**
  1. Attempted detailed cost–benefit calculations but struggled with the complexity of battery costs and warranties.
  2. Perceived EV economics as “net zero”, not clearly better than ICE unless ownership extended beyond warranty periods without battery replacement.
  3. Expressed frustration at the limited EV model variety compared to ICE options.
- **Deliberator**
  1. Heavily fixated on battery replacement anxiety, asking “Who should pay at the end of the warranty, the consumer, company, or the government?”
  2. Hesitant about the EMI burden, given that the ICE cars often had lower entry price points.
  3. Sustainability was factored, but at the consumer end (less fuel usage, no tailpipe emissions) and not as a complete environmental solution.
- **Adopter**
  1. Used mainly due to subsidies and increasing fuel prices, rationalizing this as a long-term financial savings.
  2. Still trusted Indian brands (Tata, Mahindra) more than foreign entrants, showing how brand reputation played a role during adoption.
  3. Still relied on ICE cars for longer trips and positioned EVs as economically focused city vehicles rather than a complete substitute.

6.7.3. Wait-And-Watch Traditionalist Segment

- **Explorer**
  1. Skeptical, but with curiosity, this group learned about EVs mostly from relatives or the media.
  2. Firmly tied to ICE reliability and saw EVs as no better than “secondary vehicles”.
  3. Did not consider EVs as suitable for a rural use case or highway use case, because of a lack of charging infrastructure, and extensive gravel road usage.
- **Deliberator**

1. Clearly laid out the main obstacles to buying EVs: high upfront cost, uncertain servicing, no resale market, poor charging infrastructure, and no local mechanics.
2. Dealer incompetence was called out multiple times; multiple sales staff could not confidently answer questions on battery life, warranties, or replacement costs, reinforcing distrust.
3. Expressed the belief that EVs would "come in time" but are already sufficient to meet current household needs.

- **Adopter**
    1. Adoption was due more to family and peer pressure than conviction.
    2. Restricted use to very short commutes into the city, while retaining ICE vehicles for long-distance reliability.
    3. People saw EVs not as status symbols or something to aspire to, but simply as useful, practical vehicles for the family.

6.7.4. Key Cross-Segment Analogies

- Affluent adopters contextualized EVs in lifestyle and conscience, but explorers and deliberators were deterred by infrastructure gaps.
- Value-conscious homes grappled between economics, charging in battery-centric detail, subsidies, and EMIs; their adoption was contingent and pragmatic.
- Traditionalists were all in on ICE; they were influenced by outside forces and not inner-force engagement.

6.8. Cross-Case Analysis

Our cross-case analysis of interviews showed three themes that crossed segments and categories.

a. Economics vs. Trust

All cases had a recurring paradox: on paper, the economics of EVs were impressive; however, trust was always likely to lag.

- Consumers recognized fuel savings, lower operating costs, and lower maintenance compared to ICE vehicles. Many even applied their own cost-benefit analyses, especially within value-seeking households. However, many value-seeking consumers stalled when faced with uncertainties such as the cost of battery replacement after the warranty period, unclear dealer guidance, or concerns about long-term durability.
- Resale value was rarely a decisive factor, contrary to global literature. Instead, battery degradation and the possibility of "catastrophic" costs later in the ownership cycle became the dominant psychological barrier.
- Consumers frequently rationalized EV adoption as a "net zero" proposition, perhaps marginally cheaper in the long run, but not worth the anxiety of unresolved unknowns.

This gap illustrates that adoption is driven less by strict rationality than by households' sense of security about ownership.

b. Infrastructure as the tipping point

Infrastructure was the single most influential determinant of adoption timings. It was not the number of chargers that mattered, but rather their visibility and reliability.

- In metropolitan areas, even a handful of visible charging points gave enough comfort. They indicated that adoption was plausible, even though actual usage was predominantly city driving.
- In smaller towns, there were no visible chargers, so there was a belief that EVs were not practical, regardless of the wealth of the household.

In some cases, chargers existed but were hidden or non-functional, further feeding skepticism.

This distinction between quantity and visibility proved critical. Several respondents suggested that chargers be placed at petrol pumps, not for physical convenience, but because petrol pumps are highly visible symbols of infrastructure readiness.

However, if chargers were integrated into petrol stations, the benefit of reduced queues would be diminished, thereby demonstrating the need for chargers to be in a more visible, standalone location.

So, infrastructure is both a functional enabler and symbolic of preparedness. It can be highly visible, instilling confidence in consumers, or completely invisible; the latter amplifies uncertainty about reliability.

c. Social proof and Dealer influence

- EV adoption in India is strongly mediated by social context. In most cases, peer adoption served as an accelerator, with several families reporting they purchased EVs primarily after endorsement by trusted relatives.
- Seeing an EV operate in one's neighborhood or social circle normalizes the idea, reducing perceived risk more effectively than advertisements or government campaigns.
- Dealer experience was mixed at best. On the one hand, test drives were powerful tools for converting curiosity into genuine intent. On the other hand, dealership staff frequently undermined this momentum by failing to answer "hard" questions about battery life, warranty details, servicing availability, or post-warranty costs. Their selective emphasis on lifestyle features or subsidies, while avoiding technical detail, created suspicion.
- The absence of an informal servicing ecosystem, a key strength of ICE ownership in India, exacerbated this trust gap.
- Households were acutely aware that EVs lacked the "local mechanic" safety net and the improvisational makeshift workarounds that keep ICE vehicles running even with limited parts.

Dealers became the only source of reassurance, yet often failed to provide it.

d. Cultural anchors in adoption

Another cross-cutting theme was the persistence of cultural associations with cars that embedded masculine symbolism. In several interviews, the lack of engine sound was derisively described as less "masculine" for EVs. In one instance, a respondent stated EVs were a "girls' car." Such perceptions illustrate that consumers' hesitancy is not solely based on infrastructural or financial issues. The hesitancy is symbolic, reflecting the historical reality that ICE cars were marketed as powerful, masculine vehicles.

e. Synthesis

Put together, the findings suggest that EV adoption in India is socially contagious, but structurally temporary. Word-of-mouth and peer endorsement might be sufficient to create momentum for a short period, but the lack of visibility of infrastructure and competence from dealers, or symbolic reassurance, can also halt momentum. Economic reasoning alone is not sufficient; adoption will only advance when households feel emotional safety, cultural affirmation, and practical support.

6.9. Implications for Automakers and Policymakers

The interviews make one thing clear: the barriers to EV adoption in India are not just technical; they are psychological, cultural, and experiential. Marketing, when treated as a trust-building system (not just advertising), can move the dial. Below, we translate the findings into a set of marketing-led actions for automakers and dealers, then list structural and policy moves that sit outside marketing but are essential complements. Where useful, we lean on two frameworks:

- AIDA (Awareness → Interest → Desire → Action) to guide interventions along the journey.
- Neuromarketing/ Behavioral insights to reduce anxiety, increase clarity, and reshape symbolism.

6.9.1. Implications for Automakers – The Marketing Lens

Table 8: Stage-wise EV Adoption Framework: Key Barriers, Strategic Interventions, and KPIs Across the Consumer Decision Journey

Stage	Problem Surfaced	Moves	KPIs
Awareness	Awareness is established, but credibility will always require visible evidence (chargers, peer confidence) rather than generic advertising.	Transition from generic "green" to visibility campaigns: where-can-I-charge storytelling, geo-tag social posts, live maps. Fear-relief narrative ads: recognize situation (e.g., fires/range anxiety) and resolve via evidence (i.e., testing/certifications/testimonials). Context-appropriate media: eco/reassurance messaging in reflective contexts, power/innovation cues in dynamic contexts. Segment cues: affluent = lifestyle/tech; value-conscious = running-cost evidence; traditionalists = trusted local voices.	Unaided awareness of nearby chargers. Perceived ease-of-charging lift. Brand credibility on safety.
Interest	Families try to do some basic cost-benefit math, but they get stuck on battery, warranty, and range. Dealers are sidestepping on	Interactive digital twin TCO simulator (app/kiosk): realistic scenarios + printouts. Discounted plain language warranty sheets: coverage, timelines & typical replacement costs.	Simulator completions. Comprehension of battery/warranty (surveys).

	battery, warranty, and range.	An interactive live charger map and a real-time uptime feature within the simulator. Tethering savings to life goals (e.g., "8 years = child's college fees"). Dealer as an educator with tools & scripts.	Test-drive bookings from tool users.
Desire	Cultural symbolism is weak: The silence of the EV is defined as "feminine" or powerless and has limited desire due to identity issues.	Sound branding: offering optional sound profiles (powerful hum or futuristic tones). Safety-forward brand position: conveying pride in protecting families, demoing ADAS/crash. Community micro-hubs: outside of high-visibility charging zones (demoing high-profile trips) hosted by owner ambassadors, include gamified referrals. Modern status design: subtle, customizable accessories (lights/trims/sounds).	Desire/appeal lift in research. Event/referral test-drive numbers. Uptake of customization packs.
Action	Test drives develop trust, but dealership incompetence and dodgy responses often kill momentum.	EV Dealer Academy - certifications on batteries, infra, warranties, cost tools; audits quarterly. Objection handling scripts for battery fires, resale, and post-warranty cost. Curated test drive routes - traffic + highway + live charger stops. Conversion bundles - Battery Assurance, home-charger, builder letter kit, free charging credits.	Test-drive → bookings conversion. Dealer knowledge audit scores. Attach the rate of the Battery Assurance bundle.
Loyalty & Advocacy	Owners appreciate city driving but are cautious; advocacy occurs informally.	Owner-ambassador program: credits for hosting demos/referrals. Battery Health Certificate (in-app) to relieve resale anxiety. Second-life battery program: repurpose into home/community storage; climate communication. Proactive service reassurance: push notifications before long-distance trips, free check-ups, and loaners while repairs are made.	Referral share of sales. App engagement. Resale turnaround time. Service NPS. Battery enrolment in the second-life program.

6.9.2. Other Creative Moves

- Fear-relief storytelling: Acknowledge fire and range anxiety explicitly, then resolve with certification footage, safety standards, and real owner testimonials.
- Configurable sound identities: Optional interior/exterior sound packs that signal power or futurism—transforming silence from a perceived weakness into a brand asset.
- Community micro-hubs: Small, high-visibility charge-and-demo nodes hosted by local owner-ambassadors to trigger peer effects and social contagion.

- Gamified “digital twin” TCO tool: Interactive sliders, instant cost graphs, and environmental equivalents (e.g., trees saved), with take-home printouts for family deliberation.
- Mood-state media planning: Align message tone with consumption context (reflective vs. high-energy environments) to improve persuasion efficiency.
- Branded second-life pathway: Position battery reuse (home storage, community backup) as planned lifecycle stewardship—reducing post-warranty anxiety and enhancing sustainability credibility.

6.9.3. Beyond Marketing: What Must Change Structurally

a. For Automakers

- Builder partnerships (EV-ready by design). Provide plug-and-play drawings, bulk hardware, and co-branded signage for new projects; bundle “RWA kits” for existing societies.
- Distributed service capacity. Train and certify independent garages on safe high-voltage work; make basic diagnostic tools and parts available so owners aren’t stranded when a part is back-ordered.
- Battery risk products. Offer post-warranty Battery Assurance (extended warranty/insurance), battery leasing, and buy-back floors; show these clearly in the simulator.
- CPO (Certified Pre-Owned) EVs. Trade-in with Battery Health Certificates; guaranteed buy-back reduces perceived downside.

b. For Policy Makers

- Visibility first, then count. Site chargers at prominent, high-footfall locations near (not inside) petrol pumps, transit hubs, and malls; mandate clear roadside signage; publish live uptime dashboards.
- Residential mandate. Require a minimum share of EV-ready parking in new housing; fast-track retrofits with standardized RWA guidelines.
- Post-warranty guardrails. Encourage battery insurance/extended warranties; standardize Battery Health Reporting (SoH) for resale; seed a second-life market with safety standards.
- Workforce and safety. Grants to upskill local mechanics; national safety communications that address fires/blasts responsibly (causes, fixes, standards).
- Local battery manufacturing. Support cost reduction and supply security; pair incentives with strict end-of-life standards.

6.9.4. Ethics And Guardrails

- No overclaiming. Treat safety with humility; never trivialize fire risk, explain standards and fix them plainly.
- Transparent data use. Mood/context targeting should respect privacy and avoid discriminatory patterns.
- Inclusive narratives. Feature women as decision-makers, not only passengers; avoid reinforcing dated masculinity tropes even as you address them.

- Green honesty. Balance tailpipe gains with end-of-life stewardship (second-life, recycling) to avoid shallow “greenwashing.”

6.10. Conclusion

India is at a critical junction in its EV development journey. There have been enough early adopters demonstrating that EVs can deliver significant advantages, such as lower ongoing costs, lower local emissions, and a smoother, more premium driving experience, but our research indicates that the majority of households are still hesitant. And their reluctance is not merely about affordability; it is tied to trust in what feels like a fledgling ecosystem, charging visibility, battery life post-warranty, post-purchase service, and the social implications of car ownership.

The crucial point of the study is that EV adoption is not based solely on rational cost–benefit analysis. Families are not just asking “How much will I save?”; they are also asking “Is this technology trustworthy? Am I going to be able to fit this into my lifestyle, protect my family, and maintain my social identity?” Adoption is therefore as much about emotional negotiation as it is about economic gains.

Our segmentation framework illustrates these distinctions: affluent buyers are balancing the signaling of lifestyle choices against infrastructure issues; value-conscious households are anxious about battery costs and the integration of new costs into EMIs; and traditionalist families lean heavily on peer recommendations and the anchors of cultural trust. There are various barriers across this adoption spectrum, but the need for reassurance is common.

This points to a critical lesson: subsidies and technology upgrades, while important, will not on their own catalyze mass adoption. What matters equally is the architecture of trust, competent and transparent dealers, visible and reliable infrastructure, clear communication about warranties and end-of-life solutions, and community-based peer validation. Cultural factors also play a role: lingering associations of cars with masculinity and power must be acknowledged and reframed if EVs are to gain aspirational traction across demographics.

If both industry and policy work together to create infrastructure that is both functional and visible, and if industry establishes dealer education rather than dealer selling and builds meaningful credibility around batteries and resale, India can leapfrog from uncertain to broad-based uptake. The outcome would not only be a major transformation of the automobile sector but also another significant milestone in India's shift towards sustainable mobility and environmental responsibility.

6.11. Limitations & Scope for Future Research

While this study provides important insights into the evolving landscape of EV engagement in India, there are some limitations. First, the research comprised a relatively small sample size of in-depth interviews. This qualitative method allowed us to engage with rich narratives and household dynamics, but the findings cannot be statistically generalized. To validate the patterns we explored, larger surveys that cover varied geographies would be needed.

Second, we have constrained our focus on private passenger car buyers. Segments such as commercial fleets, two-wheelers, and three-wheelers, which together account for a significant portion of India’s

mobility, were excluded. These categories may follow very different adoption logics and would benefit from dedicated inquiry.

Third, the study centered on current adopters, deliberators, and explorers in mostly urban and semi-urban contexts. Rural consumers, who face distinct infrastructural and cultural constraints, were not adequately represented. Future research could broaden the lens to include rural geographies and assess how EV narratives diffuse outside metropolitan clusters.

Finally, the study primarily relies on self-reported perceptions. While these reflect genuine consumer anxieties and aspirations, behavioral experiments or longitudinal studies would help distinguish between stated intentions and actual long-term adoption patterns.

Thus, future research can proceed along three avenues: (a) large sample quantitative survey research to test the generalizability of our segmentation framework, (b) comparative studies focusing on rural and urban adoption trajectories, and (c) studies focusing on post-purchase behavior, as well as the resale market and perceptions of battery end-of-life. Taken together, these avenues for research could contribute to a deeper academic understanding of EV adoption and provide policymakers and firms with a more granular roadmap to accelerate mobility transitions in India.

7. Conclusion

This chapter synthesizes a value-chain view of India's EV transition by bringing together five interlinked perspectives: OEM supply-side constraints; B2B demand dynamics; charging-infrastructure and battery-service models; domestic cell manufacturing and mineral security; and the consumer journey that finally converts interest into purchases. Together, these sections show that India's EV challenge is not a single technical deficit but a system-level misalignment across costs, infrastructure, market institutions, and trust.

On the supply side, OEMs face a persistent price gap versus ICE vehicles—driven primarily by battery costs and a heavy reliance on imported cells and components — that keeps many mass-market segments out of reach and raises affordability and financing risks.

Demand-side analysis shows that commercial fleets and logistics operators are the most immediate adopters because of clear operating-cost advantages (EVs have substantially lower per-km running costs). Yet B2B uptake is constrained by high capex for charging hubs, operational downtime from charging, and financing/tendering frictions, barriers that differ in kind from retail buyer concerns and therefore require different policy instruments.

Charging and battery-service infrastructure emerge as a critical bottleneck. The chapter documents projections of substantial charging needs (on the order of 1.32 million stations by 2030) and highlights how gaps in siting, interoperability, uptime, and charger auditability exacerbate range anxiety and undermine service reliability. It also evaluates emerging delivery models—Battery-as-a-Service (BaaS), standardized swapping, depot-centric charging, and route-level planning—as pragmatic responses to the infrastructure shortfall.

Upstream, the chapter examines cell manufacturing and mineral strategies. Policy instruments such as PLI-ACC and initiatives to secure critical minerals are already reshaping investment incentives;

nonetheless, the analysis highlights remaining capability, skills, and R&D gaps that constrain faster localization and make the sector vulnerable to import-price and supply-chain shocks.

Finally, the chapter's consumer-facing section shows that purchase intent is mediated by an "architecture of trust": visible, reliable infrastructure; credible resale and battery-health information; accessible, decentralized after-sales/repair networks; and competent dealer engagement. These sociotechnical and informational frictions explain why awareness and stated intent have not consistently translated into sustained market uptake.

Taken together, the five sections point to a single, practical conclusion: accelerating India's EV transition requires coordinated, sequenced interventions across the value chain rather than isolated fixes. In practice, this means aligning industrial incentives (PLI, localization) with visible demand (aggregated public procurement and B2B support), rapidly scaling interoperable and audited charging infrastructure (including BaaS/swap pilots where appropriate), strengthening domestic R&D and skills for cell manufacture, and restoring consumer confidence through resale frameworks and decentralized serviceability. The chapter shows these priorities are mutually reinforcing—progress on any one front increases the returns to progress on the others.

If the country can sequence these actions—moving from predictable institutional demand and route-level readiness to parallel investment in manufacturing, standards, and consumer safeguards—the chapter concludes that India can convert current policy momentum into a durable, market-led EV transition rather than a transient, subsidy-led phase.

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Chapter 4

India's EV Policies: Assessment and Future Directions

Chapter Summary

Content:

1. Reviews the evolution of India's EV policy and OEM strategies from NEMMP and FAME-I/II to PLI schemes and PM e-DRIVE and situates these within international policy comparisons.
2. Analyses supply-chain, charging, grid, financing, and TCO issues and synthesizes primary stakeholder inputs to produce actionable policy and industry recommendations.

Findings:

1. Demand-side incentives (notably FAME-II) have supported the scaling of 2W/3W uptake, while supply-side initiatives such as PLI/ACC and localization efforts are still evolving, with continued reliance on imports, DVA requirements, and skill development needs.
2. Charging and grid shortfalls, GST/tax, high upfront costs for buses/trucks, and policy instability create procurement, financing, and operational bottlenecks.

Takeaways:

1. Reform PLIs pragmatically, adopt PPP and data-driven charging rollout, finalize a national battery-swapping policy (with GST rationalization), and expand targeted financing (PSL/guarantees, battery passport).
2. Reallocate support toward heavy/public transport and R&D (alternative chemistries, megawatt charging), introduce time-bound, geography-specific measures, and commit to a stable 5–10-year policy roadmap.

1. Introduction

India's journey towards electric mobility over the past decade represents a compelling case for industrial policy, marked by notable triumphs, some failures, and a gradual evolution from demand-side stimulation to a more complex, supply-focused strategy. Through research in this section, we aim to analyze the evolution of policy in India and examine the relationship between policy and the development of India's EV ecosystem (Agarwal, 2024; India Brand Equity Foundation, 2025).

India's first major policy initiative in this space was the National Electric Mobility Mission Plan (NEMMP), followed by Faster Adoption and Manufacturing of Electric Vehicles (FAME-I). While these early schemes had limited success in driving mass EV adoption, they established the institutional and policy foundations for subsequent interventions (India Brand Equity Foundation, 2025; Kohli, 2024).

The subsequent FAME-II scheme proved more effective, particularly in accelerating adoption in segments such as electric two- and three-wheelers. It addressed one of the key barriers to EV adoption by reducing upfront costs through demand incentives linked to battery capacity. This contributed to rapid growth in these segments, with annual EV sales approaching two million units by FY 2025 and electric two-wheeler sales crossing the one-million-unit mark for the first time (Kohli, 2024; EVreporter, 2025; JMK Research, 2025; SIAM, 2025).

Beyond the demand-side success, there were significant supply- and infrastructure-related challenges. The government's Production-Linked Incentive (PLI) schemes for automobiles have not achieved the same success. The stringent 50% domestic value-addition requirement has proven a barrier for the industry, as a major segment of the value chain still lies in countries such as China. Many critical components, such as battery cells, motors, and semiconductors, are dependent on China. The PLI-ACC scheme has faced geopolitical headwinds and policy design problems, which have largely failed to realize aspirations for cell manufacturing self-sufficiency (Dutta 2025; Grover, 2025).

If we look at the national strategy for charging infrastructure, there might be room for improvement. As per P4.1, P4.4, and P4.5, a top-down, public-sector-led approach led to pervasive range anxiety and significantly underutilized infrastructure. The policy was aligned with market realities, particularly in the two-wheeler segment, where over 95% of charging occurs at workplaces. However, innovative solutions like battery swapping, which address problems such as commercial costs, downtime, and obsolescence, have not taken off due to policy ambiguity, unfavorable GST, and a lack of clarity.

In the current policy phase, the active central-level scheme is PM e-DRIVE. This signals a gradual tapering of subsidies for the two- and three-wheeler segments, while redirecting policy focus towards public transport and other hard-to-abate segments such as heavy commercial vehicles. This shift aligns with expert consensus and reflects a more efficient allocation of public funds (Press Information Bureau, 2025).

Looking ahead to achieving India's 2030 EV target, this chapter explores the policy steps and measures suggested by various industry experts. This section concludes with a set of strategic recommendations synthesized from extensive stakeholder consultations and comparative international analysis. These include:

1. **PLI Reforms**: The domestic value edition norms should be pragmatically recalibrated, and the PLI-ACC scheme must be opened to all qualified players to foster a competitive cell manufacturing ecosystem and begin reducing dependence on Chinese components. PLIs linked to research and development promoting the development of new battery chemistries, assembly methods, etc., must be prioritized.

2. **PPP-led model for Developing Charging Infrastructure**: Till now, the infrastructure development effort has been led by PSUs. However, the coverage is lagging, and the developed infrastructure is also underutilized. Adopting the PPP model and opening this space to private-sector involvement would be critical to adopting a more data-driven, user-centric approach.

3. **Supporting Innovative Business Models**: A national battery swapping policy must be immediately finalized and implemented, addressing critical GST anomalies (mentioned by numerous experts) and mandating some level of interoperability.

4. **Strengthening the Financial Ecosystem**: EV financing must be formally included under Priority Sector Lending, and a "Battery Passport" system should be developed to create a viable second-hand market.

5. **Shift Towards Mandates**: To ensure consistent supply and competition, India should adopt a Zero-Emission Vehicle (ZEV) Mandate, requiring automakers to sell a certain percentage of EVs annually.

6. **Ensuring Long-Term Policy Stability**: The government must provide a clear, consistent, and long-term (5-10 year) policy roadmap to inspire the sustained capital investment required for the ecosystem's growth.

By embracing these reforms, India can build upon the foundational success of its early demand-side policies and create a truly robust, self-reliant, and sustainable electric mobility ecosystem.

2. Methodology

This chapter adopts a qualitative approach combining semi-structured expert interviews with secondary policy and market data analysis. Primary insights were drawn from selected stakeholders across industry, government, and research institutions, while secondary sources, including official policy documents, industry reports, and comparative international cases, were used to triangulate findings. Thematic analysis was employed to identify recurring policy, market, and value-chain challenges shaping India’s EV transition.

Table 1: Respondents' Profiles

Code	Role	Organization Type	Region
P4.1	Independent Consultant	International Research Organization – Sustainable Mobility & Transport Policy	International / India
P4.2	EV Manufacturing Professional	Major Indian Two-Wheeler Manufacturer	National

P4.3	Chief Executive Officer	Electric Mobility Energy Infrastructure & Battery Swapping Company	National
P4.4	Co-founder	Electric Mobility Services & Fleet Solutions Start-up	National
P4.5	Academic	Premier Indian Engineering Institute – Transport Systems & Infrastructure	National
P4.6	Senior Academic	Premier Indian Science & Engineering Institute – Sustainable Transport	National

3. The Evolving Policy Landscape

3.1. The First Phase: NEMMP and FAME-I (2013-2019)

3.1.1. The National Electric Mobility Mission Plan (NEMMP): Setting the Stage

India's journey towards electric mobility began in 2013 with the launch of the National Electric Mobility Plan (NEMMP). This policy was the first attempt to formalize targets, a vision, and other measures to shift towards electric and hybrid vehicles. NEMMP was constituted for several reasons, such as the urgent need to reduce dependence on imported crude oil, address the severe and worsening air quality in its rapidly urbanizing cities, and position India's automotive industry to be independent and a leader in the next generation of mobility technologies (Agarwal, 2024).

In terms of scope, the targets were ambitious, and the strategy encompassed demand creation, research and development, projects, charging infrastructure, and supply-side incentives. It set a bold target of achieving 6-7 million electric and hybrid vehicle sales by 2020 (Agarwal, 2024). While the numerical targets were ultimately not met, the significance of NEMMP was not in the immediate outcome but in its role as a powerful signaling mechanism. It declared the government's intent to foster a long-term EV ecosystem, providing the industry with confidence (Kohli, 2024).

3.1.2. FAME-I (2015-2019): A Tentative First Step

The first policy after the NEMMP framework was the Faster Adoption and Manufacturing of Electric Vehicles (FAME-1) scheme, launched in April 2015 with an initial outlay of ₹895 crore. FAME-1 was designed as a multi-pronged initiative focusing on four key areas: demand incentives, technology platforms, pilot projects, and charging infrastructure. The scheme was a direct upfront subsidy provided to consumers at the point of purchase to reduce the high upfront cost of EVs (Kohli, 2024).

The implementation and impact of FAME-1 were relatively limited. According to public policy expert P4.1, the scheme was associated with factors such as a complex design, comparatively lower incentive levels, and detailed eligibility criteria. Over its four-year tenure, FAME-I supported the sale of approximately 2.55 lakh EVs, with around ₹307 crore spent on direct purchase incentives.

A significant portion of the vehicles supported were low-speed electric two-wheelers and e-rickshaws, which, while beneficial for last-mile connectivity, did not represent a technological leap forward for the automotive industry. As P4.2, an industry expert, recalled, the market during this period was largely dominated by EVs powered by lead-acid batteries.

3.1.3. Early Market Response and Lessons Learned

The response to FAME-I incentives was relatively moderate, with adoption levels below the initial expectations outlined under the NEMMP framework. In some cases, subsidy levels were insufficient to fully offset the price differential between EVs and comparable ICE vehicles.

The eligibility criteria under FAME-I were relatively detailed, which may have influenced accessibility for certain stakeholders. In comparison, FAME-II was introduced with a significantly larger budget allocation and an expanded scope.

Therefore, the primary legacy of FAME-I was not the number of vehicles it helped sell but the critical policy intelligence it generated, paving the way for a more robust and effective strategy in the subsequent phase (Kohli, 2024).

3.2. The Acceleration Phase: FAME-II and the Market Take-Off (2019-2024)

3.2.1. Policy Deep Dive: The Architecture of FAME-II

The FAME-2 scheme was launched in April 2019 with a budget of ₹10,000 crore, which was later increased to ₹11,500 crore. This represented a shift in government priorities towards a more aggressive, focused policy. The objective of the scheme was to drive demand for public and two-wheeler electric transport through upfront demand incentives (Press Information Bureau, 2025; ICCT, 2024; JMK Research, 2025). The subsidy mechanism was the fundamental block of FAME-2. Initially, it offered an incentive of ₹10,000 per kilowatt-hour (kWh) of battery capacity. This was important because it linked the subsidy to battery size; the policy favored vehicles with advanced lithium-ion batteries over older technologies. The scheme set ambitious targets to support 10 lakh electric two-wheelers (e-2Ws), 5 lakh electric three-wheelers (e-3Ws), 55,000 electric four-wheelers (e-4Ws), and 7,090 electric buses.

In June 2021, the government increased the subsidy for e-2Ws by 50% to ₹15,000 per kWh and raised the cap on the incentive from 20% to 40% of the vehicle's cost. However, as the scheme's budget began to deplete due to overwhelming demand, the incentive was dialed back in June 2023 to ₹10,000 per kWh with a lower cap of 15% of the ex-factory price. Beyond vehicle subsidies, FAME-II also earmarked ₹1,000 crore for the development of public charging infrastructure, sanctioning thousands of stations across cities and highways to address the critical issue of range anxiety (Kohli, 2024).

3.2.2. The Impact on Vehicle Affordability and Total Cost of Ownership (TCO)

The combined effect of FAME-II and other fiscal measures had a positive impact on consumers. In August 2019, the Goods and Services Tax (GST) on EVs was slashed from 12% to 5%, instead of the 28% (plus cess) levied on ICE vehicles. This alone saved a buyer approximately ₹70,000 on a ₹10 lakh electric car. The central government encouraged states to waive road tax and registration fees, an incentive adopted by many, which could save consumers an additional 4-10% of the vehicle's cost.

This multi-layered incentive structure dramatically lowered the high upfront cost, which was identified by industry leaders like P4.3, Chief Executive of an Electric Mobility Energy Infrastructure and Battery Swapping Technology Company in India, as a primary barrier to adoption. For commercial users, the calculation became even more compelling. As P4.4, co-founder at an Electric Mobility Services and Fleet Solutions Start-up, explained, the B2B segment shifted rapidly because the economics were undeniable. For a gig-economy rider covering 2,000-3,000 km per month, the lower running cost of an EV—approximately ₹1/km compared to ₹2.5-3/km for petrol—translates into substantial monthly savings. When combined with FAME-II subsidies and the emergence of Battery-as-a-Service (BaaS) models that removed battery costs from the vehicle's upfront price, the Total Cost of Ownership (TCO) for commercial EVs fell decisively below that of their ICE counterparts (Kohli, 2024; JMK Research, 2025).

3.2.3. The Sales Surge: A Policy-Driven Market Boom

The impact of this policy push on the market was explosive. Annual EV sales, which stood at a modest 1.6 lakh units in FY20, skyrocketed to nearly 2 million units by FY25, a more-than-tenfold increase in just five years.

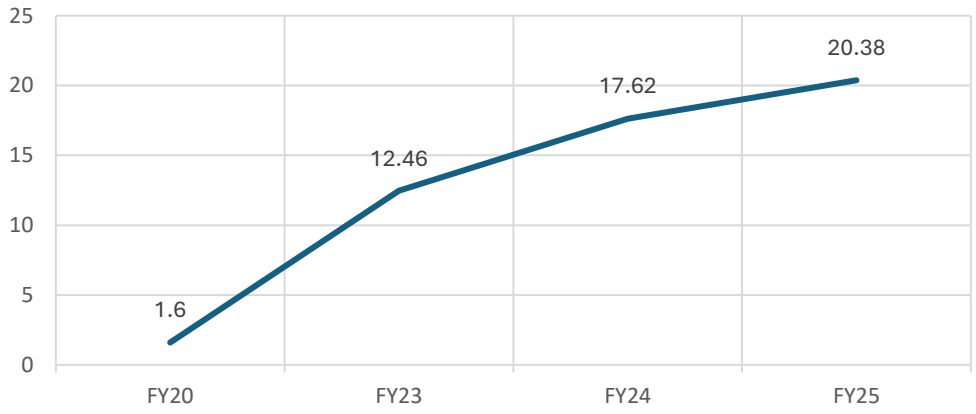


Figure 1: Annual EV Sales in India (in lakhs) (FY2020-25)

The e-2W segment, the primary beneficiary of the enhanced FAME-II subsidy, led this charge. In FY25, e-2W sales crossed the 1-million-unit milestone for the first time, capturing a market share of approximately 6.2% of total two-wheeler sales. The e-3W segment also saw remarkable penetration, with the passenger L5 category reaching an impressive 22.8% market share in FY25. Even the passenger car segment, which received less direct support under FAME-II, saw sales grow from a few hundred units in 2015 to over 99,000 units in calendar year 2024, crossing the 2% market share threshold for the first time.

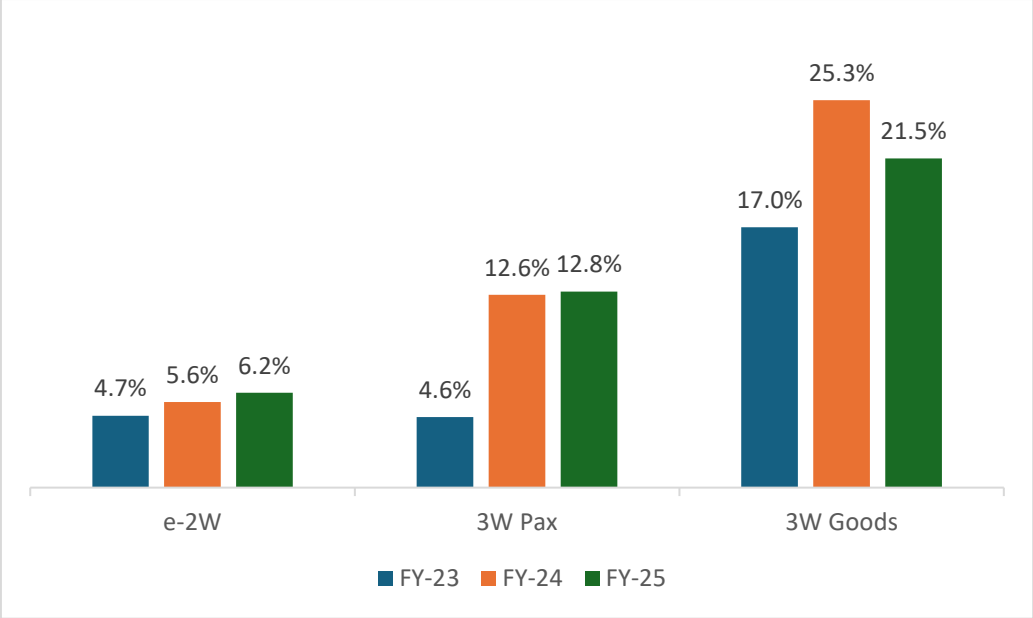


Figure 2: EV Market Share by Segment in India (FY2025)

The design of the FAME-2 subsidy helped in increasing sales volume; it also accelerated technological maturation. By linking incentives to the battery capacity (kWh), the policy created a clear financial advantage for vehicles equipped with modern, high-capacity lithium-ion batteries. This made high-performance electric scooters from players like Ola and TVS price-competitive with older models that previously dominated the market. As a result, consumers were incentivized to choose technologically superior products, and manufacturers were pushed to innovate and scale up production of these advanced models. The policy, therefore, acted as a catalyst, effectively subsidizing the market's leap from a low-tech, nascent stage to a high-tech, high-growth phase (EVreporter, 2025; JMK Research, 2025; SIAM, 2025).

3.2.4. Industry Verdict on FAME-II

The industry consensus is that FAME-II was a resounding success and a pivotal policy intervention. P4.2 described the scheme as "critical during the early loss-making years," drawing a sharp contrast with FAME-I, which they noted was misused by some players.

A transport systems and infrastructure expert (P4.5) concurred, stating that the policies were highly effective in boosting adoption, particularly in the two-wheeler, three-wheeler, and bus segments.

However, the scheme was not without its challenges. The stringent localization requirements tied to the subsidies proved difficult for some manufacturers to meet. This led to instances of non-compliance and subsequent penalties, an issue highlighted by P4.4, which noted that major players were heavily penalized for allegedly misusing incentives without achieving true localization. These enforcement actions, while causing short-term disruption, underscored the government's seriousness about the "Make in India" component of the policy, pushing the industry towards greater domestic value addition.

3.3. The Third Phase: PLI Schemes

3.3.1. The Twin Pillars: PLI-Auto and PLI-ACC

As the FAME-II scheme successfully ignited demand, the policy focus began to pivot towards building a robust domestic manufacturing ecosystem. The government's primary instruments for this objective were two ambitious Production-Linked Incentive (PLI) schemes launched in 2021: the PLI scheme for Automobile and Auto Components (PLI-Auto) with an outlay of ₹25,938 crore, and the PLI scheme for Advanced Chemistry Cell (ACC) Battery Storage with an outlay of ₹18,100 crore.

The goal of these schemes was to incentivize domestic manufacturing of advanced automotive technology products, with a strong focus on EVs, their components, and battery cells, thereby reducing India's significant import dependence. The mechanism was designed to reward incremental production and sales. A key feature of the schemes is the requirement for companies to achieve a minimum of 50% Domestic Value Addition (DVA) in their eligible products. This high threshold was intended to ensure deeper localization and prevent the schemes from subsidizing mere "screwdriver" assembly operations (Dutta, 2025; Grover, 2025; PIB, 2025).

As of July 2025, four years after the scheme's launch, 16 out of 85 approved firms under the PLI-Auto scheme had qualified for incentives by meeting the DVA criteria. Budgetary data for FY 2024–25 shows that against an allocation of ₹3,500 crore for PLI-Auto disbursements, the revised estimates indicate expenditure of ₹346 crore, just under 10% of the allocated amount (Modifi, 2025; Economic Times Auto, 2025; Grover, 2025).

3.3.2. Progress in Cell Manufacturing (PLI-ACC)

The implementation of the PLI-ACC scheme, a key component of India's EV manufacturing strategy, has been discussed in stakeholder inputs. P4.1 highlighted aspects related to scheme design and participation structure, noting that these may influence and slow the pace of progress. As of June 2025, a total of four applications had been approved under the scheme.

3.3.3. The Import Dependency Dilemma

A key consideration in the PLI schemes concerns the interaction between the 50% DVA requirement and India's current EV supply chain structure. Stakeholder inputs highlight that there remains a significant reliance on imports for certain high-value EV components. As P4.3 noted, "India doesn't make cells, chips, or semiconductors," indicating continued dependence in these areas.

This dependence is particularly relevant in the context of global supply chains for battery cells, rare-earth magnets used in motors, and power electronics, where countries such as China play a dominant role. As a result, achieving the 50% DVA threshold may present challenges. Even leading EV manufacturers continue to rely on imported battery systems from global suppliers.

The situation was further exacerbated by China's recent export restrictions on key rare-earth magnets, which, as P4.2 highlighted, created a "motor and magnet crisis" for the industry. This forced some manufacturers to consider importing entire motor assemblies, making DVA compliance a challenge.

The PLI scheme's design, while right in its approach to fostering deep manufacturing of advanced technology, has also influenced certain implementation outcomes. To have any chance of meeting the 50% DVA threshold, manufacturers are compelled to maximize localization of lower-value, less technologically complex components—such as the chassis, plastic body parts, and basic wiring—while continuing to import the high-value technological core of the vehicle: the battery pack, motor, and battery management system (BMS). These dynamic risks create a fragile "screwdriver" industry that is proficient at assembly but remains strategically dependent on imported technology (Dutta, 2025; Wischer, 2024; Goel et al., 2024).

3.4. The Fourth Phase: PM e-DRIVE (2024 Onwards)

3.4.1. Analyzing the New Framework: PM e-DRIVE

The conclusion of the highly successful FAME-II schemes in March 2024 marked the end of the initial, high-subsidy phase of India's EV policy. Its successor, the Prime Minister’s Electric Drive Revolution in Innovative Vehicle Enhancement (PM e-DRIVE) scheme, was launched on October 1, 2024, signaling a new, more mature phase in the government's strategy. With a substantial outlay of ₹10,900 crore and a longer-term horizon extending to FY2028, PM e-DRIVE represents a strategic recalibration based on lessons from the past decade.

The scheme aims to support the deployment of approximately 28 lakh new EVs, with specific targets including 24.8 lakh e-2Ws, 3.16 lakh e-3Ws, and, significantly, 14,028 e-buses and e-trucks. This marks a pivotal strategic shift. As noted by P4.1, for the first time, a central scheme provides purchase incentives for heavy-duty trucks. This is a crucial development, as freight trucks, while small in number, contribute disproportionately to emissions and represent a hard-to-abate segment of the transport sector. The scheme's architecture reflects a more nuanced understanding of the market, moving away from broad-based support to targeted interventions (PIB, 2025)

3.4.2. The Tapering of Subsidies: A Market Test

One of the most significant features of PM e-DRIVE is the deliberate and scheduled phasing out of demand-side subsidies for the two- and three-wheeler segments. The policy explicitly plans to end all subsidies for these categories by March 2026. In the interim, the incentive levels have been reduced. From April 2025, the subsidy was halved to just ₹2,500 per kWh, with a nominal cap of only ₹5,000 per two-wheeler—a fraction of the ₹30,000-₹45,000 benefits available at the peak of FAME-II.

This policy move is a sign of confidence in the market's maturity and is remarkably aligned with the prevailing industry sentiment. As Respondent P4.2 articulated, demand-side incentives for two-wheelers are "not needed anymore". They argued that the industry is approaching profitability, and with many e-scooters already achieving price parity with their ICE counterparts in the sub-₹1 lakh segment, the market is ready to stand on its own feet. The government's decision to withdraw these subsidies represents a market test, pushing the industry to compete on product quality and TCO rather than relying on state support. It also frees up significant public funds that can be reallocated to more nascent or challenging segments (Kohli, 2024).

3.4.3. A New Focus on Public and Heavy Transport

The reallocation of fiscal resources is clearly visible in the structure of PM e-DRIVE and its associated schemes. A substantial portion of the outlay is now directed towards the electrification of public and heavy commercial transport. The scheme includes a large allocation for e-buses and introduces incentives for e-trucks, coupled with a requirement for a vehicle scrapping certificate, thus promoting a circular economy. This strategic pivot directly reflects the policy recommendations of experts like P4.6, who have long advocated for prioritizing the electrification of public transport over subsidizing private cars. They argued that subsidizing personal cars primarily benefits wealthier individuals and exacerbates urban congestion, whereas electrifying buses and commercial fleets yields a much higher societal return in terms of emission reduction and public good.

3.5. Global Policies and Outcomes

As India navigates the next phase of its EV transition, examining the policy frameworks of other nations that have achieved high adoption rates offers valuable strategic insights. The experiences of Norway, China, and the United States highlight different philosophical approaches to market creation and industrial policy.

3.5.1. The Norwegian Model: Comprehensive Incentives and Long-Term Commitment

Norway stands as the global benchmark for EV adoption, with electric vehicles consistently accounting for most new car sales. This success was not accidental but the result of a long-term, comprehensive, and powerful set of policy interventions. The cornerstone of the Norwegian model was a suite of fiscal incentives so generous that they often made buying and owning an EV significantly cheaper than an equivalent ICE vehicle.

The primary lever was the complete exemption of EVs from two substantial taxes levied on ICE cars: a high, one-time registration tax and a 25% Value Added Tax (VAT). This alone could make an EV's sticker price lower than its petrol counterpart. This powerful price signal was reinforced by a host of non-fiscal "perks" that enhanced the daily value proposition for EV owners, including waivers or significant reductions on road tolls, public parking fees, and ferry charges, as well as privileged access to bus lanes in congested urban areas. According to a detailed policy analysis, the key drivers of Norway's success were an unwavering and long-term political will, a commitment to substantial financial support (estimated at over $22,000 per vehicle in 2022), and a willingness to experiment and adapt policies over time (OECD, 2022; Yatsura, 2025; IEEE Power & Energy Magazine, 2023).

3.5.2. The Chinese Model: State-Driven Industrial Policy

China's approach to electrification has been a textbook example of state-led industrial policy, aimed at achieving global dominance in a strategic sunrise industry. The strategy employed a powerful dual-pronged approach that simultaneously stimulated demand and mandated supply.

On the demand side, China offered massive consumer subsidies for over a decade, which were instrumental in creating the world's largest EV market. These subsidies were gradually phased out as the market matured, ending in 2022. However, the more potent and enduring policy lever has been on the supply side: the "dual-credit" policy, also known as the New Energy Vehicle (NEV) mandate. This regulation requires every major automaker to meet an EV quota as a percentage of total sales. Manufacturers who fail to meet their targets must either buy credits from competitors who have exceeded their quotas (such as Tesla or BYD) or face significant financial penalties. This powerful mandate effectively forced the entire industry, including reluctant legacy automakers, to invest in and produce EVs, ensuring a consistent and growing supply of models in the market. This was supported by a massive, state-directed rollout of public charging infrastructure, with China installing far more chargers than any other nation (EESI, 2025; CSIS, 2025; DieselNet, n.d.).

3.5.3. The U.S. Approach: A Federal-State Hybrid Model

The United States has pursued a more fragmented, hybrid approach to EV promotion, characterized by a combination of federal incentives and a diverse patchwork of state-level policies. The primary federal instrument is a tax credit for new EV purchases, which, under the 2022 Inflation Reduction Act, can be up to $7,500. However, this credit is subject to a complex and evolving set of eligibility criteria, including strict caps on the vehicle's Manufacturer's Suggested Retail Price (MSRP), the buyer's adjusted gross income, and, most notably, stringent requirements for the sourcing of battery components and critical minerals from North America or free-trade partners.

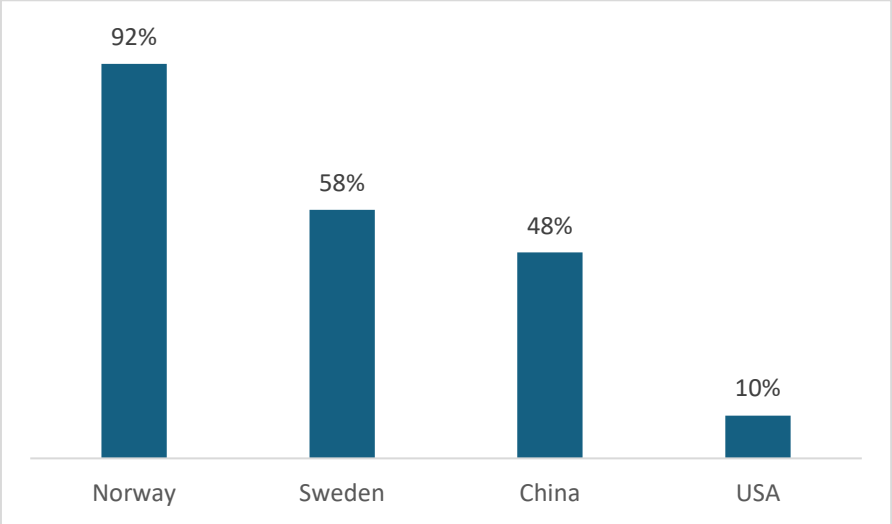


Figure 3: Electric Car Market Share in Select Countries (2024) (IEA)

This federal incentive is then supplemented by a wide array of state-level programs. States like California have been particularly aggressive, offering additional consumer rebates, grants for charging infrastructure, and non-fiscal perks like single-occupant access to High-Occupancy Vehicle (HOV) lanes. Other states offer more modest incentives, such as waivers on registration fees or rebates for home charger installation. This federal-state model has led to highly uneven EV adoption across the country, with penetration rates being significantly higher in states with strong local policies (Tesla Support, n.d; DriveClean, n.d).

Table 2: Comparative Analysis of International EV Policy Levers

Country	Primary Policy Lever	Key Implementation Details	Observed Outcome/Impact
Norway	Overwhelming Tax Exemption	Full exemption from high registration tax & 25% VAT. Complemented by strong non-fiscal perks (tolls, parking, bus lanes).	World's highest EV market share. Made EVs cheaper to buy and own than ICE vehicles, creating a powerful consumer pull.
China	Supply-Side Mandate ("Dual-Credit" Policy)	Forced automakers to produce a quota of EVs or buy credits. Preceded by massive, now-phased-out demand subsidies and state-led charging rollout.	World's largest EV market by volume. Created a hyper-competitive domestic industry and ensured a consistent supply of new models.
USA	Federal Tax Credit + State-Level Patchwork	Federal tax credit up to $7,500 with strict income, price, and supply chain (sourcing) restrictions. Varies greatly by state.	Uneven adoption across the country. The complexity of federal rules and reliance on state action have led to slower national penetration.
India	Demand-Side Subsidy (FAME) + Supply-Side Incentive (PLI)	Direct upfront subsidy (FAME), now tapering. PLI scheme to incentivize local production, but with high DVA hurdles and low uptake.	Hybrid model. Highly successful in 2W/3W segments due to FAME. Struggling in 4W and domestic manufacturing due to ineffective PLI and a lack of a strong, decisive lever.

3.5.4. Actionable Insights for India

A comparative analysis shows that India’s policy framework combines demand- and supply-side measures but differs in intensity and focus from international models such as those in Norway and China. These countries have adopted more concentrated and accelerated policy approaches to drive EV adoption.

India’s primary demand-side instrument, the FAME subsidy, has helped reduce the price differential between EVs and ICE vehicles. However, the extent of price parity varies across segments, particularly

relative to Norway's extensive tax exemptions, which have significantly lowered the cost of EV ownership.

On the supply side, India's PLI scheme operates as an incentive-based mechanism, whereas China's dual-credit system incorporates a more forceful production mandate. Available data and stakeholder input indicate that policy intensity and decisiveness can influence outcomes across markets.

These comparisons highlight the importance of aligning policy tools with segment-specific dynamics. While incremental, subsidy-led approaches have supported adoption in segments such as two-wheelers, where cost gaps are relatively smaller, more targeted and regulatory policy instruments may be relevant for segments with slow uptake, such as passenger cars.

4. Mapping the Supply Chain

4.1. Upstream: Raw Materials and Component Manufacturing

4.1.1. Raw Material Sourcing

As the foundational stage of the EV battery value chain, this segment is closely linked to global supply chains. India has limited domestic reserves of critical minerals such as lithium, nickel, and cobalt, which are essential for high-energy-density lithium-ion batteries. Consequently, supply for these minerals, along with other key materials such as graphite, is largely supported through imports (Wischer, 2024; Goel et al., 2024).

4.1.2. Component Manufacturing

a. Battery Components:

The most significant gap is in battery cells. India has no large-scale commercial production of lithium-ion cells and overwhelmingly imports them from China, South Korea, and Japan. While Battery Management Systems (BMS) are designed locally, crucial electronic components like semiconductors are imported. This aligns with the critique by industry experts who advocate for a "component-level PLI scheme" to build a resilient supply chain beyond final assembly.

b. Electric Powertrain Components:

A mix of local assembly and imports characterizes the powertrain segment. Critical subcomponents such as permanent magnets and power electronics (inverters, converters) are often imported due to a lack of a domestic semiconductor ecosystem (Goel et al., 2024).

4.2. Midstream: Vehicle and Pack Assembly

4.2.1. Cell-to-Pack Assembly

This segment involves assembling imported cells into complete battery packs, which are integrated with locally designed battery management systems (BMS), thermal management systems, and casings.

The growth of battery-as-a-service models that rely on local pack assembly reflects the evolving capabilities in this area.

4.2.2. Vehicle OEM Assembly

This is the most mature part of the Indian EV supply chain. Leading domestic and international OEMs, like Tata Motors, Mahindra, Ola Electric, and Ather Energy, are locally assembling a wide range of two-wheelers, three-wheelers, passenger cars, and buses. A strategic focus on electrifying public transport, such as e-buses, has been recommended to maximize environmental impact (JMK Research, 2025).

4.3. Downstream: Market and Consumer Ecosystem

4.3.1. Charging and Energy Infrastructure

The downstream ecosystem includes a growing network of public charging stations and emerging battery-swapping services. This involves densifying strategically located charging infrastructure while also developing battery swapping as an alternative for commercial fleets, particularly to address upfront costs and charging time.

4.3.2. Vehicle Financing

Access to affordable finance remains a major barrier for consumers. Financial institutions perceive higher risks associated with EVs due to uncertainty in battery life and resale value, leading to unfavorable loan terms. Experts have called for policy interventions, such as the inclusion of EV financing under Priority Sector Lending (PSL), to de-risk the proposition for lenders (NITI Aayog, 2025).

4.3.3. End-of-Life: The Circular Economy

Governed by the Battery Waste Management Rules, 2022, this nascent segment is critical for long-term sustainability and resource security. It involves repurposing used EV batteries for second-life applications, such as stationary energy storage, and eventually recycling them to recover valuable minerals. This is essential for creating a closed-loop supply chain and reducing reliance on imports of fresh raw materials (Goel et al., 2024).

5. Challenges on the Ground

While policy has successfully spurred vehicle sales, the broader ecosystem needed to sustain this growth must be established. Significant challenges in charging infrastructure, innovative business models, and financing have emerged as critical bottlenecks, revealing gaps between policy intent and market reality.

5.1. Infrastructure and Technology Challenges

5.1.1. Charging Deficit

The development of the charging network has been identified as an important aspect of the EV transition, with ₹1,000 crore allocated under FAME-II and a further ₹2,000 crore under PM e-DRIVE. However, the government's chosen strategy, which is a top-down model led by Public Sector Undertakings (PSUs), has been discussed in stakeholder inputs.

According to P4.1, the current approach presents certain implementation challenges. The respondent indicated that factors such as guideline design and limited integration of private-sector expertise may have affected outcomes in FAME-II, noting that a significant share of PSU-installed chargers is reported to be non-functional, with implications for resource utilization. P4.1 also characterized charging infrastructure as a key factor in EV adoption and suggested that similar considerations will be relevant to the PM e-DRIVE scheme.

This perspective highlights a divergence between reported installation figures and user-level experience, where the availability and reliability of charging infrastructure vary across locations.

This is further influenced by considerations around commercial viability. As P4.5 explained, the use of existing public chargers is relatively low, which can discourage private investment, particularly given payback periods. This highlights the importance of aligning infrastructure development with observed user behavior.

P4.2, talking about his experience with leading two-wheeler OEMs, argued that for the dominant e-2W segment, public charging anxiety is limited. They indicated that a significant share of charging—over 95%—occurs at home or at workplaces. This highlights the need to consider usage patterns across segments when planning the deployment of charging infrastructure, particularly the requirements of high-volume segments in the EV market.

5.1.2. Grid & Power Issues

The reliability and capacity of the electrical grid are fundamental to a successful EV charging ecosystem. India faces significant challenges from the high-tension grid down to the last-mile connection.

a. Slow High-Power Connection Approvals

Setting up a public charging station, particularly a fast-charging plaza, requires a high-tension connection from the local distribution company (DISCOM). CPOs report that this process is often mired in bureaucratic delays.

b. Grid Instability and Unreliable Supply

The Indian power grid, especially in rural and semi-urban areas, suffers from instability and frequent outages. Rural feeders often provide power for only 8-12 hours a day, making them unreliable for EV charging and eroding driver confidence.

P4.4's operational experience directly confirms these challenges. They described the immense difficulty in securing high-capacity power lines for their swapping stations. They mentioned that getting a connection is a significant undertaking that involves lengthy negotiations and approvals from DISCOMs. These processes can influence project timelines and cost structures for charging infrastructure deployment. The experience underscores the importance of grid access in infrastructure planning and execution.

5.1.3. Lack of Standardization

a. Multiple Charging Protocols

India currently supports multiple charging standards (e.g., CCS, CHAdeMO, Bharat DC), resulting in vehicles using different protocols. This requires Charge Point Operators (CPOs) to install multiple connector types, which can increase costs and affect interoperability across vehicle models.

b. Fragmented User Experience

Consumers often need to use multiple mobile applications for different charging networks, which can reduce convenience. The development of interoperable systems, such as unified payment interfaces or roaming networks, may improve user experience by enabling access across multiple providers through a single platform.

5.1.4. Battery Technology

The battery is the single most expensive component of an EV, and concerns related to its cost, lifespan, and environmental impact are major considerations.

a. High Battery Replacement Cost

The cost of replacing an EV battery pack outside its warranty period can be prohibitively high, often 30-50% of the vehicle's original price (Vignesh, 2026). This future financial risk is a significant deterrent.

b. Lack of a Circular Economy

The ecosystem for second-life applications and recycling of EV batteries is still developing in India. This raises concerns about the long-term environmental impact and represents a lost economic opportunity to recover valuable materials.

5.1.5. Infrastructure Needs

To make EVs a viable alternative to ICE vehicles, the charging network must match the density and reliability of petrol pumps. This requires a concerted effort involving both public policy and private investment.

a. Access to Prime Real Estate

Charging infrastructure deployment may benefit from access to strategically located land, including government-owned spaces, supported through models such as Public-Private Partnerships (PPP), which can help manage capital costs.

b. Favorable Electricity Tariffs

Stakeholder inputs (P4.1 and P4.5) indicate that electricity tariffs are an important factor in the commercial viability of charging infrastructure. Variations in commercial tariffs across DISCOMs can influence operating costs, and discussions have included the potential role of more standardized or EV-specific tariff structures.

5.2. Policy & Regulatory Hurdles

5.2.1. Policy Instability

The effectiveness of India's EV transition is severely undermined by a lack of long-term policy consistency. This creates a high-risk environment for businesses, discouraging the very investments needed to build a robust domestic EV ecosystem.

a. Policy Continuity and Timeline Considerations

Policies such as the FAME (Faster Adoption and Manufacturing of Electric Vehicles) scheme have undergone periodic revisions, updates, and extensions, which can influence market conditions. This may affect manufacturers' and component suppliers' ability to make long-term capital investment decisions in an evolving subsidy and regulatory environment.

This issue was highlighted by industry experts as a key concern. P4.1 referred to this as a lack of continuity in policy timelines, noting that uncertainty can influence investment decisions. The respondent cited instances in which scheme durations—such as the initial 2-year horizon for PM e-DRIVE—may be perceived as relatively short by producers.

Such factors can affect companies' willingness to commit significant capital to new production lines or R&D facilities, particularly when policy support enhances project viability. This may, in turn, influence the pace of innovation and the realization of economies of scale within the sector.

5.2.2. GST Structure and the Battery Swapping Ecosystem

Variations in the Goods and Services Tax (GST) structure across components of the battery-swapping ecosystem have been highlighted in stakeholder inputs, particularly regarding the adoption of electric two- and three-wheelers.

a. Differential Tax Rates

While a complete EV is taxed at a favorable 5% GST, the core components of the swapping ecosystem are taxed at 18% GST. This includes the batteries and the charging/swapping stations.

b. Working Capital Considerations

Stakeholders noted that this structure has implications for cash flow management. Swapping operators procure batteries at 18% GST and can offset this only through the Input Tax Credit (ITC) against the GST applied to services. Given that batteries are long-term capital assets, adjustments to input tax credits may occur over a long period, thereby influencing working capital requirements.

Stakeholder perspectives indicate a strong interest in GST rationalization. P4.3 referred to this as a key issue for the sector, while P4.3 and P4.4 highlighted its implications for financial planning and cash flow management. Suggestions discussed include aligning GST rates across batteries, swapping infrastructure, and services with the 5% rate applicable to EVs, which may support working capital efficiency and sectoral scale-up.

5.2.3. Incentive Structures Under FAME-II

The design of incentive structures under FAME-II has been examined in stakeholder discussions, particularly regarding their impact across vehicle segments.

a. Incentives Tied to Battery Size

The initial structure of FAME-II linked subsidy levels to battery capacity (kWh). This approach provided relatively higher incentives for larger-battery vehicles, including higher-end scooters and motorcycles, while offering comparatively lower incentives for smaller, more affordable two-wheelers.

Stakeholders noted that such differentiation may influence adoption patterns across segments. P4.6 emphasized the importance of balanced incentive structures and highlighted the need to ensure that subsidy frameworks support broad-based accessibility while aligning with market needs.

5.2.4. Policy Coverage for Battery Swapping

P4.4 noted that existing schemes are predominantly oriented toward charging infrastructure and highlighted the importance of considering battery swapping as part of the broader energy ecosystem. P4.4 emphasized that battery swapping is a legitimate and highly efficient form of energy infrastructure that requires greater policy focus. It needs to be included in government tenders and made eligible for the same fiscal and non-fiscal incentives offered to the plug-in charging ecosystem. Without this level playing field, a crucial part of the EV solution is being held back.

5.2.5. Implementation Considerations

Stakeholders highlighted that implementation dynamics can influence policy outcomes, particularly in terms of industry confidence and market stability.

a. Subsidy Compliance and Enforcement

Instances have been reported in which certain manufacturers claimed FAME-II subsidies without fully meeting the localization (Phased Manufacturing Program – PMP) requirements. Subsequent enforcement actions, including penalties and recovery measures, were undertaken.

Stakeholders noted that such developments can influence perceptions of policy predictability and compliance processes. Inputs from experts, including P4.6, underscore the importance of stable, transparent policy environments for supporting long-term investment decisions.

5.2.6. Policy Development Status

P4.1 indicated that a policy related to battery swapping had been developed with industry inputs, but has not been implemented yet. In the absence of a formalized framework, certain areas—such as GST alignment and technical standardization—continue to evolve. Stakeholders noted that clarity in these areas may support the development of the battery-swapping ecosystem, particularly for two- and three-wheeler segments.

5.3. Economic & Financial Barriers

5.3.1. High Upfront Cost

Despite government subsidies under schemes like FAME, the initial purchase price of an EV remains significantly higher than its Internal Combustion Engine (ICE) counterpart. This sticker shock is a primary deterrent for the price-sensitive Indian consumer. While the Total Cost of Ownership (TCO) of an EV is often lower over its lifetime due to savings on fuel and maintenance, the high initial capital outlay is a major barrier to entry, preventing many potential buyers from even considering an electric option.

5.3.2. Difficult Financing

The high upfront cost is compounded by the difficulty in securing affordable financing. Mainstream financial institutions have remained cautious and risk-averse in financing EVs.

a. Lender Hesitancy

Banks and Non-Banking Financial Companies (NBFCs) often perceive EVs as a high-risk category. This is due to concerns about the rapid evolution of battery technology (potentially making current models obsolete), uncertainty about the battery's long-term health and performance, and the lack of a robust resale market to accurately assess residual value.

b. Unfavorable Loan Terms

This perceived risk translates into unfavorable terms for the borrower, such as requiring higher down payments (lower loan-to-value ratios), charging higher interest rates, and offering shorter loan terms than for petrol or diesel vehicles.

This issue was raised independently by both P4.3 and P4.5, who observed that commercial banks are often hesitant to finance electric two- and three-wheelers due to perceived risks related to technology, battery life, and resale value. This creates a significant barrier for individual drivers and small fleet operators who wish to transition to electric vehicles. The consensus recommendation from these experts is for the government to formally include EV financing under the ambit of Priority Sector Lending and to create government-backed credit guarantee schemes. This would de-risk the proposition for lenders and unlock the flow of affordable capital necessary to finance the next wave of EV adoption.

5.3.3. Uncertain Resale Value

The lack of a mature and organized secondary market for used EVs is a significant concern for consumers. The value of a used EV is closely tied to its battery's health, which degrades over time. Without standardized methods for battery health assessment and a clear understanding of replacement costs, potential buyers are worried that their significant initial investment will evaporate, leaving them with a vehicle that has very low resale value after a few years. This uncertainty further fuels financing institutions' reluctance.

5.3.4. Supply Chain & Manufacturing Issues

a. Import Dependency

India's ambition to become a global EV manufacturing hub is challenged by its heavy reliance on imports for the most critical components.

b. Lithium-Ion Cell Imports

India has no significant domestic manufacturing capacity for lithium-ion cells, the fundamental building block of an EV battery pack. The country is almost entirely dependent on imports, primarily from China, for these cells. This dependency exposes the Indian EV industry to geopolitical supply chain disruptions and price volatility.

c. Lack of Raw Materials

Compounding the import dependency is the geological reality that India lacks significant domestic reserves of the essential raw materials required for current battery chemistries. This includes lithium, nickel, and cobalt. Securing a stable and long-term supply of these minerals requires strategic international partnerships, investments in overseas mines, and aggressive promotion of research into alternative battery chemistries that use more abundant materials.

d. Skill Gap

The transition to e-mobility requires a workforce with new and specialized skills. There is a notable shortage of skilled labor across the entire EV value chain, from R&D in battery chemistry and Battery Management Systems (BMS) to advanced automotive manufacturing, thermal management design to even dealership consulting. This skill gap can lead to delays in product development, quality control issues, and safety concerns

5.3.5. Consumer Adoption Barriers

a. Range Anxiety

The fear that an EV will run out of battery charge before a charging point can be found remains one of the most powerful psychological barriers. This is a top concern for potential buyers, particularly outside the major urban centers where charging infrastructure is sparse.

b. Lack of Awareness

A significant portion of the population, especially in Tier-2 and Tier-3 cities and rural areas, lacks awareness of EV benefits. There is limited knowledge of the long-term economic advantages (lower operating costs), the different types of available models, the availability of government incentives, and the basics of charging.

c. Public Transport Focus

While the government has promoted personal EVs, some experts argue that this focus is misplaced and advocate for a strategic shift in subsidies and policy support towards the electrification of public and commercial transport. P4.6 argued that the primary policy goal should be to reduce pollution in the most efficient way possible. From this perspective, subsidies should be heavily skewed toward electrifying vehicles with the highest utilization, such as city buses, taxis, and last-mile delivery vehicles, rather than over-subsidizing personal vehicles.

6. Policy Recommendations

Based on insights from secondary research and stakeholder consultations, the following recommendations are presented to support ongoing policy evolution for EV adoption in India. The analysis indicates a potential shift from broad-based policy instruments toward more targeted interventions, particularly for segments with relatively lower adoption, underdeveloped value chain components, and opportunities for cross-sector collaboration.

6.1. Policies Focused on Trucks and Buses

Demand-side incentives have supported early EV adoption, particularly in two- and three-wheelers, which are now showing increasing market maturity. In this context, incentives can be gradually adjusted across segments.

Future incentives can be better aligned with segment-specific needs. For example, support for relatively mature segments may decline over time, while greater focus can be placed on segments that are still in their early stages and offer higher emissions-reduction potential. Stakeholders such as P4.1 and P4.6 highlighted the importance of focusing on heavy-duty trucks, inter-city buses, and commercial fleet vehicles.

Inputs from stakeholders and policymakers at NITI Aayog also suggest that incentive design may be more effective when differentiated across vehicle categories. The following segment-specific approaches have been discussed:

a. N1 (Light Commercial Vehicles)

Focus on tapering demand subsidies as they approach TCO parity, utilizing "soft mandates" for large e-commerce and logistics fleets.

b. N2 (Medium Commercial Vehicles)

Provide higher, long-term purchase incentives and support for Public-Private Partnership (PPP) models to develop fast-charging corridors.

c. N3 (Heavy-Duty Trucks)

Recommendations indicate prioritizing strategic infrastructure, such as the Golden Quadrilateral electrification, and targeted PLIs for R&D on megawatt-level charging and high-capacity battery packs.

6.2. Reforms required in the existing PLI scheme

Electric vehicles are an important component of India's "Make in India" ambition. Existing Production Linked Incentive (PLI) schemes have contributed to this objective, while stakeholder inputs suggest scope for further refinement.

For the PLI-ACC scheme, P4.1 highlighted considerations related to the structure of participation, suggesting that broader accessibility, supported by clearly defined technical and financial eligibility criteria, may encourage wider industry participation. For the PLI-Auto scheme, stakeholders, such as P4.3, noted that the 50% DVA requirement could be calibrated to reflect current supply chain realities. One approach discussed involves phased localization, wherein certain high-value components—such as battery cells and rare-earth magnets—may continue to be sourced globally in the near term while domestic capabilities are developed.

6.3. PLI for Research & Development (Battery Chemistries, Innovative Charging Solutions, etc.)

P4.5 and P4.2 said that the government should introduce dedicated subsidies for the future of battery technology beyond lithium-ion. Lithium-ion is the dominant chemistry, but it depends on imports from external suppliers because raw materials like lithium, nickel, and cobalt are not abundant in India.

The current EV ecosystem is almost entirely dependent on a single battery chemistry. This creates several risks, including geopolitical, supply chain, economic, and resource scarcity risks.

The experts recommended dedicated subsidies and PLIs specifically for research, development, and chemistries. The goal is to build long-term self-reliance by leveraging abundant raw materials in India. This can be done through targeted R&D Grants, PLI for Alternatives, and Public-Private Partnerships.

Specific emphasis must be placed on alternative battery chemistries beyond lithium-ion, such as sodium-ion and zinc-air. Promoting R&D in these areas is vital for building long-term self-reliance by utilizing raw materials that are more abundant within India.

6.4. Adoption of the PPP Model for infrastructure

Stakeholder inputs indicate that infrastructure development may benefit from increased collaboration between public and private actors. P4.1 and P4.5 highlighted the potential role of Public-Private Partnership (PPP) models, supported by mechanisms such as viability gap funding, in accelerating and improving the efficiency of charging infrastructure deployment.

In addition, stakeholders emphasized the importance of aligning infrastructure planning with user needs. For instance, in the two-wheeler segment, access to affordable home and workplace charging remains important, while public charging infrastructure may be strategically deployed along highways and in logistics hubs to support commercial vehicles and inter-city mobility.

6.5. National Battery Swapping Policy

The National Battery Swapping Policy, which was to be developed in 2022, needs to be pushed through. This policy must address the sector's specific needs, as highlighted by P4.4 and P4.3. Rationalizing the GST structure to a flat 5% on both battery purchases and swapping services, access to land and subsidized power, and mandating interoperability standards to prevent market fragmentation are some important aspects the policy must address.

However, policymakers must be cautious; mandating interoperability standards too early could hinder crucial market-led innovation in battery technology, which remains a key competitive differentiator for manufacturers. Furthermore, the policy should be expanded to explore viable business models that make capital-intensive battery swapping feasible for heavy vehicles like e-buses and trucks, moving beyond the current focus on micro-mobility.

Battery swapping directly addresses the most significant barriers to EV adoption for commercial users, as mentioned by P4.3. P4.3 identified four key anxieties: high upfront cost, range anxiety, charging time, and technological obsolescence. Battery swapping solves these at a stroke. By treating the Battery as a Service (BaaS), the initial vehicle cost is reduced by 40-45%. Range becomes irrelevant as a depleted battery can be swapped for a fully charged one in minutes, eliminating downtime. And because the swapping company owns the batteries, the risk of technological obsolescence is shifted from the user to the operator.

The economic benefits are particularly stark for gig-economy workers. P4.4 detailed that a rider on their network saves over 50%, paying a flat monthly subscription of ₹2,700 for 3,000 km, compared to approximately ₹6,000 in petrol costs for the same distance. This model has proven to be a powerful driver of electrification in the B2B micro-mobility space.

6.6. Financing Needs Through Priority Sector Lending

The EV ecosystem also depends upon a supportive financial and regulatory framework that builds consumer confidence and unlocks capital. To address the significant financing gap, the government should act on the industry's call to formally include EV financing under the RBI's Priority Sector Lending norms. This should be coupled with the creation of government-backed credit guarantee schemes to de-risk lending, particularly for commercial two- and three-wheelers, as proposed by P4.3 and P4.5.

While industry experts advocate for Priority Sector Lending (PSL), NITI Aayog officials have highlighted that this category is already fully allocated to core priorities like agriculture and education. Overloading this sector risks reducing the impact on other fields without being impactful enough for EVs. As an alternative, the government should focus on targeted de-risking tools, including a Partial Risk Sharing

Facility (PRSF) for small fleet operators and a Residual Value Guarantee (RVG) to mitigate financier risk regarding the long-term resale value of EVs.

6.7. Battery Passport

A unique idea to address consumer concerns about battery life and resale value (barriers to adoption in the passenger car segment), the government should facilitate the development of a standardized framework for battery health certification. As suggested by P4.5, a "Battery Passport" system, like the frameworks being developed in the EU, would provide transparency into a battery's state of health, laying the foundation for a viable and trusted second-hand market for EVs.

This concept should evolve into a practical Predictive Framework for Resale Value, potentially a standardized calculator or app. Such a tool would reliably predict the resale value of used EVs, providing the confidence necessary for a thriving second-hand market and de-risking the sector for both consumers and financiers.

6.8. Shift Towards Mandates

India can adopt more decisive policy levers instead of relying solely on incremental incentives. P4.3 recommended introducing a Zero-Emission Vehicle (ZEV) Mandate. The government should move from a purely incentive-based model to one that includes mandates. A ZEV mandate, like China's "dual-credit" policy, would require automakers to sell a certain percentage of EVs in their total sales portfolio each year. Manufacturers who exceed their target could sell credits to those who fall short. This supply-side "push" guarantees a consistent availability of diverse EV models in the market.

While a "hard mandate" may not be suitable for India’s current stage of EV adoption, a more effective approach would be to implement "soft mandates." These should initially target government and public sector fleets, leveraging India's history of incentive-led adoption to build scale before applying broader market requirements.

6.9. Time-Bound Fiscal Measures

Drawing on the Norwegian model, India could consider a more aggressive fiscal strategy. Instead of complex, capped subsidies, a time-bound, full waiver of GST and registration taxes for all EVs below a certain price threshold could create an unambiguous, powerful price signal for consumers, dramatically accelerating adoption in the price-sensitive passenger car segment (Kohli, 2024; OECD, 2022; Yatsura, 2025).

6.10. Development of Geography-Specific Interventions

A "one-size-fits-all" national policy is insufficient. As recommended by P4.5, the government should develop geography-specific policies that cater to the unique needs of different states and terrains. For instance, hilly regions in the Northeast may require targeted programs for high-torque vehicles and specialized charging solutions, while dense urban centers need policies focused on last-mile mobility and smart charging to manage grid load.

6.11. Ensure Strategic and Scientific Infrastructure Planning

While a PPP-led model is essential, the rollout must be guided by data. Echoing the concerns of P4.6, a scientific approach to planning is needed to prevent the over-saturation of chargers in some areas while others remain underserved. This involves using data on traffic patterns, vehicle density, and grid capacity to strategically identify locations for public chargers, ensuring maximum utility and financial viability.

6.12. Scrappage Policy Reform: Linking Scrapping to EV Purchase

India has a vehicle scrappage policy to phase out older, more polluting vehicles. In its current form, the policy enables vehicle owners to scrap older vehicles and avail benefits such as a scrappage certificate and road tax concessions, which can be applied toward the purchase of a new vehicle, including Internal Combustion Engine (ICE) vehicles. This supports fleet modernization, though the link to electric mobility adoption remains evolving.

P4.6 suggested that there may be potential to further align these policy objectives. The respondent proposed a reform that would link scrappage-related financial benefits to the purchase of EVs or other cleaner technologies, thereby supporting both vehicle replacement and the transition to lower-emission mobility options.

How it would work:

1. A consumer decides to scrap their 15-year-old petrol car.

2. Under the reformed policy, they would only receive the full set of scrappage benefits (e.g., the scrap value, a waiver on registration fees for a new vehicle, and a potential discount from the manufacturer) if they purchase a new Electric Vehicle.

3. This effectively creates an "extra amount" or a significant, targeted discount for those who make the switch to electric. The incentive is no longer just for scrapping but for scrapping and replacing with a clean alternative.

Respondent believes that this policy can create a strong demand-side pull. It targets consumers at the exact moment they are making a new-vehicle purchase decision and provides a compelling financial reason to choose an EV over an ICE vehicle, thereby leveraging one policy (scrappage) to directly advance the objective of another.

6.13. A Roadmap for Long-Term Policy Stability

A stable and predictable policy environment has been identified as an important requirement for the EV industry. Policy timelines and continuity can influence long-term capital investment decisions related to manufacturing, R&D, and supply chain development.

Stakeholder inputs indicate that policy clarity and longer-term visibility are important for investment planning, particularly for projects with extended gestation periods.

In this context, a clear and consistent policy roadmap, with a longer-term perspective, may support investment confidence. Well-defined policy direction and regulatory clarity can act as important non-fiscal enablers for the sustained growth of India's electric mobility ecosystem.

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Chapter 5

India's OEM Strategies: Assessment and Future Directions

Chapter Summary

Content:

1. Examines India's EV transition through an R&D-centric and OEM strategy lens, with a focus on battery technologies, value chains, charging systems, and policy scaffolding shaping near- and medium-term adoption.
2. Synthesizes extensive literature, policy reviews, market data, and in-depth stakeholder interviews across OEMs, battery developers, researchers, and infrastructure providers to map technology–policy–industry interactions.

Findings:

1. The battery stack, particularly upstream materials, process IP, yield learning, and TRL-4–6 scale-up, emerges as the primary constraint on cost, safety, and localization, with current policies misaligned to this stage of innovation.
2. OEMs are advancing most rapidly where they control integration and software (BMS, VCU, power electronics), while hedging supply risks through portfolio chemistry strategies, motor re-architecture, and second-life planning rather than single-technology bets.

Takeaways:

1. India's next EV phase requires institutional support for lab-to-pilot R&D, upstream material security, and system-level integrators to move beyond pack assembly toward genuine technology ownership.
2. Segment-specific technology choices, bankable charging models, reliability-linked incentives, and circularity-oriented design are critical to translating EV adoption into a sustainable, domestically anchored ecosystem.

1. Introduction

1.1. Research Scope and Framing

Past research on India's EV transition has recently moved from "if EVs will take off" to "what frictions still slow the scaling of EVs and how technology, policy, and industry can design to remove them." Considering the above research review for the specific R&D-centric battery lens, four strands can be found to be most relevant: (i) system views of adoption dynamics; (ii) India's evidence on subsidy effectiveness; (iii) battery chemistry, value chain, and circularity; and (iv) India-specific infrastructure and industry structure (cells, packs, charging, and domestic capability). According to the literature reviewed, the battery stack (which includes chemistry, cells, pack, BMS, vehicle integration, and end-of-life in serial order) consistently emerges as the limiting factor for reliability, safety, and cost. India's own policy architecture (FAME demand incentives, ACC-PLI supply incentives) is explicitly designed to push on the battery stack while growing domestic capability (Trivedi et al., 2025).

A cross-cutting pattern in the reviewed literature can be referred to as "two loops": reinforcing loops between incentives, visible charging, and social proof that accelerate absorption; and balancing loops from cost, range, or thermal anxiety, and supply-chain risk that slow diffusion, implying interventions must target both loops at once, not in isolation. India-specific evidence in the next sections largely supports this view (Trivedi et al., 2025).

1.2. Where Does India's EV Market Stand Today?

India's EV market is expanding, but it remains skewed. FY2024–25 data compiled by EVreporter show EVs at ~7.8% of overall auto sales (2,037,831 units), with high-speed e-2W at ~59% of EV volumes. Penetration varies: ~22.8% in passenger L5 three-wheelers, ~6.2% in two-wheelers, and ~2.7% in four-wheelers; the top 10 e-2W OEMs account for ~94% of sales.

Two implications follow for R&D. First, because 2W/3W dominate, compact pack design, abuse-tolerant chemistries, robust BMS, and thermal management matter at least as much as "long-range" breakthroughs. Second, control-stack localization (BMS, motor control, vehicle software) can scale through 2W/3W volumes before 4W reaches widespread parity, an emphasis echoed in India-focused engineering notes and planning documents (EVreporter, 2024).

1.3. India's Policy Experience and Adoption Outcomes

A decadal empirical assessment (2014-2023) of India's EV fiscal support uses difference-in-differences and synthetic controls to separate signal from noise. It finds that under FAME-II, a one-standard-deviation increase in E2W subsidy intensity is associated with ~12.7% higher sales, a potential maximum "market multiplier" of up to 9x, and 54.5% higher E2W sales in states that layered their own incentives on top of central policy. Yet the adoption share of e-2Ws was near 4% by end-2023, suggesting that subsidies raised absolute volumes but did not fully dislodge ICE, with infrastructure, financing, and residual-value perceptions lagging (Trivedi et al., 2025).

Segment detail in the same evaluation reinforces the point that “no one lever fits all.” FAME-I jump-started e-rickshaw passenger markets (E3WP) and then matured; cargo e-3W grew primarily on TCO fundamentals; commercial e-4W benefited from FAME-II + PLI with strong state effects; and e-buses require redesigned finance/ops models, not just bigger purchase subsidies. The through-line is to tailor policy by segment and synchronize demand incentives with infrastructure, finance, and standards (Trivedi et al., 2025).

1.4. How an EV is Made in India: Value-chain and Localization

Pragmatic “tear-down” style writing and OEM notes indicate a split between what is increasingly local and what remains import-dependent. Many Indian OEMs design powertrain topology, gearbox, inverters, or VCU, and pack or BMS in-house, then use build-to-print vendors for manufacturing. But cell manufacturing, rare-earth magnets, critical precursors (e.g., $LiPF_6$ electrolyte salt, PVDF binder), and automotive-grade semiconductors are still largely imported, keeping a sizable share of value and know-how offshore (EVreporter, 2024).

Sector scans show domestic lines being set up (largely LFP/NMC under ACC-PLI), yet upstream materials and much process equipment remain imported; competitiveness thus hinges on securing precursors and process IP while growing recycling and second-life capacity. Policy pillars, FAME on the demand side, and the ₹18,100 crore ACC-PLI on the supply side explicitly target these gaps (Department of Science and Technology, 2024)

1.5. Battery Technology: Where R&D Meets Adoption Frictions

1.5.1. State-of-practice Li-ion and India’s constraints

Li-ion packs (LFP and NMC families) dominate roadmaps for manufacturability and performance. In India’s hot climate and mixed duty cycles, thermal management and BMS sophistication are first-order reliability issues; hence, LFP’s safety or thermal stability is increasingly in demand, while NMC’s higher energy density requires tighter safety engineering and exposes buyers to nickel or cobalt price swings. The Indian battery sector review pairs this with a market outlook that is bullish on volume growth but clear about the present import dependence for cells and precursors, and the material realities that can pinch cost curves (Department of Science and Technology, 2024).

1.5.2. Alternatives and Complements: Na-ion and Zinc-air

Sodium-ion (Na-ion): The appeal is wide-temperature tolerance and abundant feedstocks at the cost of lower voltage/energy density than Li-ion, making Na-ion a candidate complement (not replacement) in Indian duty cycles where robustness may trump peak density. The “compatibility over competition” framing recurs in India-focused briefing notes (EVreporter, 2024).

Zinc-air (mechanically rechargeable): A practitioner account from a zinc-air startup describes TRL 5-6, with strong safety/cost characteristics but lower power capability (practical below ~70 km/h; use cases like 3W or city buses), and a funding gap for lab-to-pilot scale-up. It also argues that current schemes

(FAME/PLI) help at the production scale but leave pre-commercial R&D underfunded, risking permanent import dependence.

1.5.3. Supply-Chain Sustainability and Circularity

Reviews of the battery life cycle highlight key concerns, including the concentration of critical materials such as lithium, cobalt, and graphite, the need for credible life-cycle assessments (LCAs), and the gap between nominally compliant recycling systems and actual reverse-logistics throughput. India's battery sector outlook reflects this dual reality: while revenues are projected to grow rapidly, from approximately USD 5.1 billion in 2023 to USD 30.9 billion by 2032 at a CAGR of around 22%, the sector remains dependent on imported cells and precursor materials. This underscores the need to scale circular business models and recycling capacity to mitigate risks to raw-material supply (Department of Science and Technology, 2024).

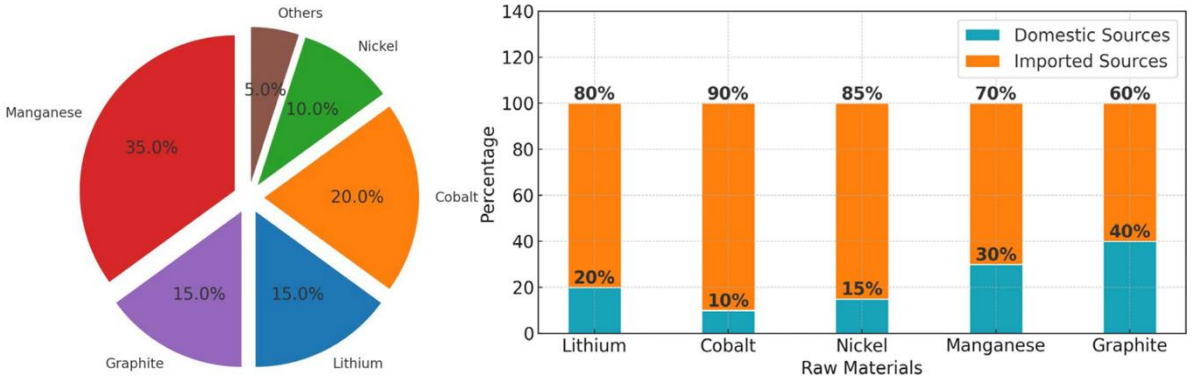


Figure 1: Raw materials composition of Lithium-ion batteries and their sources

((Dhairiyasamy, (2024))

1.6. BMS, Power Electronics and Software: India's Near-Term R&D

Indian OEMs report sustained in-house activity in BMS (hardware and algorithms), motor control (inverters or FOC), vehicle control units, and powertrain integration, with strong field-failure learning loops and generation-to-generation cost-down without quality loss. Problems include thermal robustness in hot summers and monsoons, pack architecture for space-constrained scooters (range vs safety), fleet-scale diagnostics or prognostics, and reliability targets shaped by legacy ICE expectations. These priorities show up directly in internal planning questions compiled for R&D (EVreporter, 2024).

1.7. Charging Infrastructure: Design Choices, Grid Realities, and Cost

The literature on EV charging warns against "more megawatts everywhere." Cities need dense, low-capex AC access for scooters and e-rickshaws; highways/depots need fewer but higher-power DC nodes with proper queuing, land tenure, and grid interconnection. A substantial share of station cost is *non-charger*, civil works, and grid connection can be 40-50% of capex, and opex is often dominated

by demand charges; success therefore depends as much on tariff rationalization and permits as on hardware (Kongara et al., 2024).

For India's near-term mix (2W/3W heavy), the practical emphasis is on everyday AC convenience over ubiquitous ultra-fast DC, aligned with observed charging behavior and current sales concentration in short-range urban use-cases (EVreporter, 2024).

1.8. Policy Scaffolding: What it Solves and What it Does Not (Yet)

On the demand side, FAME has clearly catalyzed volumes, particularly in the electric two- and three-wheeler segments. On the supply side, the ACC-PLI scheme is helping establish domestic cell and module manufacturing capacity. However, two structural gaps continue to emerge in both the literature and practitioner feedback:

1. **Pre-commercial R&D finance** (TRL 4-6). Grants to bridge the lab-to-pilot gap are scarce; firms at this stage struggle to raise risk-tolerant capital, slowing indigenous IP creation (EVreporter, 2024).

2. **Upstream material security.** India remains exposed to cathode/anode active materials, electrolyte salts/binders, and magnets, without upstream integration or process IP. Local lines face a cost ceiling set by imported inputs (Department of Science and Technology, 2024).

1.9. Synthesis: Where the Literature Converges and Diverges

a. Convergences

1. **Ecosystem is greater than any single lever.** Incentives, infrastructure, finance, and standards must move together; segment-tailored approaches beat blanket policies.

2. **Battery stack is the rate-limiter.** Safety/thermal performance in hot climates, materials criticality, and end-of-life systems are first-order adoption constraints, not edge cases.

3. **2W/3W are India's spearhead.** Their duty cycles and charging patterns make them natural early winners; commercial 4W and buses need bespoke finance/ops models.

b. Debates

1. **Cost trajectories.** Will Li-ion genuinely cross <$100/kWh in practice by 2030, given raw-material volatility and recycling scale-up needs? Current Indian sector notes attach caveats, emphasizing import exposure and circularity gaps (Trivedi et al., 2025).

2. **Alt-chemistry timelines.** Na-ion hybridization and zinc-air for low- to mid-power use cases are technically feasible; widespread commercialization awaits breakthroughs in pack integration, durability, and refuel/recharge logistics, as well as funding to cross TRL 5–7 (Department of Science and Technology, 2024).

3. **Circularity at scale.** Policy outlines exist, but measured reverse logistics throughput and trusted LCA data are scarce; this is a prime area for standards and translational R&D (Trivedi et al., 2025).

1.10. Literature-Derived Implications for an R&D-Centric Adoption Agenda

Drawing from the above, four priorities emerge as the most critical to addressing India's near-term EV adoption constraints:

1. **Climate-robust battery systems.** Chemistries (e.g., LFP, with Na-ion complements), packs, and BMS tuned for high-heat operation, monsoon resilience, abuse tolerance, and safety diagnostics; test protocols that reflect Indian duty cycles (EVreporter, 2024).

2. **Cost-down via design and circularity.** Localized pack/EVSE design, modularity for repair/refurbishment, and validated second-life or recycling pathways to buffer raw-material risk and improve TCO (Department of Science and Technology, 2024).

3. **Charging as engineering + business model.** Open protocols, reliability SLAs, tariff rationalization, and depot or corridor designs that deliver utilization and bankable CPO economics, acknowledging the 40-50% non-hardware capex reality (Kongara et al., 2024).

4. **Segment-specific tech choices.** For last-mile 2W/3W and city buses, evaluate Na-ion hybrids and zinc-air and buffer architectures; for heavy commercial, prioritize thermal management, durability, and TCO-oriented powertrain integration (EVreporter, 2024).

2. OEM Strategies, Capabilities, and R&D in India's EV Transition

2.1. Where the Market is and Who is Winning (and Why it Matters for R&D)

India's EV penetration remains sharply segment-skewed: passenger L5 three-wheelers lead, followed by two-wheelers, with four-wheelers still low but rising. FY2024–25 tracking shows ~22.8% penetration in L5 passenger 3W, ~6.2% in 2W, and ~2.7% in 4W. The e-2W market is highly concentrated: the top 10 brands account for ~93.8% of sales, led by Ola Electric, TVS, Bajaj, and Ather (EVreporter, 2025)

R&D implication: Because 2W/3W carry volumes, the highest near-term leverage for Indian OEMs is (i) making small-form-factor packs safer and cheaper for hot, stop-go duty; and (ii) localizing the control-stack (BMS, VCU, inverter/motor control) that improves with field data and scales quickly through these segments (Department of Science and Technology, 2024).

2.2. Make Vs. Buy: What OEMs Localize Today

On the vehicle side, many Indian OEMs now design and integrate the pack/BMS and power electronics locally, but upstream cells and several critical inputs remain import-dependent. Typical imports include $LiPF_6$ electrolyte salts and binders or separators for cells, automotive-grade semiconductors, and rare-earth magnets (NdFeB) for motors, in contrast with growing domestic design/assembly of packs, BMS, and vehicle controls. This mix keeps a sizeable share of value and know-how offshore and exposes BOMs to global price swings.

2.3. Battery Strategy: Current Chemistries, Future Alternatives

Policy-industry outlooks expect India's Li-ion market to grow from ~US$5.1 bn (2023) to ~US$30.9 bn by 2032 (CAGR ~22%), supported by demand incentives and the ACC-PLI program (₹18,100 crore) for domestic cell manufacturing, yet cell supply will remain import-heavy in the near term. Upstream materials are still the binding constraint. OEMs thus pragmatically split between LFP (thermal stability, safety) and NMC (higher energy density) while upstream integration matures (Department of Science and Technology, 2024).

What is next? India-relevant alternatives are moving through TRLs. A practitioner account places zinc-air at TRL 5-6, compelling on cost and safety and viable for sub-70 km/h duty (e.g., 3W/city buses), but still power-limited and stuck as public support targets production/sales (FAME/PLI), not lab-to-pilot grants. For OEMs, these chemistries are complements to LFP/NMC for fit-for-purpose niches (often with buffer hybrids), not immediate replacements (Wright, 2025).

Table 1: R&D Breakthroughs/Innovations

S.No.	Organization/ Company	R&D Breakthrough/ Innovation	Month-Year	Technology Readiness	Current Status (Aug 2025)
1	TDSG (Toshiba-Denso-Suzuki JV)	India's First Localized Hybrid Battery Manufacturing	January 2024	TRL 9 (Commercial)	Operational, supplying to OEMs
2	Ola Electric	Indigenous 4680 "Bharat Cell" Development	August 2024	TRL 8-9 (Commercial)	Commercial production launched in April 2025

3	Hindustan Zinc	Next-gen Zinc-based Battery Research	August 2024	TRL 3-4 (Early R&D)	MoUs signed, R&D partnerships established
4	Amara Raja Energy	16 GWh Cell + 5 GWh Pack Capacity Development	September 2024	TRL 6-7 (Construction)	Construction phase, first lines Q4 2026
5	Reliance Industries	Sodium-ion Battery Technology (Faradion Acquisition)	October 2024	TRL 7-8 (Pre-commercial)	Production facility under construction
6	IIT Madras	Advanced Zinc-Air Battery Technology	October 2024	TRL 4-5 (Lab Scale)	Research collaboration active
7	Epsilon Advanced Materials	100 GWh Battery Materials Testing Facility	November 2024	TRL 5-6 (Planning)	MoU executed, facility planning underway
8	Exide Industries	6 GWh Cell Manufacturing Phase	December 2024	TRL 7-8 (Pre-commercial)	Phase 1 production ramping up
9	Hyundai Motor Group & IITs	$7M Battery & Electrification Research Partnership	December 2024	TRL 4-5 (Research)	Research collaboration commenced
10	Inventus Battery Energy	Solid-state Battery Technology Development	January 2025	TRL 4-5 (R&D)	R&D phase, commercialization planning
11	Vikram Solar	1 GWh Solid-State Battery Manufacturing	February 2025	TRL 5-6 (Pilot)	Facility planning and technology development
12	JNCASR Bengaluru	Ultra-fast Sodium-ion Battery (6-minute charging)	March 2025	TRL 6-7 (Lab-Demo)	Lab breakthrough,

					scaling research ongoing
13	KPIT Technologies	Sodium-ion Battery Commercialization	May 2025	TRL 6-7 (Development)	Partnership operational, product development
14	Tata Chemicals/Agratas	20 GWh Li-ion Cell Manufacturing Plant	June 2025	TRL 6-7 (Pilot-Demo)	MoU signed, construction planning phase
15	IIT-BHU	National Battery Research Facility (Te-MobiX)	June 2025	TRL 5-6 (R&D-Pilot)	Facility establishment in progress

2.4. Control-Stack R&D: Where Indian OEMs are Building Muscle

The most consistent localization wins are in the “brains” and integration: BMS (hardware and algorithms), traction inverter or motor control, VCU, and pack safety/thermal architecture, areas that benefit directly from field-failure learning and software iteration, and do not require owning upstream chemistry yet (Department of Science and Technology, 2024).

2.5. Motors and Magnets: Navigating Rare-Earth Exposure

Permanent magnet synchronous motor (PMSM) systems remain exposed to NdFeB supply risks, prompting several OEMs to adopt multi-vendor sourcing strategies and explore magnet-lean alternatives, such as reluctance-based motor topologies, where performance requirements permit. The component profile also highlights continued import dependence for magnets and key power-electronics parts, keeping engineering efforts focused on alternative design strategies and reliability improvements (Department of Science and Technology, 2024).

2.6. Operational Models for EV Charging: OEM Roles and Partnerships

Charging is an ecosystem play. Auto OEMs are explicitly named participants, installing stations at dealerships and collaborating with CPOs or others, alongside utilities, site providers, and government operators. The same sources document sustained investment in CPOs and swapping players, as well

as policy levers such as PMP-xEV localization rules and state-level capital or tariff supports. For OEMs, the winning approach is open protocols, clear uptime SLAs, and city-dense AC access plus targeted DC at depots, often via partnerships rather than owning the full stack (Nomura Research Institute, 2024).

2.7. Policy Landscape: Enablers and Persistent Constraints

A decadal evaluation links stronger electric-car (E4W) uptake to supply-side manufacturing incentives (PLI/ACC) and shows that states offering 4W subsidies achieve materially higher sales than those without, highlighting the role of state-level complements to central policy. Even so, slow private-4W penetration signals non-price frictions, limited infra visibility, TCO uncertainty, and residual value beyond sticker price (Wright, 2025).

Two gaps, particularly handicap OEM R&D roadmaps:

1. **Pre-commercial (TRL 4–6) finance.** Current schemes are biased toward production/sales; the lab-to-pilot bridge for next-gen chemistries is thin. (EVreporter, 2024)

2. **Upstream material/process security.** Without access to precursors and process IP, domestic cell lines face cost ceilings dictated by global inputs; the import mix in today's BOMs makes that clear. (Wright, 2025)

2.8. Strategic Archetypes of Indian EV OEMs

1. **Full-stack integrators (control-stack-led).** Design pack, BMS, VCU, or inverter in-house; outsource manufacturing to a qualified EMS while keeping architecture/IP and fast iteration without capex bloat (Department of Science and Technology, 2024).

2. **Cell-forward partnerships.** Co-spec cells and lock supply with ACC-PLI awardees or global partners; policy is structured to pull such tie-ups (and upstream MoUs) into India (Wright, 2025).

3. **Network strategists.** Pair product with visible, reliable charging, via dealership installs and CPO alliances, to reduce perceived risk and build brand stickiness, especially in e-2W/e-3W, where home/work AC covers most charging but public visibility matters (Nomura Research Institute, 2024).

3. Policy Documents Review

This section is about what India's EV policy architecture does (and does not), with emphasis on how schemes shape battery-centric R&D, manufacturing, charging**,** and circularity**.** We group policies into: (1) demand creation, (2) supply-side manufacturing**,** (3) charging & grid**,** (4) end-of-life/circularity**,** and (5) enabling fiscal/land/building levers**,** then flag cross-cutting gaps and R&D-centric recommendations.

3.1. Demand Creation: Purchase Incentives & Segment Targeting

FAME India (Faster Adoption & Manufacturing of Electric Vehicles): Phase-II (approved with an outlay of ₹10,000 crore; launched on 1 April 2019) supported demand for e-2W/e-3W/e-4W and e-buses, along with public charging infrastructure; the scheme ran until 31 March 2024 with periodic tweaks. (Ministry of Heavy Industries, 2022; Press Information Bureau, 2023)

EMPS-2024 (Electric Mobility Promotion Scheme): A time-bound bridge after FAME-II: initially ₹500 crore for 1 Apr–31 Jul 2024 to keep e-2W/e-3W momentum; later extended to 30 Sept 2024 with a higher outlay (₹778 crore). (Press Information Bureau, 2023; Electric Mobility Promotion Scheme, 2024)

What the evidence says: A decadal evaluation (2014-2023) finds statistically significant, segment-specific subsidy effects and strong center–state policy synergies; it also cautions that e-buses require better financing/operations models, not just larger purchase subsidies. Market tracking for FY2024-25 shows EVs at ~7.8% of auto sales, led by e-2Ws and e-3Ws, reinforcing the case for segment-specific design rather than blanket discounts.

R&D implication: Demand incentives lift volumes and learning, but do not substitute for investments in battery safety/thermal robustness and charging reliability, the adoption levers most salient in India's 2W/3W-heavy mix.

3.2. Supply-Side Manufacturing: Cells, Modules & Advanced Auto-Tech

ACC-PLI (Advanced Chemistry Cell Production-Linked Incentive): Approved ₹18,100 crore to localize cell manufacturing; winners set up GWh-scale lines with technology-agnostic eligibility (e.g., LFP/NMC). Sector syntheses emphasize that cost competitiveness hinges on process IP, yield mastery, and precursor access, not merely installing lines**.**

Auto/Auto-Components PLI (Advanced Automotive Technology): A parallel PLI nudges EV powertrains/electronics/software. Today, Indian OEMs typically localize the control stack (pack/BMS, inverters/motor control, VCUs) while cells, electrolyte salts ($LiPF_6$), binders (PVDF), and NdFeB magnets remain import-heavy, keeping value and supply risk offshore.

R&D implication: PLIs help unlock capex for manufacturing lines and components, but support for technologies at TRL 4–6 remains limited. This could leave a potential lab-to-pilot gap for emerging technologies such as Na-ion, Zn-air, and advanced battery packs/BMS that are not yet eligible for sales-linked incentives.

3.3. Charging & Grid-edge: Guidelines, Tariffs & What Makes Sites Bankable

National guidelines & standards (Ministry of Power): Revised consolidated guidelines (14 Jan 2022; amended 7 Nov 2022) clarify public vs. captive charging, open access, connection timelines, and **tariff** principles, e.g., public charging tariffs not to exceed Average Cost of Supply during a transition period, plus expectations for DISCOM planning (Ministry of Heavy Industries, 2023; Niti Aayog, 2022).

What deployment documents highlight: Deployment experience shows that charging station viability depends on more than hardware alone. Permits, land tenure, civil works, and grid connectivity often account for a significant share of capital and operating costs. Delivery models such as public-private partnership (PPP) concessions, tariff rationalization, and standardized implementation templates can help de-risk investments by charge point operators (CPOs). Indian policy discussions also highlight the importance of GST rationalization for EV chargers, as well as stronger facilitation by state and urban authorities.

Design principle for India's mix: Prioritize dense, low-capex AC access for 2W/3W in cities; deploy targeted DC at depots or inter-city corridors paired with uptime SLAs, open protocols, and rationalized tariffs (Kohli, 2024).

3.4. End-of-life & Circularity: EPR, Recycling & Second Life

Battery Waste Management Rules, 2022 (MoEFCC/CPCB): Establish Extended Producer Responsibility (EPR) across the battery life-cycle collection, recycling/refurbishment targets, record-keeping, and enforcement via CPCB's EPR portal and EC (Environmental Compensation) guidelines. (CPCB, 2022; CPCB, 2024; Shoonya, 2022)

Insights from Literature Reviewed: To translate EPR into real circularity, India needs traceable reverse-logistics throughput, quality recycling capacity, and shared LCA baselines, prime areas for standards and translational R&D (e.g., state-of-health estimation for reuse; safe discharge/dismantling; reagent-efficient hydromet).

3.5. Fiscal & Enabling Regulations: GST, Land, Buildings, States

1. **GST:** EVs taxed at **5%**; several policy notes reference GST reductions also applying **to** EV chargers/charging stations, supporting the affordability of both vehicles and infrastructure.

2. **Urban planning/buildings:** Model Bye-Laws and state policies **encourage** EV-ready wiring and parking, easing home/office AC access that underpins e-2W/e-3W adoption (Ministry of Power, 2022).

3. **State EV policies:** Leading states pair purchase top-ups with road-tax or registration waivers, land/tariff support for charging, and manufacturing incentives, creating substantial center-state multipliers in adoption outcomes.

3.6. What it Solves and What it Does Not (yet)

a. What is working

1. **Demand and early supply:** FAME/EMPS kept retail volumes rising while ACC-PLI catalyzes domestic cell/module line-building (primarily LFP/NMC).

2. **Charging rules:** National guidelines and state facilitation reduce soft-cost uncertainty for CPOs and utilities (Ministry of Heavy Industries, 2023).

3. **EPR:** A modern framework to push recycling/second life beyond paperwork via a live CPCB portal and compliance tools (CPCB, 2024).

b. What is missing

1. **TRL-4–6 grant finance:** Sales-linked incentives do not fund **lab to pilot** for Na-ion, Zn-air, solid-state, or advanced packs or BMS, the very R&D that sets India's future cost/safety frontier.

2. **Upstream security:** Heavy import dependence for cells, Li salts/binders, NdFeB magnets keeps BOMs vulnerable; PLIs will not fully bite without process IP, yield mastery, and raw-material processing**.**

3. **Charging economics at scale:** Land & grid-connection costs and variable utilization still challenge bankable CPO models outside metros, calling for tariff rationalization, land allotment, depot-first corridors**,** and distribution upgrades.

4. **Data & standards for circularity:** EPR needs common LCA metrics, verified recovery targets, and traceability platforms to align intent with outcomes.

3.7. How Policy is Shaping OEM Choices

1. Demand and infrastructure visibility can support adoption; firms that pair their products with reliable charging networks illustrate how ecosystem strategies can complement subsidies (Kohli, 2024).

2. Supply-side PLI is associated with stronger e-4W outcomes in the decadal review, potentially reinforcing OEM interest in co-specifying cells and deepening control-stack localization (pack, BMS, VCU, and inverters) as domestic chemistry and process capabilities mature.

3.8. Bottom Line for an R&D-Centric Next Phase

As seen in policies reviewed and sectoral review, a pragmatic to-do for government–industry–academia is:

1. **Institutionalize TRL-4-6 grants** for **chemistries** (including LFP improvements, sodium-ion, and zinc-air), pack and BMS safety, recycling process technologies, and grid-edge software. These should explicitly support the transition from laboratory to pilot scale, ahead of PLI schemes and demand-side incentives.

2. **Lock upstream**: Long-term offtake & processing MoUs (lithium, graphite, phosphates; magnet materials), plus domestic precursor processing **and** audited recycling capacity to buffer cost shocks.

3. **Make charging bankable**: Standardize uptime SLAs, publish model PPP/concession templates, ring-fence EV tariffs for depots and city AC networks, and fund distribution upgrades where EV loads cluster. (Ministry of Heavy Industries, 2023)

4. **Tie incentives to reliability & circularity**: Align demand incentives with safety or warranty outcomes and verified EPR compliance, so rupees spent buy trust along with volume (CPCB, 2022).

Together, these steps turn today's adoption push into a **technology-ownership strategy,** so India is not just assembling EVs but also inventing batteries and operating grid-edge systems that enable electrification to scale.

4. Insights from Stakeholder Consultations

Table 2: Stakeholder's profile

Code	Role	Organization Type	Region
P4.7	Senior Academic	Premier Indian Engineering Institute– Power Systems & Electric Mobility	National
P4.8	R&D Manager – Electronics	Major Indian Automotive Manufacturer	National
P4.9	R&D Manager – Electronics	Large Indian Automotive Manufacturing Company	National
P4.10	Head – Electrical & Electronics R&D	Electric Heavy-vehicle Technology Company	National
P4.11	Associate Director	Indian Electric Two-Wheeler Manufacturer	National
P4.12	Co-founder & Chief Technology Officer	Energy Storage & Advanced Battery Technology Start-up	National

Building on the secondary analysis, our primary work tested four levers that repeatedly surfaced as binding in India's context:

1. **Cell process/yield mastery** as the dominant early-cost driver

2. **Control-stack localization** (BMS/VCU/inverter, thermal logic) as the near-term R&D beachhead

3. **Upstream material security** (cathodes/graphite/$LiPF_6$/PVDF/NdFeB) as the structural risk

4. **Fit-for-purpose portfolios** (LFP/Na-ion/zinc-air; PMSM vs. synchronous-reluctance + gearbox) rather than single-technology bets.

We purposively sampled across the battery-vehicle-infrastructure chain and TRL stages: P4.7 on indigenous chemistry and systems integration; two R&D managers- P4.8 and P4.9 on OEM design and sourcing choices; P4.10 on heavy-truck electrification; P4.11 on cell ramp economics; and P4.12 on zinc-air at TRL 5-6.

a. Interview with an Academic – Power Systems and Electric Mobility (P4.7):

P4.7's views about the present state of play: India's lithium "manufacturing" is largely assembly. Few, if any, domestic players make cathodes, anodes, separators, and electrolytes end-to-end and then convert them into cells with yield discipline. As long as upstream process know-how and material IP sit offshore, India pays the royalty and yield penalty embedded in every cell. This is why they repeatedly pivot from "Made in India" to "Thought in India." The strategic objective is to own ideas (chemistry, process IP, yield playbooks) first, and only then scale hardware. Against that backdrop, their sodium-ion timeline is strikingly concrete. Multiple Indian labs, including theirs, have already demonstrated sodium systems in real-world settings, at roughly TRL 6-7, so the bottleneck is not laboratory science but the meandering, capital-intensive jump to TRL 8/9. In other words, the right instrument now is pilot-line finance and industry technology-transfer contracts, not more early-stage grants. They also offer a useful historical correction: sodium research predates lithium; lithium won the first commercialization race because its materials were easier to make. With modern synthesis, sodium can be manufactured again, if backed by the right industrial architecture.

P4.7's cost logic emphasizes people as much as plants. Importing cells is, in effect, renting another country's sunk human capital; building genuine Indian capacity demands expensive, scarce talent long before the capex shows results. They argue for financing the manpower curve (endowed chairs, multi-year contracts, retention pools) alongside equipment; otherwise, the economics will keep tilting toward imports simply because others have already paid those human capital costs.

Commercialization, they insist, should be form-factor-first and market-backed. Pick one form (coin, pouch, prismatic, cylindrical) tied to a clearly defined use case and scale path (pilot to MW to GWh), then ladder up. That discipline prevents "a technology in search of a market" and forces early offtake discipline: who needs which cell, at what warranty and performance envelope, and when. They add that India lacks a true "final assembler" at the systems level, an integrator capable of owning interfaces from materials to pack, coordinating cross-licensing, certifying suppliers, and driving yield learning across the chain.

On chemistry, P4.7's stance rejects "winner-takes-all." Lead-acid never disappeared; lithium, sodium, zinc/Al-air, and even nickel chemistries will coexist if we match them to duty cycles and constraints. P4.7 pins sodium's physics with simple numbers, lithium ~3.03 V vs. sodium ~2.7 V, so sodium's energy density is lower (energy ~V^2), but it is likely ~20% cheaper, more temperature-robust, and more tolerant of deep discharge. Those traits suit Indian conditions for targeted segments (urban 2W/3W, stationary storage) if we stop framing the choice as a war and start designing portfolios.

Two programmatic threads round out his perspective. First, they trace India's sodium-ion arc to a 2016 DST call that seeded 8–10 groups, evidence of a national knowledge base that can be industrialized if scale capital and partners show up. Second, they warn against "green tech with dirty infra": Their group quantifies carbon footprints not only for batteries but for charging hubs, arguing that tenders should require credible LCA, grid-edge design, and storage-renewable coupling so we are not just sweeping emissions under the carpet. Looking ahead, they signal active work on aluminum-ion as another India-relevant option, an explicit hedge against single-chain exposure, and return to a simple diligence rule: build DPRs that start with segment demand, form factor, performance, and warranty, then plan the scale.

b. Interview with an R&D Manager – Electronics, Major Indian Automotive Manufacturer (P4.8)

A week later from P4.7's interview, we interviewed P4.8. Their views make two things very explicit: big Indian OEMs will not bet their production lines on chemistries that are not already at mass-manufacturing scale, and the fastest levers they control today sit in the control stack, BMS hardware/algorithms, power electronics, and mechanical packaging, not in cell chemistry. P4.8 is clear that their company designs packs and BMS in-house but does not run cell-chemistry R&D; cells are sourced from "big players." The adoption threshold they describe is practical, not ideological: until a new chemistry has a mature supply chain with multi-vendor availability, proven yields, and logistics volume, it will not enter a high-volume two- or three-wheeler program, no matter how promising the lab data looks.

A distinctive design shift highlighted by P4.8 is "engineering for user interference." Early EV pack designs, they say, did not account for how Indian riders add aftermarket accessories or misuse electrical systems. Field failures forced a rethink: BMS requirements now start from market feedback and include protective features to survive owner modifications and abuse (e.g., stray loads, wiring tampering).

P4.8 highlighted that NMC historically fits scooters because space is tight and energy density matters; LFP fits four-wheelers with more room. But after headline-setting fire incidents, they say even two-wheeler OEMs are pivoting toward LFP despite the range penalty, because a single thermal event can crater brand trust. That is a notable reversal of the usual "NMC for 2W" trope, and it frames safety as a brand-level economic variable rather than just a spec-sheet line.

On lifetime targets, P4.8 quantifies internal gates most OEMs only imply: design for 10+ years and ~1,000–2,000 cycles with ~80% SOH remaining. They also describe a quiet standardization tactic that uses the same cell across multiple models to simplify sourcing and qualification, while allowing the mechanical team to "pack out" different kWh within the fixed volumes each vehicle offers. That mechanical packaging then hard-constrains the BMS: their team receives a fixed envelope and must meet safety and functionality requirements within it, a reversal of the usual "electronics first" mindset.

P4.8 also spells out the second-life logic the company is already baking into its value assumptions: a degraded traction pack is not scrap; it often fails on power, not capacity, so it can be resold for stationary use. That future resale value, reinforced by a small but growing refurb ecosystem, underpins

residuals and reduces customer anxiety about battery replacement, an insight that links engineering choices to finance and remarketing.

Cost engineering is where P4.8 says the recent R&D surge has gone. With subsidy levels stepped down, their company's mandate has been to take vehicles that once needed incentives and deliver them near ₹1 lakh without subsidy, without quality regression. The cadence they describe — new or refreshed models every 6–12 months — necessitates accelerated bill-of-materials optimization, supplier re-qualification cycles, and firmware iteration. However, product launches are gated by "ready-to-sell" reliability thresholds rather than calendar-driven commitments.

Finally, P4.8 offers two strategic filters on "alternatives." First, hybrids for 2W are a poor fit: boot-space expectations, tight packaging, and added failure modes from more components outweigh the reliability story hybrids enjoy in cars. Second, while their company is evaluating sodium-ion (and they are aware of aluminum-air experiments), P4.8 points to two blockers few discuss openly: cell manufacturing precision (they mention the real risk of shorts from slight mis-rolls/misalignment in jelly-rolls) and supply assurance, big OEMs cannot risk a chemistry that might strand production for lack of cells. Their policy instinct follows from that: accelerate domestic upstream (lithium mining/processing) because the pack is ~40% of vehicle cost; if local supply can drag that share down into low double digits, a mid-life battery replacement becomes economically acceptable for consumers, changing the adoption math as much as any new chemistry would.

c. Interview with an R&D Manager – Electronics, Major Indian Automotive Manufacturer (P4.9)

P4.9 offers a nuts-and-bolts picture of how a large Indian OEM is actively redesigning the EV powertrain to avoid rare-earth risk, not by waiting for new magnets but by changing motor topology and gearing. They explain that their company is deliberately shifting part of its portfolio from PMSM (rare-earth magnet) machines to synchronous-reluctance motors, which can spin much faster but produce less torque per unit volume. The trade-off is explicit: about a ~30% larger motor envelope coupled with a gearbox designed in-house to translate high-RPM, low-torque characteristics back into familiar wheel torque. This is a concrete, engineering-level hedging strategy against heavy rare-earths, not a slide-deck aspiration.

P4.9 also breaks down magnets in a way most interviews do not: three distinct lanes, heavy rare-earth (HRE)-rich NdFeB grades (best power density, most China-dependent), light rare-earth-lean grades (lower doping, with a few non-China suppliers like Hitachi), and ferrite magnets (no rare earths, but much lower power density). That taxonomy drives real sourcing choices within the company's motor programs, with design targets adjusted based on which lane is feasible for a given model and market.

A second non-obvious insight is how "ICE feel" is treated as a hard requirement in early EV generations. For Gen-1 platforms, the company first matched drivability curves**,** the sensation a rider gets when opening throttle on a 125cc/150cc ICE, *before* chasing weight or cost. The VCU maps are built to reproduce those legacy acceleration/pickup expectations; only after that bar is met do Gen-2/Gen-3 programs prioritize mass and cost down while holding the same feel. P4.9 notes that Chetak is in market at Gen-3, with Gen-4 under development, to precisely execute those reductions without regressing drivability.

On batteries, P4.9 draws a line between ownership of control and ownership of chemistry. In 3-wheelers**,** the company may buy the pack from outside, but is now internalizing BMS software, so "a third party isn't controlling our vehicles." That is an under-reported governance choice: software authority over limits, safety thresholds, and updates sits with the OEM, even when the physical pack is supplied by a third party. Battery sizing is then back-solved from a city-range target (~100 km) and the actual motor or gearbox efficiency the team achieves, making traction efficiency the primary lever on pack kWh.

P4.9 clearly describes build-to-print manufacturing as a strategic default. The company designs the full technology stack in-house, including motors, inverters, vehicle control units (VCUs), gearboxes, and battery management systems (BMS), while relying on external vendors to manufacture components according to its specifications and quality standards. Final vehicle assembly, however, is retained at the company's own facilities. The benefit is not just cost; it preserves deep regional tuning freedom (e.g., Dominar variants for Brazil vs. India) and avoids being boxed in by a supplier's closed designs. They contrast this with competitors who still buy complete motor/control units from tier-1s, implying slower iteration on feel and feature sets.

P4.9's history lesson on the company's R&D also carries a distinctive point about why capex went into prototype facilities post-2012: once the company moved beyond assembling for partners, the only way to keep country-specific agility (the company exports to 70+ countries) was to own validation and tuning internally. They cite a current ~₹450-crore R&D capex thrust for labs and prototyping as the enabler of the fast cadence they describe, new or refreshed models every 6–12 months, yet only released when "ready-to-sell" reliability is met.

The requirements flow reflects a disciplined, closed-loop development process. Market and corporate teams provide segment- and country-level insight into unmet needs and pain points. R&D responds with two to three architectural options and rapid prototypes for management review, while also encouraging bottom-up proposals when engineers identify step-change opportunities. This creates a generation-by-generation feedback loop: for example, heightened magnet supply risk can trigger a motor or gearbox redesign; the redesign alters system efficiency, which in turn recalibrates battery capacity and BMS limits; the integrated system is then returned to preserve the ICE-like driving characteristics customers expect. Overall, this approach offers a practical blueprint for reducing supply-chain risk without relying on breakthroughs in battery chemistry.

d. Interview with the Head of Electricals & Electronics R&D, Electric Heavy Vehicle Manufacturer (P4.10)

As the R&D lead at a pioneer in India's electric truck segment, P4.10 observes that heavy-duty vehicles are the "late adopters" of the EV transition compared to the passenger car and 2W/3W segments. This delay is attributed to the massive battery sizes required, significant charging downtime, and the high cost-sensitivity of the Indian commercial market. However, P4.10 argues that the Total Cost of Ownership (TCO) logic is strongest in this segment: because commercial trucks run almost continuously—unlike passenger cars, which remain parked 80% of the time—they achieve financial break-even much faster despite the initial cost penalty.

The primary R&D departure from the 2W/3W segment is the shift to high-voltage architecture. While smaller vehicles operate on 48V–60V systems, electric trucks require 600V–800V systems,

necessitating significantly more robust power electronics and stringent safety protocols. P4.10 highlights that their R&D focus is on making these systems withstand "very tough road conditions" in industries such as mining, cement, and steel, where vehicle uptime is directly tied to revenue.

P4.10 offers a contrarian view on infrastructure: for commercial fleets, charging is not a bottleneck. Because trucks operate on well-defined "Point A to Point B" routes, companies can install private, closed infrastructure, effectively removing "range anxiety".

Regarding the value chain, the company follows a disciplined "Make-Design, Buy-Cell" model:

1. The Control Stack: They design the BMS, VCU, and embedded systems in-house (both hardware and software) to maintain technical authority.

2. The Manufacturing Split: They utilize build-to-print EMS partners for fabrication but handle final vehicle assembly internally.

3. Cell Pragmatism: P4.10 explicitly states that vertical integration into cell manufacturing is currently "not a very wise idea" for an OEM. The expertise and capital required for a gigafactory are too high; instead, they rely on established global cell technology to avoid lagging behind rapid development cycles.

The transition is currently hindered by a "Skilled Human Resource Gap" in the field. While R&D talent is available, there is a lack of technicians capable of troubleshooting high-voltage systems in the aftermarket. Furthermore, prospective buyers are stalled by "Resale and Replacement Anxiety", as the battery alone constitutes 40–50% of the vehicle cost. P4.10 notes that once drivers experience the instant torque and ease of automatic driving, they rarely want to return to diesel, yet "unofficial" frictions—such as the inability for drivers to manipulate fuel bills—sometimes result in resistance to adoption.

P4.10 calls for a "Willpower and Clear-cut Direction" from the government. This includes:

1. Carbon Penalties: Implementing ESG regulations and carbon credits to push polluting industries (coal, cement) toward green logistics.

2. Supply Chain De-risking: Incentivizing local suppliers to reduce the heavy China-dependency for rare-earth magnets and semiconductors.

3. Grid Modernization: P4.10 dismisses the "grid overload" concern as a myth, suggesting that with smart planning, EVs can act as grid stabilizers and accumulators for excess thermal or renewable energy.

In summary, P4.10 reframes the heavy-duty EV challenge as an execution and education problem rather than a fundamental technology gap, emphasizing that commercial viability is already present for fleet operators with fixed routes.

e. Interview with an Associate Director – Battery Cell Design, Indian Electric Two-Wheeler Manufacturer (P4.11)

P4.11 offers a rare, inside-the-factory view of what drives cost, risk, and timelines in India's cell and scooter programs, and much of it runs counter to the usual narratives. P4.11 pins the company's cell program to an aggressive, dated ramp: R&D kickoff in March 2022, completion by April 2024, and large-scale production beginning in March 2025. That 24-month lab-to-line sprint is itself an insight: the company bet early that a high–energy-density route (his discussion centers on NMC-class, 46-series cylindrical cells) is the best fit for two-wheelers' brutal space/weight constraints, even while acknowledging alternative chemistries exist. In his telling, the choice was a *risk decision* first, a materials decision second; the belief that energy density would dominate scooter packaging made the capital gamble thinkable.

P4.11's most direct observation is about yield economics. In early production, even "world-class" lines only deliver ~60–70% good cells, meaning 30-40% scrap that must be priced into every usable cell. The reason is not exotic raw materials; it is precision and tolerance stack-ups, coatings, winding or stacking, and moisture control, where acceptable variation is measured to the fourth or fifth decimal place. Until a plant earns that precision with time and discipline, cost stays structurally high. This single variable, they argue, explains far more of India's near-term cell cost gap than most policy debates admit.

That yield reality shapes pricing strategy in ways few outsiders see. P4.11 clearly describes the loss-leader phase: an Indian cell that costs ₹300 to make may be sold at ₹190 to compete with a ₹200 imported cell, with the manufacturer absorbing the difference as it climbs the learning curve. If volumes do not materialize fast enough to push yields up, companies collapse, hence the string of battery startups that have gone under. On the company's own learning curve, they forecast breaking even in 2-3 years if demand stays on track.

On the vehicle side, P4.11 attributes ~40% bill-of-materials reduction from Gen-1 to the upcoming Gen-4 scooters, largely through de-overdesign, shedding unnecessary weight and material thickness once field data showed margins were excessive. In other words, the biggest early lever was not a magic chemistry switch; it was hard, iterative engineering that trims metal and packaging while holding performance and safety.

P4.11's view of policy support is unambiguous: no real help before commercialization. They say government money appears as per-unit incentives only after you ship certified cells or vehicles; there is effectively no risk sharing at the R&D or factory setup stage. This forces OEMs to frontload capex (including imported high-precision equipment) and shoulder multi-year losses until yields and scale stabilize, another reason large, integrated players are the ones attempting cell lines.

On supply chains, P4.11 challenges a common assumption. While acknowledging that many firms continue to source from China for quality reasons, the respondent argues that Indian suppliers already exist for several inputs and expects domestic vendors to meet requirements by 2030. Whether or not this materializes, the view reveals the company's underlying planning premise: local content is expected to become both available and sufficiently reliable within the investment horizon, thereby justifying the decision to build in-house cell capabilities now.

P4.11's reading of infrastructure risk is also contrarian. For today's India, where EV volumes skew toward two-wheelers, and most use is intra-city, they do not see public charging as a binding constraint: home and workplace ACs cover the bulk of real-world charging, and early four-wheelers

are primarily city cabs with depot solutions. In short, they believe products and charging will co-evolve, and the *absence* of a highway DC network is not a showstopper for current demand.

Finally, P4.11 is pragmatic about the make-or-buy decision for electronics. Their company designs the control stack (BMS/VCU/etc.) but still imports much of the semiconductor content; the specialized fab/packaging equipment they have purchased is part of the up-front loss calculus. As with cells, they expect local manufacturing to undercut imports only *after* volumes and yields climb; until then, India-made products often cost more, even if they are sold for less to win the market.

Taken together, P4.11's account reframes India's EV cost problem as a yield-and-learning problem more than a raw-materials or charger problem. His numbers and timelines make clear why deep-pocketed players can move first, why early losses are rational, and why the most durable cost downs come from patient engineering and manufacturing discipline, not just chemistry bets.

f. Interview with a Co-Founder and Chief Technology Officer, Energy Storage and Advanced Battery Technology Start-up (P4.12)

P4.12 presented an alternative product approach to battery deployment. Instead of integrating zinc-air chemistry into vehicle drivetrains, the company has positioned it as a stationary energy asset at approximately TRL 5–6. This reflects the inherent characteristics of zinc-air systems—lower discharge power —alongside advantages such as safety, low material cost, and high practical energy density—making them more suitable for supporting EV charging infrastructure than for onboard propulsion.

The respondent also identified a defined operational envelope, indicating that zinc-air systems are best suited for applications below approximately 70 km/h. This aligns with use cases such as three-wheelers and city buses operating on fixed or predictable routes, where duty cycles, dwell times, and depot-based charging models can be structured accordingly.

P4.12 further emphasized a distinction in policy support across technology readiness levels. TRL 4–6 technologies typically require capital for pilot-scale development and system validation, whereas TRL > 6 technologies face adoption and market-scaling challenges. According to the respondent, current policy instruments such as FAME and PLI are more closely aligned with deployment outcomes, including production and adoption, with no focus on mid-stage scale-up. This creates a gap in support for chemistries such as zinc-air and sodium-ion during the transition from pilot to commercial scale.

The respondent also noted that reliance on imported core technologies may limit the extent to which domestic assembly translates into cost reductions. According to them, while schemes such as FAME and PLI can support increased production volumes, they may not significantly alter underlying cost structures (BOMs) when key intellectual property and upstream components are externally sourced. As a result, learning advantages and profit margins benefit international suppliers.

P4.12 also highlighted the importance of policy timelines in technology development. The respondent noted that developing indigenous electrochemical capabilities typically requires sustained investment over extended periods. In this context, countries such as China have invested significant time and funds in laboratory research and pilot-scale development before transitioning to large-scale mandated commercialization. According to the respondent, limited support during these intermediate stages may contribute to continued reliance on external technologies.

Their recommendation focuses on the need for patient, non-dilutive funding specifically targeted at TRL 4–6 stages, with mechanisms that incentivize progression from laboratory-scale validation to pilot-scale deployment rather than solely on end-market outcomes.

Finally, the company's roadmap suggests a layered system architecture suited to Indian operating conditions. In this approach, zinc-air systems are deployed as stationary energy assets, while high-power chemistries are used for onboard vehicle performance. This separation of roles allows different technologies to be utilized based on their functional strengths, offering a structured pathway for scaling deployment in line with technology readiness.

5. Results & Discussions

5.1. Thematic Analysis

Across interviews, a consistent set of system-level constraints and strategic shifts emerges, pointing to how India's EV transition is unfolding in practice.

First, battery manufacturing remains structurally upstream-constrained. While domestic activity has expanded at the pack level, the core of the value chain—materials, cell chemistry, process IP, and yield engineering—remains externally anchored. A commercial cell represents a tightly integrated system across cathodes, anodes, electrolytes, separators, and manufacturing processes, each requiring specialized capabilities. In the absence of domestic depth or licensed integration across these layers, scaling cell manufacturing risks remaining dependent on imported value. Stakeholders also highlighted the limited presence of end-to-end system integrators capable of coordinating interfaces and driving cross-supplier yield improvements.

Second, a clear gap exists at the lab-to-pilot transition stage. Emerging chemistries such as sodium-ion (TRL 6–7) and zinc-air (TRL 5–6) are technically viable for pilot-scale deployment but face constraints in progressing toward commercialization. Current policy instruments, including FAME and PLI, are primarily aligned with deployment outcomes—sales, capacity, and localization—while comparatively limited support exists for mid-stage scale-up, including pilot manufacturing, supplier qualification, and yield validation. As a result, firms absorb early-stage risks over multi-year horizons until volumes stabilize.

Third, near-term cost competitiveness is closely linked to manufacturing yields rather than raw material access alone. Early production lines operating at ~60–70% yield and 30–40% scrap rates significantly affect unit economics. Manufacturers may initially operate at a loss while scaling volumes and stabilizing processes. In this context, investments in metrology, process control, and skilled human capital are central to cost reduction, indicating that learning curves are driven as much by operational discipline as by scale.

Fourth, OEMs are consolidating their advantage in system integration and control layers. Software ownership in BMS and VCU systems is increasingly being internalized, enabling control over safety limits, diagnostics, and performance optimization independent of hardware vendors. Design strategies are also adapting to India-specific operating conditions, including tolerance for user modifications and

variable usage patterns. Safety considerations have influenced the selection of chemistry, with a shift toward LFP in certain segments to prioritize thermal stability over range.

Fifth, supply-chain risk is being addressed through engineering-led adaptation rather than solely through procurement. For instance, the shift from Permanent Magnet Synchronous Motors (PMSM) to synchronous reluctance motors reflects an active strategy to reduce reliance on rare-earth materials. These changes have cascading implications for drivetrain design, efficiency mapping, battery sizing, and control systems, and are being managed through iterative development cycles.

Sixth, battery economics are increasingly being evaluated over the full lifecycle. Internal targets emphasize durability (e.g., 1,000–2,000 cycles to ~80% state of health), alongside the integration of second-life applications. Since batteries typically degrade in power before capacity, planned reuse in stationary applications is being incorporated into business models, with implications for residual value and ownership economics.

Seventh, infrastructure constraints are segment-specific rather than uniform. In India's current usage profile—dominated by two- and three-wheelers with intra-city travel—home and workplace charging meet a substantial share of demand. At the same time, alternative architectures are emerging, such as zinc-air systems used as stationary energy sources for charging infrastructure, reflecting a functional separation between onboard power and offboard energy storage.

Eighth, cost reductions in EV systems to date have been driven primarily by iterative design optimization rather than step changes in chemistry. Successive product generations have reduced material intensity and over-engineering based on field data. Procurement strategies remain risk-aware, with a preference for multi-supplier ecosystems and proven manufacturing stability, particularly for precision-sensitive processes.

Finally, a portfolio-based approach to technology deployment is gaining traction. Rather than converging on a single "winning" chemistry, stakeholders are aligning technologies with use-case requirements—lithium-ion for onboard power, alternative chemistries for stationary applications, and second-life systems for extended value capture. At the same time, there is increasing recognition of the need to integrate lifecycle considerations, including emissions from battery production and charging infrastructure, into planning frameworks.

Overall, these insights indicate that India's EV transition is not constrained by a single factor but by the alignment of multiple layers: upstream capability, mid-stage technology support, manufacturing efficiency, system integration, and lifecycle design. Progress is likely to accelerate when these dimensions evolve in coordination, particularly by linking technology development stages to appropriate financing, strengthening control over critical system components, and improving yield-driven cost competitiveness.

5.2. Recommendations

Strengthen the lab-to-pilot bridge. India's next phase of EV policy could place greater emphasis on supporting the transition from laboratory research to pilot-scale production, an area that current policy does not yet fully address. A dedicated TRL 4–6 grant window could support pilot tooling, metrology, SPC set-up, supplier qualification, and safety certification, with milestones linked to yield

trajectories (good-cell %, ppm defects) rather than prototypes alone. Such support could help technologies such as sodium-ion and zinc-air progress from promising research towards commercially viable deployment.

Build and retain technical capabilities alongside manufacturing capacity. Greater attention could also be given to developing specialized human capital through mechanisms such as endowed chairs, multi-year process-IP fellowships, and industry sabbaticals. These programs could encourage the development of transferable processes and yield knowledge alongside academic outputs. Linking such support to retention mechanisms within Indian firms may also help reduce dependence on imported capabilities while strengthening domestic expertise.

Explore a system-integration role for dedicated consortia. One or more consortia could potentially serve as system integrators, helping manage interfaces across materials, cells, packs, BMS, and other components. Such arrangements could facilitate cross-licensing, multi-vendor supply certification, and learning across different tiers of the value chain. Improved coordination may be particularly important for preventing emerging chemistries from becoming fragmented across laboratories, suppliers, and vehicle programs.

Maintain a portfolio approach to emerging chemistries. Rather than concentrating support on a single technology pathway, a portfolio approach could allow different chemistries to be matched with applications where their characteristics are most relevant. Sodium-ion, for instance, could be explored in heat-tolerant and abuse-resilient applications such as urban 2W/3W mobility and stationary storage, while zinc-air could be assessed for off-board energy applications supporting depot charging rather than vehicle traction. Lighthouse deployments could help generate evidence, including depot DC charging supported by zinc-air systems and rooftop PV, and mixed Na-ion/LFP packs for urban duty cycles, accompanied by independent LCA and reliability assessments.

Align charging infrastructure with India's vehicle mix. The charging policy could more closely reflect the distinct requirements of India's 2W/3W passenger-vehicle and fleet segments. This may include dense, relatively low-capex AC charging in urban areas for 2W/3W vehicles and depot DC charging for fleet operations. Model PPP or concession templates, clearer uptime SLAs, and more rational tariff structures—including demand-charge relief where utilization justifies it—could further improve project viability. Targeted distribution upgrades at EV load clusters and selective V2X pilots may also be useful where they offer demonstrable benefits for load management.

Complement volume-based incentives with reliability considerations. As the market matures, there may be value in incorporating additional performance and reliability parameters into incentive frameworks. These could include minimum warranty standards, thermal-event rates (per million vehicles), charger uptime, and verified LCA for vehicles and charging infrastructure. On the supply side, additional emphasis on upstream domestic value addition—including precursors, binders, $LiPF_6$, and magnets—could help extend localization beyond pack assembly.

Support continuous and generational learning. Finally, mechanisms that enable faster learning from field performance could strengthen the sector's long-term capability. Anonymized telemetry could support the identification of recurring failures, while periodic updates to standards—potentially every 12–18 months—could better reflect Indian duty cycles and thermal conditions. Supporting the iteration and learning processes already emerging among OEMs may help reduce design and

integration costs as pilot lines improve their yields. Over time, these measures could support a gradual shift from assembly-led growth towards deeper domestic value creation.

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Chapter 6

Consumers' Perception of EVs in India

Chapter Summary

Content:

1. Large-scale digital-audience analysis of Indian EV four-wheelers using 3,89,391 Reddit comments and 463 YouTube review transcripts (LDA topic modeling; BERT emotion classification; VADER sentiment; 7-day moving averages), complemented by a primary Gen-Z survey (N=75) to link online discourse with cohort attitudes and purchase intent.
2. Objectives: identify recurring themes and top engaging topics, measure sentiment and emotion (platform- and model-level, over time), and generate insights for manufacturers and policymakers.

Findings:

1. Public sentiment is predominantly positive but moderate (≈54.8% positive, 24.2% neutral, 21.1% negative; mean polarity ≈0.10); YouTube reviewers skew more constructive/technical, while Reddit captures raw user worries—positives emphasize design/aspiration, negatives focus on product quality, software issues, and infrastructure.
2. Temporal trends show spikes in optimism (late-2019 to mid-2020) and rising comment volumes after 2023; Gen-Z is influential and open to EVs but exhibits a gap between openness and actual preference, with perceived convenience (charging/operational ease) the key predictor of EV preference; EV brands lack distinct positions in Gen-Z perception.

Takeaways:

1. Prioritize infrastructure visibility and reliability (densely sited, interoperable chargers plus real-time digital visibility) and institutionalize battery-health transparency and standardized diagnostics to convert moderate optimism into purchase confidence.
2. Manufacturers must differentiate products and marketing for Gen-Z and mainstream buyers (emphasize convenience, comfort, and high-tech appeal), invest in after-sales and decentralized serviceability, and use platform insights to fix model-specific software/quality issues that drive negative sentiment.

1. Introduction

Previous chapters of this report have focused on the institutional and operational complexities of public and commercial segments. This chapter shifts the analytical lens to the private ownership segment. The transition to electric mobility in India cannot be sustained by institutional fleets alone; it requires a deep-seated behavioral shift within the broader consumer base. This chapter provides a dual-pillar assessment of the passenger vehicle landscape by synthesizing large-scale digital footprints with targeted demographic research to identify the "perception-reality gaps" currently hindering mass adoption.

The first pillar of this chapter (section 2) uses large-scale sentiment analysis of over 3,89,000 digital footprints from Reddit and 463 YouTube transcripts to capture the unfiltered, organic discourse of the Indian public. By analyzing these "digital footprints," we move beyond traditional surveys to uncover the authentic emotional and psychological impediments, such as skepticism toward manufacturers' assertions and infrastructure failures, that define current market sentiment. This analysis provides a "baseline" of public trust and identifies the dominant narratives that influence current adoption decisions.

Building upon this general market pulse, the second pillar (section 3) examines Generation Z as a critical "pivot point" for the future of the Indian EV landscape. This cohort is prioritized because they are digital natives who drive the online discourse analyzed in our sentiment study and because of their emerging power as primary influencers in 50% of family car purchase decisions. By evaluating how social norms, perceived high-tech utility, and infrastructure visibility interact for this specific demographic, we identify the conditions under which the Indian EV market can move from a "niche interest" to a "mass preference". Together, these two evidence streams provide a comprehensive view of both the current organic skepticism and the future purchase triggers in the private EV segment.

2. Decoding Consumer Perception on Electric 4-Wheelers in India: A Cross-Platform Analysis of YouTube Reviews and Reddit Comments

The adoption of electric four-wheelers remains a pressing challenge in India despite several policy incentives and the growing availability of models. The road transport sector accounts for about 87% of all greenhouse gas emissions in the transport sector (Gogeri & Gouda, 2024; Jain & Rankavat, 2023). Barriers such as insufficient charging infrastructure and range anxiety hinder the widespread proliferation of electric vehicles in India (B & Kumar, 2024). It is thus imperative to understand consumer perceptions of electric vehicles to better identify the cognitive barriers and opinions that influence their adoption. Conventional research methodologies, such as surveys, may not adequately capture the authentic emotional and psychological barriers to electric vehicles. This study argues that a comprehensive understanding of customer views requires examining organic discourse.

Social media channels like YouTube and Reddit offer unfiltered, organic insights into consumer sentiment and opinions. YouTube review videos reflect detailed narratives that depict consumer

concerns and performance observations. On the other hand, Reddit is a social media platform where people share and discuss their views on EVs. Evaluating opinions expressed on such portals presents significant potential to uncover societal interests, worries, and expectations regarding electric vehicles (Özkara et al., 2025).

However, despite such rich and elaborate data, limited academic work has examined digital footprints in the context of EVs.

2.1. Literature Review

Understanding the EV sector and the constraints surrounding it is crucial, given the transport sector's significant impact on environmental pollution. Moreover, India's reliance on Internal Combustion Engine (ICE) vehicles necessitates a comprehensive understanding of consumer choices to enable the transition to a sustainable transportation system (Jyothika et al., 2025). Research has revealed that characteristics such as consumer loyalty, energy efficiency, charging infrastructure, and consumer acceptance exert a moderate influence on consumer satisfaction with electric vehicles (Chawla et al., 2023). Additionally, purchase price, operating costs, and charging time have a strong negative impact on the desire to adopt electric four-wheelers, whereas driving range and charging facilities have a comparatively positive impact (Bhat et al., 2024). These shape public perception of electric vehicles and consequently influence consumers' desire to use them. Nonetheless, Indians aspire for the government body to implement financial and non-financial benefits to promote increased electric vehicle usage (Gupta et al., 2024).

Concurrently, a vast body of literature highlights the potential of social media platforms to capture consumer perceptions of EV adoption, decipher the psychological effects of technology adoption, and examine hype. For instance, Costello & Kim (2025) extracted and analyzed approximately 43,000 YouTube comments directly about EVs. On the other hand, a Chinese study analyzed reviews on PC Auto, a popular Chinese website where people share opinions on electric vehicle charging stations (Chen & Tu, 2024). Likewise, a Turkish study examined 1,000 posts from Instagram, Twitter, and Facebook to interpret customer sentiment toward electric automobiles using this discourse (Durmus Senyapar, 2024). Corroboratively, online social networks like Reddit serve as a significant resource for examining public opinions on electric vehicles and offer diverse viewpoints compared to conventional approaches such as surveys, questionnaires, or interviews (Ruan & Lv, 2022; Ruan & Lv, 2023).

However, a lack of research on Indian EV consumer perceptions, based on YouTube transcripts and Reddit discussions, especially using thematic and topic modeling methods, underscores the novelty of this study.

2.2. Objectives

This study seeks to elucidate consumer opinions on electric four-wheelers in India by analyzing user-generated content from two online platforms. First, through English-language transcripts of YouTube video reviews by notable Indian YouTubers on the EV models available in the Indian market. Second, through Reddit comments on posts discussing the same EV models. These platforms present divergent yet interactive avenues for consumer expression through narrative-focused video evaluations and

community-oriented discussions, offering a comprehensive perspective on consumers' school of thought.

The research questions that the study poses are:

1. To identify recurring themes/concerns expressed by users across Reddit comments and transcripts of YouTube review videos related to Indian EV four-wheelers currently sold in the market.

2. To analyze consumer sentiment and emotional tone using sentiment analysis and pre-trained emotion classification models.

3. To observe how consumer sentiment changes over time and across specific EV models.

4. To highlight the most engaging topics within the EV discourse online.

5. To generate insights/recommendations for manufacturers and policymakers based on public opinion/concerns around electric four-wheelers in India.

2.3. Methodology

1. The first dataset comprises English-language transcripts from YouTube review videos covering all electric four-wheeler models currently sold in the Indian market. A total of 463 transcripts were analyzed to generate the results.

2. The second dataset consists of user comments from Reddit posts focused on the same EV models. A total of 3,89,391 comments were analyzed to generate the results.

3. The data were collected for the period from the launch date of each EV car model up to 31 January 2025.

Both data sets were cleaned, stop words were removed, and duplicate and repetitive content was also deleted. Next, Latent Dirichlet Allocation (LDA) is applied to identify themes and topic distributions. A pre-trained BERT model is used to examine emotional intensity for multi-label emotion classification, while VADER sentiment analysis is also used.

In particular, the Reddit data set will be further analyzed through sentiment trend analysis using 7-day moving averages. Moreover, the top engaging texts are analyzed for sentiment, and a word cloud is generated from the word frequency analysis.

To ensure the rigor expected in high-level policy reports, this study employs a source triangulation methodology that combines primary survey data with large-scale datasets of organic digital discourse. The analysis uses Latent Dirichlet Allocation to identify recurring themes and a pre-trained BERT model for multi-label emotion classification, enabling a nuanced understanding of public sentiment beyond simple positive or negative categorizations.

Reliability was further ensured through VADER sentiment analysis and a temporal examination using seven-day moving averages to track how public optimism has evolved and stabilized over the past several years. All data extraction and analysis protocols followed strict ethical guidelines for digital

research, ensuring that the hundreds of thousands of social media comments were processed anonymously and limited to publicly available discussions, consistent with international standards for human-subject research. This multi-modal approach reduces the bias inherent in self-reported survey responses and provides a more accurate reflection of the latent "choke points" in the consumer journey.

2.4. Results

2.4.1. Analysis Of Reddit Comments From Posts That Discuss The Current EV Four-Wheeler Models Sold in India

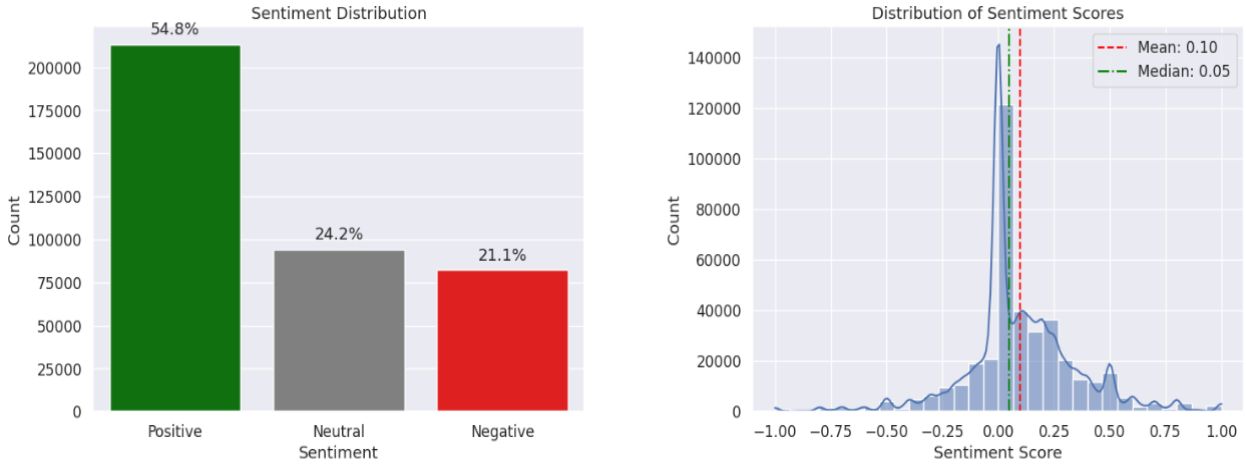


Figure 1: Sentiment Score Statistics

The emotion distribution depicted that the overall tone of the debate is primarily favorable, with 54.8% of comments categorized as positive, 24.2% as neutral, and 21.1% as negative. This indicates a predominantly positive public impression of electric four-wheelers currently available in India. The total number of positive statements was around 2,13,265, and the total number of negative statements that trailed out were 82,063.

The distribution of sentiment scores was right-skewed, with a mean of 0.10 and a median of 0.05, suggesting that although most sentiment is favorable, it is predominantly moderate rather than highly optimistic.

Temporal examination of sentiment scores indicated substantial upsurges in consumer optimism, especially from late 2019 to mid-2020. However, over time, the average sentiment stabilizes. Moreover, the volume of comments has surged significantly since 2023, reflecting heightened online discourse and interest in electric vehicle discussions.

Further, the correlation between comment length and sentiment score depicts a weak positive association (r = 0.02), highlighting that lengthier comments do not necessarily represent a stronger sentiment. This depicts that both brief and lengthy comments can articulate praise or criticism with comparable intensity.

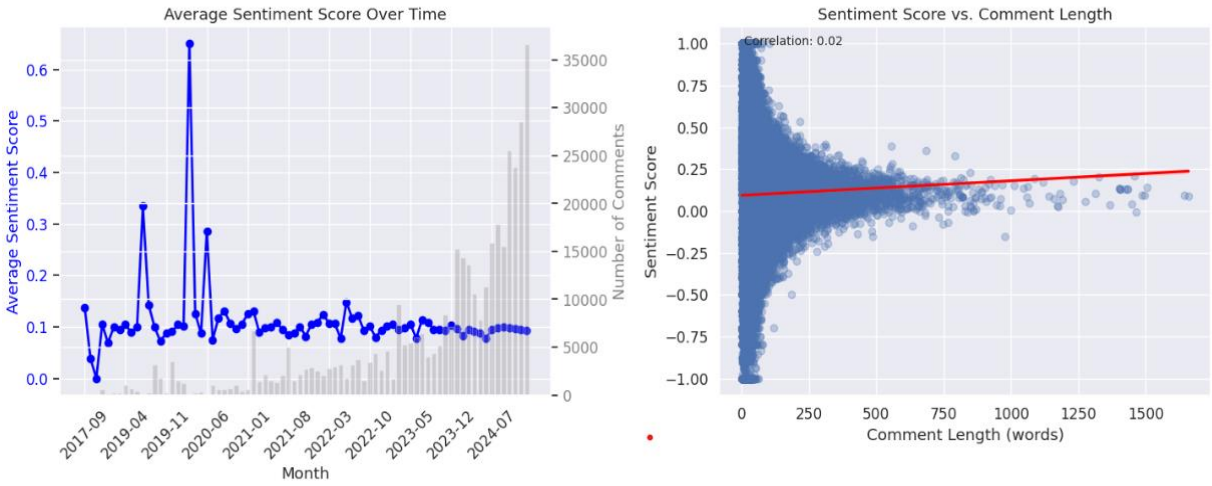


Figure 2: Sentiment Score statistics

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Sample Positive Comments:
1. Looking back on MY four biggest losers, ALL were bought after a run up - APHA, BB, PRPL, SGMO.

But ...
2. Kia and Hyundai must improve their dealership and especially service experience before I will ever c...
3. Could I just rally a bunch of people from my block to get in on it and negotiate a large purchase fr...
4. Hey thank you! Proud of that design....
5. Do you think this will push Tesla to be more lenient with the “no lease buyout” policy?...
```

Moreover, a set of positive comments was extracted to decipher the kind of positive reaffirmations surrounding EV car models in India. It was found that the affirmative remarks centered around emotional and design-centric discussion. Simultaneously, there also existed a curiosity about policy adaptability, indicating an aspirational and value-oriented disposition among users.

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Sample Negative Comments:
1. Hoping it could possibly mean an Immortal Hulk movie!...
2. recall means they stand behind their product. Tesla had its own decent share of quality problems esp...
3. By itself? No. That Tesla reduces it's COGS every quarter providing margin to burn for flexibility w...
4. Dude your gross. Thats sick. Keep your fantasies out of this....
5. i drove a few over the years. just like the germans the software is just soo buggy and obviously not...
```

On the other hand, the set of negative remarks predominantly expressed concerns about quality, software malfunctions, and skepticism towards the manufacturer's assertions. Such sentiments were found to be primarily product-specific and technologically oriented, suggesting that negative opinion tends to be more analytical.

2.4.2. Analysis Of Transcripts of YouTube Review Videos That Discuss The Current EV Four-Wheeler Models Sold In India.

This study further examined English translations of YouTube review videos created by popular Indian YouTubers. These videos feature reviews of electric four-wheeler variants currently sold in India. The objective was to analyze how reviewers characterize these vehicles in India and to further determine if recurring themes and sentiments correspond with or diverge from discussions on Reddit.

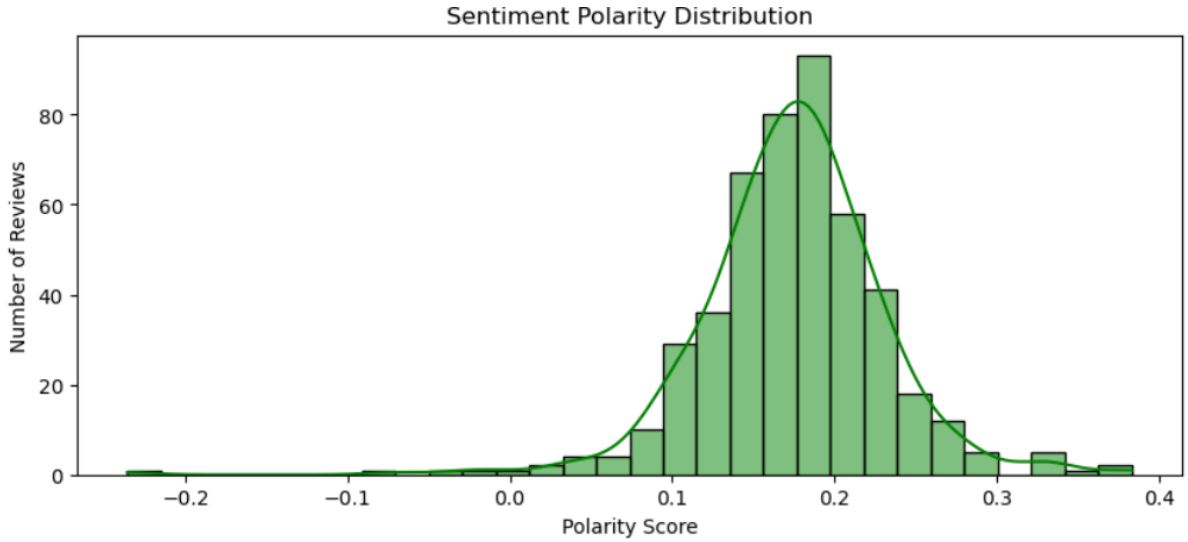


Figure 3: Sentiment Polarity Distribution

The sentiment polarity distribution in YouTube transcripts reveals a predominant positive inclination, with most polarity scores ranging from 0.1 to 0.25. The distribution exhibits right skewness, indicating that the majority of video reviewers have adopted a constructive or favorable tone. This pattern aligns with the Reddit analysis, indicating that Indian consumer discourse on EVs is optimistic. In contrast to Reddit, there are fewer instances of explicit negative emotion, likely because of the professional or promotional tone sometimes used in influencer evaluations, particularly in review videos.

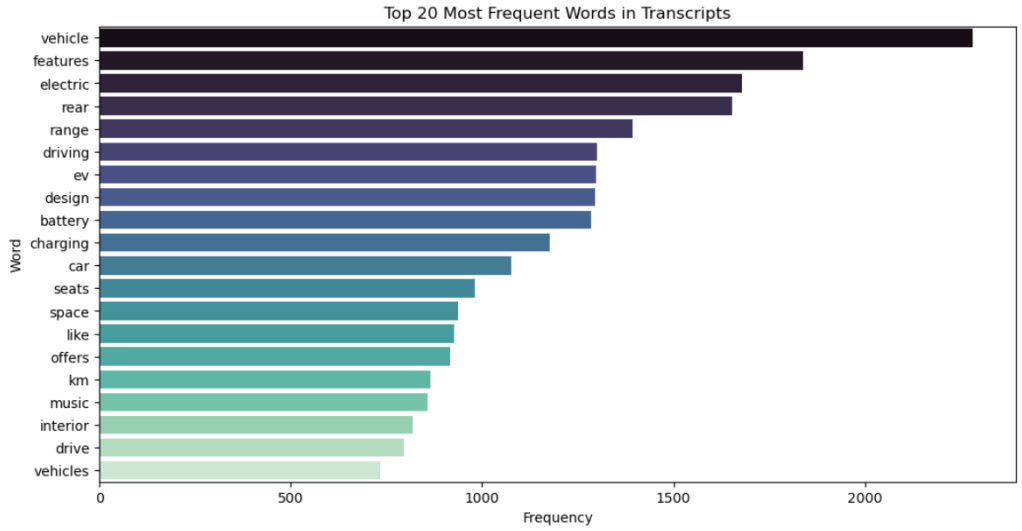
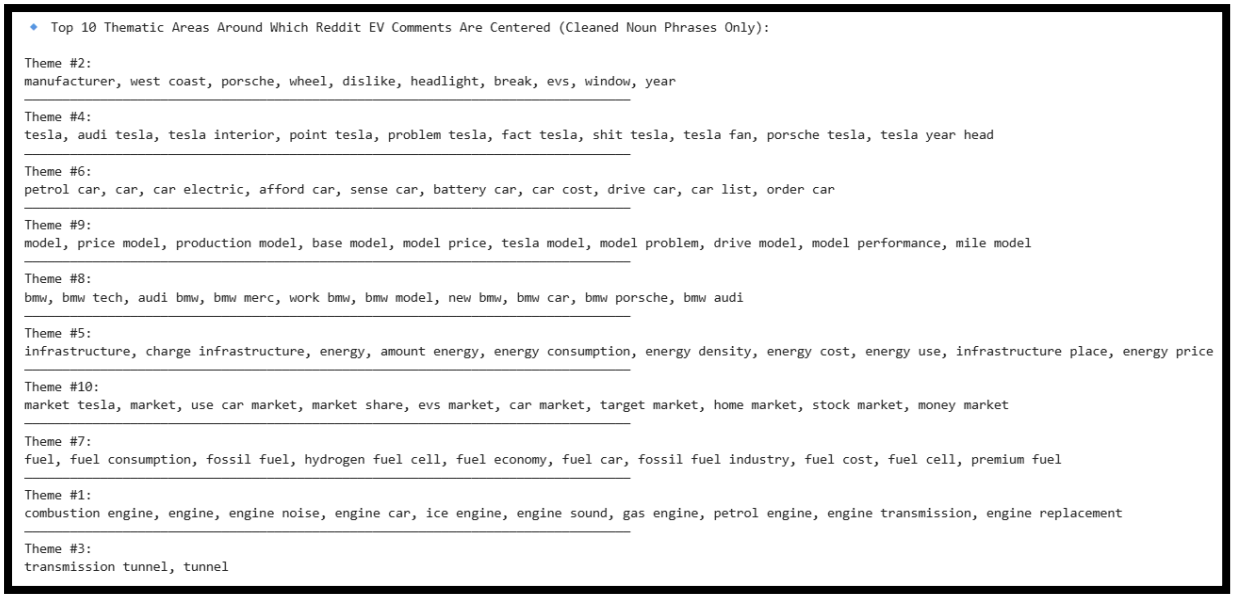


Figure 4: Top 20 Most Frequent Words in Transcripts

Further, the top frequent words in the transcripts of YouTube review videos illustrate the distribution of terms most frequently referenced across all YouTube reviews. Words such as "vehicle," "electric," "range," "battery," and "charging" dominate the conversation, signifying that technical parameters and practical usability are primary focal points. At the same time, the recurrent use of terms such as "rear," "seats," "interior," "features," and "design" suggests that comfort, aesthetics, and configuration are often assessed. Similarly, terms such as "offers," "music," and "km" emphasize value for money for consumers.



The study further attempted to decipher the emerging themes that emerged from the YouTube review videos. The analysis offers insights into the narrative themes employed by Indian YouTubers.

1. The 1st and 7th themes focused more on the engine and fuel type.
2. The 2nd and 6th themes are centered more around car features and the costing.
3. The 3rd theme focuses more on transmission.
4. The 4th and the 9th themes highlight more of the brand and the model evaluation, with a narrative focused on Tesla.
5. The 5th theme focused on energy and infrastructure.
6. The 8th theme revolved around luxury brand mentions, with a highlight on BMW.
7. Lastly, the 10th theme centered around market share and market conditions/perceptions.

2.5. Discussion and Conclusion

The study demonstrates an overall favorable, yet nuanced, customer view of electric four-wheelers in India. YouTube evaluations focus on product attributes such as design, battery life, and range, whereas Reddit conversations convey more genuine user sentiments regarding infrastructure failings, brand comparisons, and affordability issues. The study also highlights that the same brand can be discussed in multiple ways depending on the platform on which it is being addressed. The study offers a temporal examination of public opinion regarding EV models in the Indian market, although it is confined to perspectives within a specific environment. However, the study primarily focuses on existing car models, whereas other psychological barriers associated with electric vehicles in general remain to be examined. Furthermore, only two social media platforms are considered. The current findings provide a baseline of consumer perception, which can help identify shifts in sentiment and engagement levels over time.

3. Analyzing Distinct Competitive Positions of EVs in India Through the Evaluation of Consumer Perceptions

Across the world, the automotive industry is undergoing a systemic shift towards Electric Vehicles (EVs), driven by climate change concerns and advances in battery technology (BloombergNEF, 2025). In India too, the government is aggressively pushing for EV manufacturing & adoption through several subsidies, for both climate & geoeconomic reasons. While Indian consumers have high EV awareness, adoption is still low – only 7.7% of new auto sales in 2024 were EVs (NITI Aayog, 2025; Intage India, 2023). As such, there appear to be some disconnects in the consumer journey from awareness to purchase, highlighting the need to better understand Indian consumers' perceptions of EVs.

Within the consumer landscape, Generation Z (Gen Z) is a particularly important segment – it increasingly influences families' purchase choices and will soon become the main cohort of new car buyers (Ipsos, 2024; Mukherjee & Mukherjee, 2024).

However, there are very few studies on Gen Z consumers' attitudes towards EVs in India, even though they are otherwise known to exhibit greater sustainability orientation and tech savviness. We seek to bridge this gap by examining Gen Z consumers' EV-related attitudes in India, including their purchase intentions, attitudinal drivers, and brand perceptions. This will help to identify strategic insights for both policymakers and auto manufacturers.

3.1. State of EVs Globally

3.1.1. Market Overview

Since 2015, electric vehicles as a category have been growing at breakneck speed. In 2025, EV sales are expected to exceed 20 million units, accounting for over 25% of total car sales (IEA, 2025). This is 10 times the EV market size from just 8 years back in 2018, and highlights the dramatic structural shifts underway in the auto industry. The EV category is projected to continue growing at a 14% CAGR over the next 5 years, doubling to nearly 40 million units by 2030, or around 40% of global car sales (BloombergNEF, 2025a).

Most of this growth has been led by China, the US, and Europe, with China alone accounting for over half of global EV sales (IEA, 2025). Nonetheless, as these large markets mature, emerging markets in Asia and Latin Markets are becoming the new growth hotspots, growing at 60% year-on-year in 2024 (IEA, 2025).

EVs as a category span several drivetrains, and battery EVs (BEVs) are the only true EVs, in that they are powered solely by electricity. They also make up over 60% of the EV market (BloombergNEF, 2025a). As such, this study focuses only on BEVs.

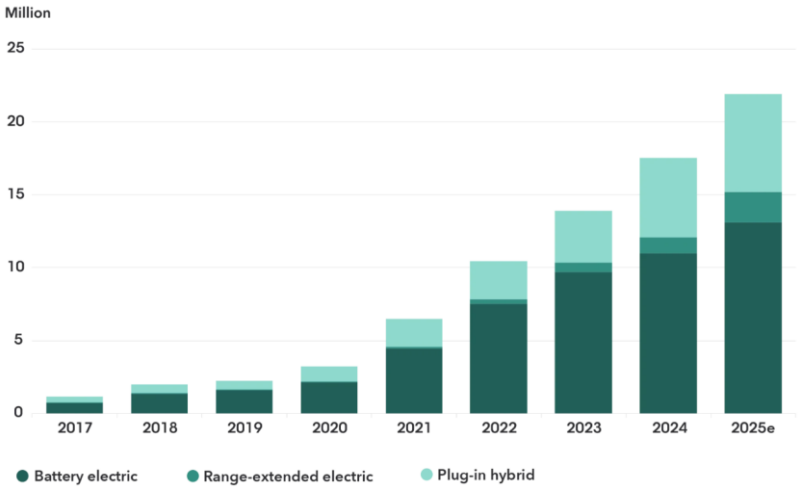


Figure 5: Global passenger EV sales by drivetrain

Source: (BloombergNEF, 2025a)

Alongside volume growth, the number of EV models being produced has also increased sharply and should soon reach parity with that for ICE cars (IEA, 2025).

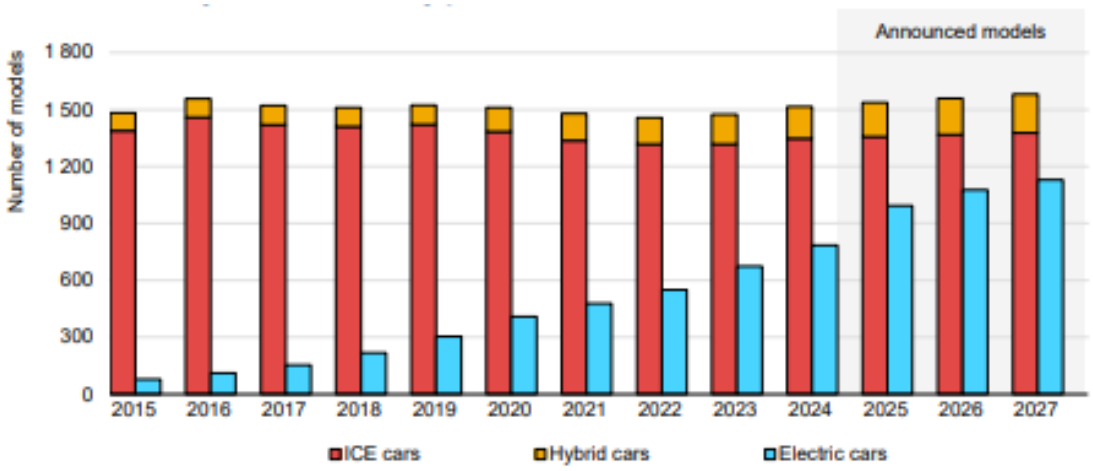


Figure 5: Global availability of car models by powertrain, 2015-2027

Source: (IEA, 2025)

3.1.2. Technological & Ecosystem Developments

EV adoption has historically faced several structural constraints vis-à-vis the conventional Internal Combustion Engine (ICE) vehicles. The chief among these is limited range per charge, sparse charging networks, long charging times, and lower drivetrain performance.

However, with technological innovations and ecosystem development over the past years, these deficits have considerably reduced. EVs today have an average range of nearly 350 km, which is 50% of the average ICE car's range. Charging infrastructure has also improved in core markets such as China, the USA, and Europe. The US's charging network has grown over sixfold from 30,000 stations in 2016 to almost 2,000,000 in 2025. Globally, 1.3 million new charging stations were added in 2024, more than the entire global stock in 2020. Also, the proportion of fast & ultra-fast charging stations has been growing, reducing charging inconvenience (IEA, 2025).

3.2. State of EVs in India

India's EV sector is relatively younger compared to global leaders such as China and the US. However, it has picked up pace significantly in the last couple of years, driven by a concerted push from the government. The market size is projected to reach $54 billion in 2025 and double to $108 billion by 2029, with a 20% CAGR (Hajare, 2025).

Unlike other countries, India's EV market is primarily dominated by 2-wheelers and 3-wheelers, which together account for over 60% of the sector (Press Trust of India, 2025).

Nonetheless, the government initiated an active policy push towards EV car adoption in 2013 with the National Electric Mobility Mission Plan 2020 (Ministry of Heavy Industries, 2015), followed by the EV Mission in 2018 (Government of India, 2025). With a policy vision to drive 30% EV penetration in private cars by 2030 (Government of India, 2025), the government has invested heavily into both EV demand (e.g., ₹10,000 Crore FAME II scheme (2019)) and EV supply (e.g., ₹25,500 Crore PLI scheme (2021), ₹10,900 Crore PM E-DRIVE (2024) scheme) alongside several other policy & regulatory measures.

Despite such extensive efforts and rising urban interest, EV sales lag well behind targets (Wagh, 2024). After 12 years of EV promotion, only 2% of India's four-wheelers and 5% of two-wheelers are EVs (IBEF, 2024). EV adoption will need to speed up significantly if India is to meet its decarbonization goals (Saraf & Shastri, 2024) and achieve returns on these policy initiatives.

From an industry angle, the landscape is dominated by local manufacturers such as Tata Motors (category leader) and Mahindra. However, foreign brands such as MG and BYD are increasingly gaining market share, and Tesla also recently entered the Indian market, further attesting to its growing attractiveness (Press Trust of India, 2025; JMK Analytics, 2025). Batteries have also improved significantly with developments in lithium-ion and LFP chemistries, improving range and affordability, while the government and manufacturers aggressively expand charging infrastructure in cities and highways.

3.3. Analytical Framing: The Urban-Mobility Socio-Technical Framework

To move beyond a purely psychological assessment of consumer intent, this study adopts an urban-mobility electrification framework that treats electric vehicle adoption as a complex system transition problem. Drawing from socio-technical transition theory, we analyze the Indian landscape through three interacting layers that co-determine whether a technological shift succeeds. The policy-market layer involves the configuration of fiscal and non-financial incentives, such as those found in current national schemes, which alter the total cost of ownership, a significant factor in Indian consumer choice. The operations-infrastructure layer addresses the convenience gap, specifically focusing on how charging infrastructure and range anxiety act as primary barriers to proliferation within urban environments. Finally, the organization-behavior layer examines how social norms, symbolic motives, and perceptions of high-tech brands influence the desire to use electric vehicles. By applying this three-

layer lens, the chapter ensures that consumer findings are not viewed in isolation but are operationally grounded in the realities of India's fragmented infrastructure and evolving policy landscape.

3.4. Review of Literature

3.4.1. Consumer Attitudes Towards Car Ownership

Soza-Parra & Cats (2023) conducted a comprehensive systematic review of 54 empirical studies to understand how subjective motives shape car ownership and usage. They found these attitudes to comprise 5 core motive categories:

1. **Instrumental motives and autonomy**: The most influential motive: people value the flexibility, convenience, speed, and reliability that cars offer. These practical reasons consistently predicted both ownership and use.
2. **Symbolic motives**: Cars serve as symbols of personal identity, status, and success. Many individuals derive emotional and social credibility from owning and driving a car, beyond its practical function.
3. **Affective motives**: These capture emotional drivers like enjoyment, comfort, pleasure, and emotional attachment to cars. While influential, these were generally secondary to instrumental and symbolic motives.
4. **Social norms**: Peer influence, family expectations, and wider society norms strongly affect intentions to own or use cars. If car ownership is common among one's social group, personal intentions rise.
5. **Environmental motives**: Concern for emissions, climate, and sustainability had a measurable, though weaker, influence on ownership decisions, especially when paired with instrumental motives.

They found that most objective models, which rely only on socio-demographic factors and infrastructure, underperform in predicting car decisions. The inclusion of subjective motive variables significantly improves model fit for predicting car purchase and use (Soza-Parra, 2023).

Pardon et al. (2025) conducted a systematic literature review using the Theory of Planned Behavior (TPB) and Material Possession Theory (MPT) to examine how psychological and attitudinal factors influence car ownership in developing countries. They found that in developing countries, owning a car usually goes beyond practical mobility and is seen as a symbol of status, identity, and social success. As such, social norms, peer influence, and perceptions of image significantly impact ownership intentions. Overall, ownership intentions were determined by a combination of functional utility, symbolic/social aspirations, and negative views of public transport systems.

This overall structure is also corroborated by several primary studies on Indian consumers, as below.

Verma et al. (2016) conducted a survey of college-educated young adults in Bangalore to understand how attitudes affect car ownership intentions. Their study found that many participants viewed owning a car as a symbol of social status and success. People who associated car travel with comfort, convenience, and less physical strain were more likely to want a car. On the other hand, those who

believed that good public transport or cycling infrastructure could meet their needs were less inclined to buy a car. The study showed that attitudes about image and travel experience strongly influence ownership intentions among urban youth.

Bansal and Kockelman (2017) combined expert interviews with state-level census data to examine car ownership patterns across India. They found that price, fuel economy, and brand reputation were the top factors influencing car purchase decisions. States with higher income levels and greater household ownership of assets (e.g., computers) tended to have more cars. The experts also highlighted a major gap in research: most models relied on broad state-level data rather than detailed household-level choices, limiting their ability to inform local transport policy.

Bansal et al. (2018) surveyed around 1,000 people in Bengaluru, Delhi, and Kolkata to analyze how car ownership relates to travel behavior. Their findings showed that income, household size, and ownership of assets such as mobile phones or computers were key predictors of the number of vehicles a family owned. People with cars often use them for work, shopping, school, and social trips. The study also projected that vehicle ownership in Indian cities would rise by 2030, with more people opting for passenger cars over other vehicle types.

3.4.2. Consumer Attitudes Towards EVs

Lashari, Ko, and Jang (2021) conducted a survey of 1,500 urban car-buyers in South Korea using binary logistic regression and regression tree analysis, showing that environmental consciousness and anticipated fuel-cost savings drive positive attitudes toward EVs, whereas doubts about technology reliability and sparse charging infrastructure undermine consumer confidence.

Ghasri et al. (2019) analyzed 1,176 residents of New South Wales, Australia, regarding their stated preferences using an integrated choice and latent-variable model, which revealed that design appeal, environmental benefits, and safety features heighten EV attractiveness, while purchase rebates and fee reductions substantially boost consumer favorability.

Nazari et al. (2023) analyzed EV owners in California, USA, using a nested logit framework with latent psychological constructs on a large stated-preference dataset. This study found that range anxiety significantly reduces the probability of choosing battery-electric vehicles over hybrids or conventional cars, underscoring the perception barrier posed by limited driving range.

Varghese et al. (2021) conducted a quantitative survey in India and identified awareness and perceived environmental benefits as vital positive influences on consumer attitudes, but highlighted that high upfront costs and inadequate charging infrastructure remain key deterrents.

3.4.3. Purchase Intention towards EVs in India

Maheshwari, Cherla, and Garg (2022) conducted a large-scale survey of roughly 6,000 respondents across ten cities in India. It pinpointed total cost of ownership, driving range, and charging time as the foremost purchase criteria, with prospective buyers expecting substantial expansion of public charging infrastructure before committing to EV ownership.

Sharma. P. (2022) conducted a study investigating key barriers to EV adoption in India through a descriptive survey and expert interviews. It highlighted high upfront costs, range anxiety, limited

charging infrastructure, and consumer awareness as major constraints on purchase intention. The paper stressed the importance of targeted policy incentives and consumer education to bridge the gap between interest and adoption.

Rafiq et al. (2024) conducted a snowball sample survey of 274 millennials and younger adults, applying TPB and TAM with awareness as a mediator, and found that perceived ease of use, social norms, and environmental concern significantly elevate purchase intention, with knowledge acting as a central mediator.

3.4.4. Consumer Attitudes of Gen Z Towards EVs

Badarpura, Haidarali & Vidani (2024) conducted a survey to analyze consumer perception towards two-wheeler EVs in India. A regression analysis on 137 Gen Z respondents showed that brand familiarity (e.g., Ola, Ather), aesthetic appeal, and advanced technology features drive positive perceptions of electric two-wheelers, while price sensitivity and range anxiety impede adoption.

Krithika et al. (2023) conducted a survey-based regression analysis that revealed that, for Gen Z car buyers, perceived price, risk perception, and expected financial benefits are the primary determinants of purchase intention, whereas technology curiosity and sustainability awareness exert comparatively weaker influences.

Sripiyanka & Venkatragavan (2024) found, through a questionnaire administered among Chennai's Gen Z, that peer influence and environmental awareness increase the willingness to adopt EVs, but high upfront costs and perceived infrastructure inadequacy remain significant barriers despite strong receptivity to sustainability messaging.

3.4.5. Summary Table

Table 1: Summary of Literature Review

Study	Sample	Size	Methodology	Key Findings
Lashari, Ko & Jang (2021)	Urban car-buyers, South Korea	1,500	Survey, logistic & tree regressions	Environmental & economic perceptions are positive; reliability & infrastructure concerns are negative.
Ghasri et al. (2019).	NSW residents, Australia	1,176	Stated preference, integrated choice, and latent model	Design, environmental, and safety advantages drive EV utility; financial incentives boost purchase intention
Nazari et al. (2023).	California residents, USA	Not stated	Nested logit with latent constructs	Range anxiety substantially reduces the probability of choosing a BEV.

Study	Sample	Size	Methodology	Key Findings
Varghese et al. (2021).	Indian consumers	Not stated	TPB & TAM survey	Awareness & environmental benefit perceptions are positive; cost & range barriers are prominent.
Maheshwari, C. & Garg (2022)	General urban mix across 10 Indian cities	~6,000	Large-scale survey	Cost, range, and charging time top criteria; infrastructure readiness is critical
Sharma et al. (2022)	Indian consumers	30 + experts	Descriptive survey & qualitative interviews	High cost, range anxiety, infrastructure, and lack of awareness are barriers; policy & education needed
Rafiq et al. (2024)	Indians under 40	274	Snowball online survey, TPB/TAM	Ease of use, social norms, and environmental concern are positive; awareness mediates intention.
Badarpura, Haidarali & Vidani (2024)	Gen Z two-wheeler buyers, India	137	Quantitative survey, regression	Brand familiarity, aesthetic appeal, tech features positive; price sensitivity & range anxiety deterrents
Krithika et al. (2023)	Gen Z EV car buyers, India	Not stated	Survey-based regression	Price, risk, and financial benefits are significant; tech curiosity & sustainability are less influential.
Sripiyanka & Venkatragavan (2024)	Gen Z respondents, Chennai, India	Not stated	Questionnaire	Social influence & environmental awareness positive; cost & infrastructure perceptions negative

3.5. Methodology

3.5.1. Research Framework

Table 2: Research Questions and Method

Research Question	Data Points Needed	Research Method	Data Analysis
Do Gen Z opinions matter in car purchases?	• Gen Z's involvement in family car purchases • Linkage of current opinions with future purchases	Secondary Research Primary Survey	• Descriptive Statistics
Do Gen Zs intend to purchase cars?	• Intent to purchase a vehicle • Intent to purchase a car • Preference for ownership vs cabs/public transport	Primary survey	• Descriptive
What do they look for in cars?	• Primary drivers of car purchase • Most important attitudinal attributes	Secondary Research Primary Survey	• Regression Analysis
How open are they to EVs?	• Awareness of EVs • Openness to Purchase EVs • Preference for EVs	Primary Survey	• Paired sample t-test • Correlation analysis
What drives their perceptions of EVs?	• Attributes salient for purchase intent at various points of the consumer journey • Where EVs (category) lie on these attributes • Where do EV brands lie on these attributes	Primary Survey	• Regression Analysis • Factor Analysis (Perceptual Map)

3.5.2. Sample

The study was conducted with a sample of 75 participants, all students aged 21-28 years. This sample represents a young, urban, and educated cohort belonging predominantly to India's Tier-1 cities. The sample's gender distribution (65%-35%) aligns with India's demographics. The sample's income distribution captures the wide range of income variability within the Indian diaspora.

The sample aims to replicate an emerging market segment for electric vehicles in India: an urban, tech-savvy, and sustainability-conscious group.

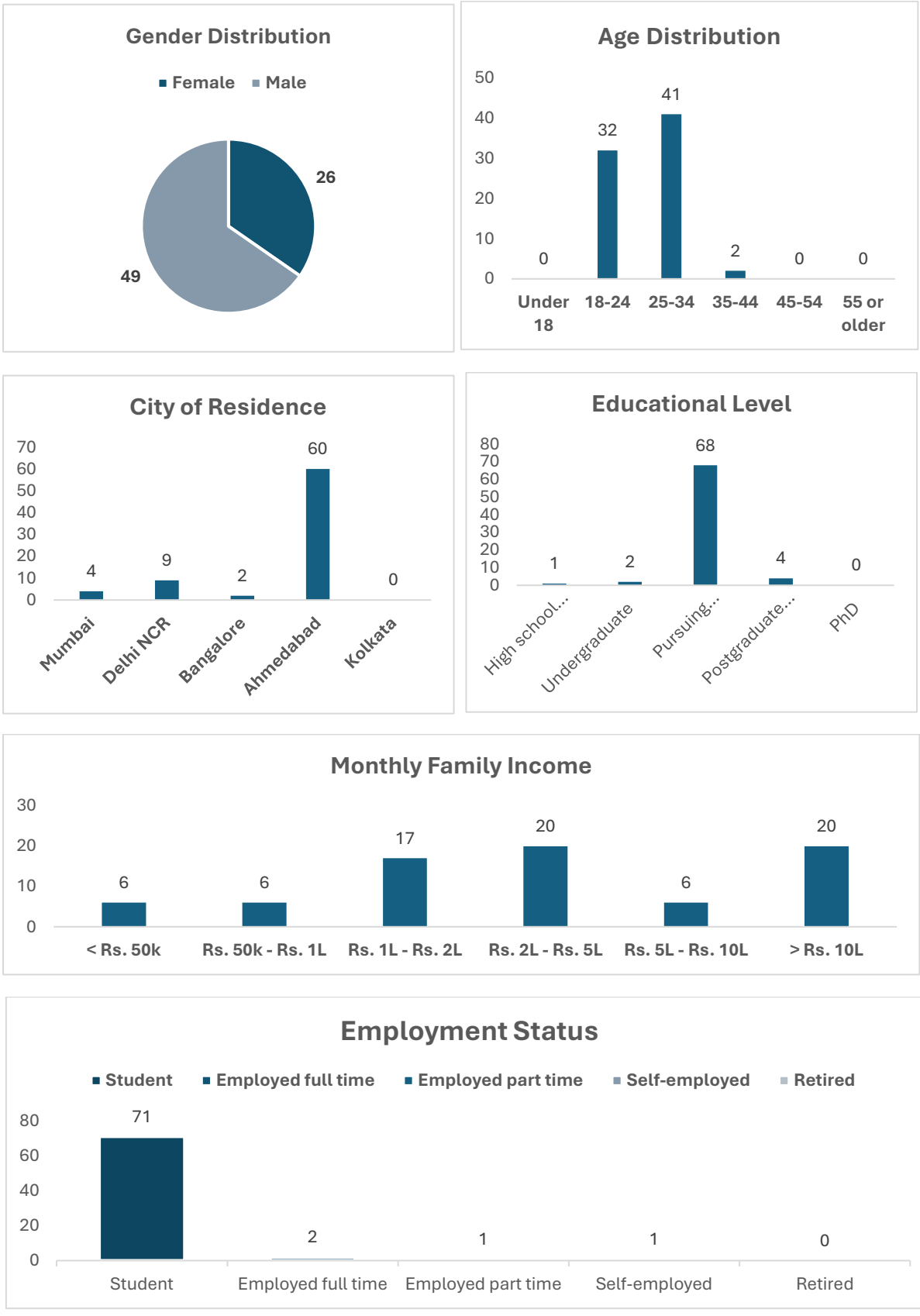


Figure 6: Socio-demographic characteristics of the sample

3.5.3. Survey Design

The survey was structured into 6 sections, with the first one capturing participants' demographic details.

This was followed by an assessment of their attitudes towards car ownership. For this, we identified 7 dimensions, building on Soza-Parra's model and other studies in the literature: convenience/comfort, enjoyment, environment orientation, prestige, city attitudes, social norms, and functional utility. Each dimension was assessed using 2 questions on a 5-point Likert scale.

Next, we collected self-reported purchase intentions for vehicles, cars, and EVs, followed by a unique setup to assess consumer perceptions of EVs as a car category and specific EV brands. We used sets of representative pictures for each category and asked participants to rank them on 5-6 parameters of interest. This allowed us to efficiently simulate a consumer choice situation (choosing between car options), make the stimuli more realistic to elicit more accurate perceptions, and to obtain relative comparisons between the choice sets.

An example question is given below. A similar approach was followed for all attributes.

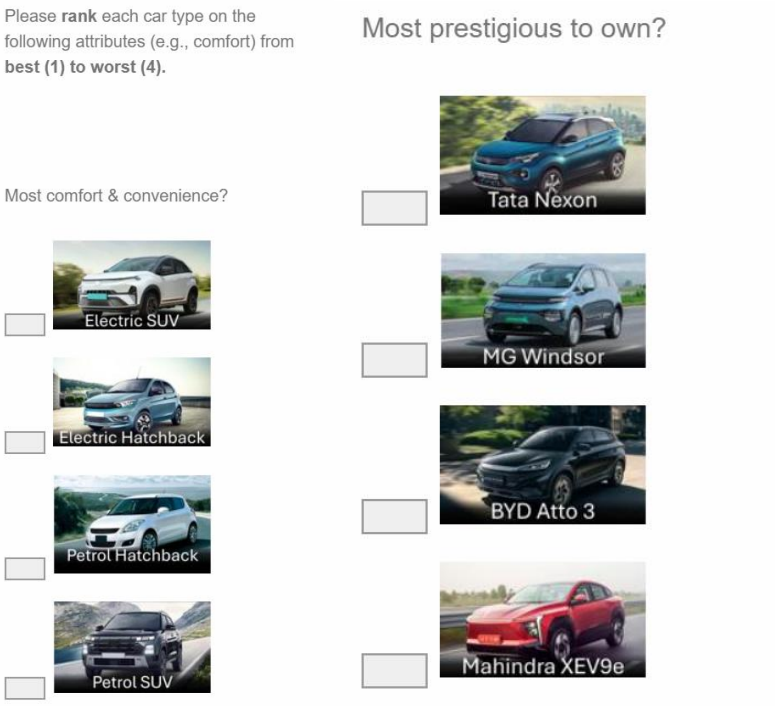


Figure 7: Example of the questions asked

3.6. Analysis

All analyses were performed using Microsoft Excel and SPSS, with the chief statistical tools used including t-tests, correlation analysis, factor analyses (principal components analysis), and multiple linear regressions for assessing drivers of purchase intention.

3.7. Findings

3.7.1. Spatial Differentiation: The Metro-Centric Critique

A critical limitation identified in current Indian electric vehicle discourse is the metro-centric bias of both infrastructure deployment and vehicle design. While our findings show a predominantly positive public impression, this optimism is often moderate and heavily influenced by the availability of charging facilities found in metropolitan hubs. As noted throughout this report's broader stakeholder consultations, vehicles must eventually address the specific grid and land constraints in Tier-2 and Tier-3 cities to achieve national impact. In metropolitan hubs, the value of electric vehicles is often tied to high-tech, futuristic appeal; however, these same vehicles face climate-resilience vulnerabilities, such as a lack of flood-proofing in charging depots, which are more pronounced in the varied topographies of smaller Indian towns. For the Indian market to reach a true tipping point, manufacturers and policymakers must pivot from designing premium, metro-focused models to creating resilient, compact vehicles that address the diverse geographical and operational realities of the broader Indian diaspora.

3.7.2. Do Gen Z's Opinions Matter in Car Purchases?

Current Role in Household Decisions

A study by de Sa et al. (2020) highlights that Gen Z, including older teens, already influences family car buying decisions significantly. Research shows that Gen Z influences family decisions, guided by preferences for safety, technology, and design features. This involvement is more active than passive as they participate in evaluating options and priorities.

Market Power and Purchasing Behavior

Research by McKinsey (2024) confirms Gen Z's rising power as direct consumers of vehicles. According to McKinsey's 2024 report, Gen Z purchases its first cars earlier than previous generations, with about 76% owning a vehicle by age 21, compared to 56% among millennials. This early vehicle ownership underlines Gen Z's direct impact on automotive sales now and over the coming decades.

Deloitte's (2024) Global Automotive Consumer Survey complements these insights by highlighting Gen Z's openness to innovative vehicle ownership models, such as subscriptions and mobility-as-a-service, which are changing traditional purchase and ownership dynamics.

Purchase Preferences and Barriers

Statista (2025) data reflect Gen Z's pragmatic approach: price and reliability top purchasing criteria, outweighing purely environmental concerns for many. While this cohort is environmentally conscious (40% consider electric vehicles and engage in green mobility actions), they still balance sustainability with economic realities.

Primary Research

Our primary survey shows that 50% of participants in Tier-1 cities (i.e., Gen Z) are highly involved in their family's car purchase decisions (Mean score = 3.69, Median = 4).



Figure 8: Q. How involved are you in your car family purchase?

Therefore, Gen Z's opinions and purchasing behaviors are crucial drivers of today's car market and the EV revolution ahead. They influence not only family buying decisions but are also rapidly becoming primary consumers themselves.

3.7.3. Do Gen Zs Intend to Purchase Cars?

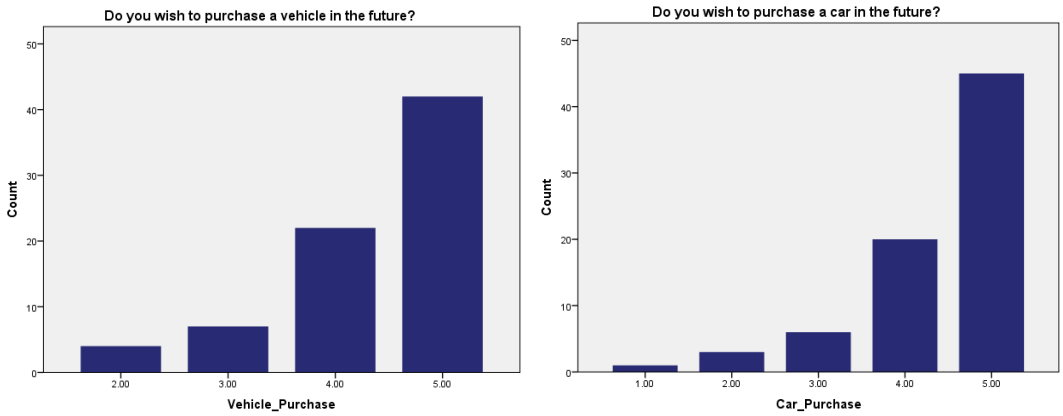


Figure 9: a) Q. Do you wish to purchase a vehicle in the future? b) Q. Do you wish to purchase a car in the future?

1. **Overall vehicle purchase intention:** The first chart shows responses to the question, *"Do you want to buy a vehicle in the future?"* The majority of respondents (64 respondents) rated their intention at the higher end of the scale. This distribution highlights a strong willingness among Gen Z to consider vehicle ownership in the future, signaling a sizable potential market.
2. **Car-Specific purchase intention:** The second chart focuses on the intention to buy a car specifically. The pattern is even more pronounced: 45 respondents scored 5 (highest) for car purchase intent, demonstrating strong interest.

This suggests that not only do many Gen Z individuals plan to buy vehicles, but a large portion specifically intend to purchase cars, reinforcing their importance as a direct consumer segment in the automotive market.

3.7.4. What Does Gen Z Look for in Cars?

a. Perceptions about Cars

We assessed the strength of several attitudes related to car ownership, as follows:

1. **Primary Preferences:** Gen Z places the highest importance on instrumental motives such as flexibility and comfort, as indicated by the median ratings in the range of 4-5 with relatively small interquartile ranges. Similarly, affective attributes such as being attracted to cars and enjoyment are also rated highly, reflecting a degree of enthusiasm for cars despite urban driving challenges. Further, the sample also shows high importance for social attributes such as societal expectations of owning a car, as well as the influence of friends and family.

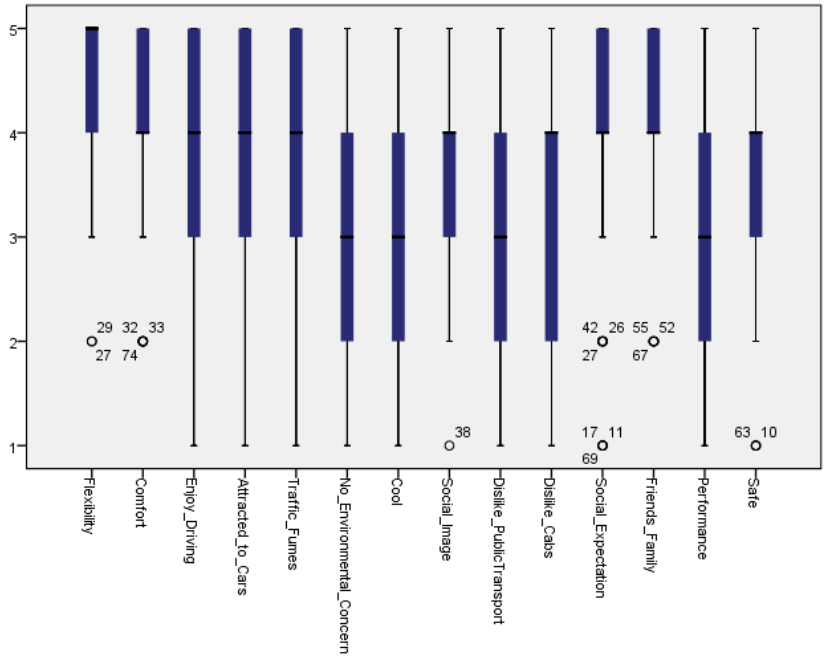


Figure 10: Primary Preferences

2. **Moderate Influencing Factors:** Attributes like cool appearance, social image, and the performance of the car have median scores around 3 to 4, showing that Gen Z cares moderately about style and status, as well as vehicle capabilities. Further, an interesting insight is that dislike of public transportation and the fact that cabs are a stronger motivator for car purchases are stronger among Gen Z.
3. **Lower Importance Factors:** We notice that Environmental and Social Concerns show a broader range with a median of around 3, indicating mixed levels of priority among Gen Z respondents.

b. Purchase Drivers

To assess how these attitudes are linked to purchase intent, we first regressed the attitudes on future vehicle purchase intent. Using stepwise regression, we arrived at a linear model that explained 28% of the variance in vehicle purchase intent, based on 3 predictors: aversion to using cabs (City2), attraction to cars since childhood (Enjoyment2), and social norms (Social2).

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.428[a]	.183	.172	.78662	.183	16.339	1	73	.000
2	.523[b]	.273	.253	.74693	.090	8.964	1	72	.004
3	.560[c]	.313	.284	.73125	.040	4.120	1	71	.046

a. Predictors: (Constant), City2

b. Predictors: (Constant), City2, Enjoyment2

c. Predictors: (Constant), City2, Enjoyment2, Social2

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.293	.279		11.801	.000
	City2	.311	.077	.428	4.042	.000
2	(Constant)	2.735	.324		8.439	.000
	City2	.266	.075	.365	3.559	.001
	Enjoyment2	.204	.068	.307	2.994	.004
3	(Constant)	2.041	.466		4.375	.000
	City2	.239	.074	.329	3.221	.002
	Enjoyment2	.189	.067	.285	2.815	.006
	Social2	.198	.098	.205	2.030	.046

a. Dependent Variable: Vehicle_intent

The greatest variance (18%) was explained by a preference for owning cars rather than hiring cabs. From a decision-making perspective, this is logical, as once someone decides they want to travel point-to-point by personal transport, cabs are the main alternative.

The next predictor – attraction to cars since childhood – highlights the crucial role marketing plays in shaping individuals' perceptions and attitudes early on, well before they are involved in car purchases. A full 9% of purchase intent variance was accounted for not by current factors but by the emotive appeal of cars that was instilled when people were kids, likely through placement in movies, attractive billboard posters, and presence in kids' media.

Finally, social norms played a small role. People who lived in social circles where most of their friends and family owned cars were also more likely to purchase a vehicle themselves. This is because vehicle ownership would have become a taken-for-granted assumption for them – simply something one did once one had the money.

Next, we regressed these attitudes on the intent to purchase cars specifically. The findings here were interesting, in that the same two predictors as earlier were significant – relative aversion to cabs & childhood attraction to cars.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.442[a]	.195	.184	.81343	.195	17.679	1	73	.000
2	.512[b]	.262	.242	.78410	.067	6.564	1	72	.012

a. Predictors: (Constant), Enjoyment2

b. Predictors: (Constant), Enjoyment2, City2

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	3.330	.271		12.280	.000
	Enjoyment2	.306	.073	.442	4.205	.000
2	(Constant)	2.773	.340		8.150	.000
	Enjoyment2	.269	.072	.388	3.749	.000
	City2	.201	.078	.265	2.562	.012

a. Dependent Variable: Car_Intent

The chief difference is that of social norms. People whose friends and family mostly own cars are more likely to have the intent to purchase a vehicle in the future, but when it comes to purchasing cars in particular, this predictor disappears, implying that car purchase decisions are primarily individualistic, based on personal preferences and more immune to peer pressures.

It is notable, though, that environmental attitudes are not significant predictors of purchase intent, even negatively. This indicates that for Gen Z consumers, environmental considerations do not even enter the purchase decision-making process despite their generally believed sustainability orientations. This has important implications for how EV adoption will need to be driven in India. Similarly striking is the fact that prestige is not a significant predictor of purchase intent. This marks a distinct generational shift in attitudes towards car ownership. Several studies of previous generations (e.g., millennials) found that signaling social status was a major driver of car purchases in India, even superseding functional utility at times. Owning a car was regarded as an indicator that one had 'made it' in life. This has now changed dramatically to the point that it is no longer a statistically significant factor.

3.7.5. How Open are Gen Z to EV Ownership?

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Openness & Preference	75	.486	.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	Openness - Preference	.84000	.93056	.10745	.62590	1.05410	7.817	74	.000

1. **Correlation Analysis:** The correlation coefficient between the variables Openness (willingness to buy an EV) and Preference (EV as first choice) is 0.486, which is a moderate positive correlation and statistically significant ($p < 0.001$). This indicates that respondents who are open to buying an EV are more likely also to prefer it as their first choice when purchasing a car.
2. **Paired Samples Test:** The paired t-test statistic ($t = 7.817$, $df = 74$, $p < 0.001$) confirms that the difference between openness and preference is statistically significant. This suggests that while Gen Z shows a generally high openness to the idea of buying EVs, their preference for EVs as a first-choice vehicle is somewhat lower.

This indicates that Gen Z youth are highly willing to consider EV ownership in future car purchases. However, there appears to be a gap between willingness and actual preference, indicating factors such as price, range anxiety, or availability may temper their preference for EVs as their primary choice.

3.7.6. What Drives Gen Z's Perception of EVs?

Our comparative analysis of relative perceptions amongst EV and ICE cars yielded highly interesting results. Across hatchbacks & SUVs, EVs ranked lower than their ICE counterparts on convenience & comfort, driving enjoyment, and sheer performance. This is understandable given EVs' lower power and range, as well as constraints due to deficient charging infrastructure.

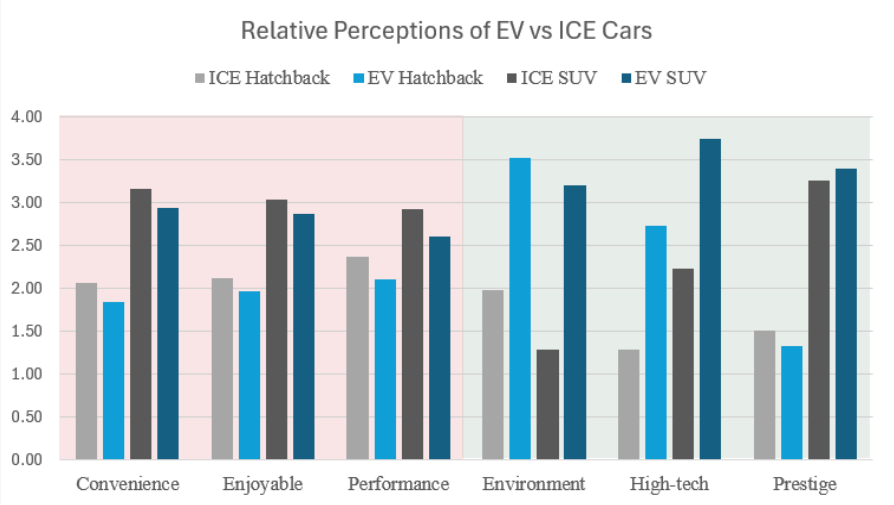


Figure 11: Relative Perceptions of EV vs ICE Cars

Note: The ranks are inverted for representation (Rank #1 corresponds to 4 on the chart)

On the other hand, EVs were regarded as significantly more environmentally friendly than their ICE counterparts, reflecting strong awareness among Gen Z of their sustainability advantage.

EVs were also perceived to be significantly more high-tech than ICE counterparts across both hatchbacks and SUVs. This is likely because EVs, as a technology, have emerged recently, compared to ICE, whose technology largely matured several decades ago and now has little novelty. EV cars are also often styled in a more futuristic way, with fewer grilles, sleeker bodywork, and LED lighting, as brands consciously position them as more innovative.



Source: Motoring World

The most striking finding, though, was that in the SUV segment, EVs are perceived as more prestigious than conventional SUVs. Given that SUVs in general are premium cars, this indicates that Gen Z youth regard EV SUVs as the most aspirational cars to own. This surprising finding could be that EV SUVs are perceived to offer similar convenience and driving enjoyment as regular SUVs, but are seen as substantially more high-tech, leading them to be regarded as 'cooler' than regular SUVs.

To test these interlinkages amongst the attributes, we conducted a nonparametric correlation analysis (Spearman's Rho), yielding the following results.

Table 3 Results from non-parametric correlation analysis

	Convenience	Enjoyable	Environment	Prestige	Performance	HighTech
Convenience	-	0.63	-0.11	0.47	0.25	0.18
Enjoyable	0.63	-	-0.08	0.43	0.29	0.19
Environment	-0.11	-0.08	-	-0.11	-0.13	0.43
Prestige	0.47	0.43	-0.11	-	0.18	0.47
Performance	0.25	0.29	-0.13	0.18	-	0.08
HighTech	0.18	0.19	0.43	0.47	0.08	-

Perceptions of car prestige were strongly correlated with comfort/convenience (ρ = 0.47), high-tech (ρ = 0.47), and the enjoyment of driving/riding (ρ = 0.43). All 3 of these correlations were significant at the p <0.001 level. Notably, prestige was not correlated as strongly with performance (ρ = 0.18). While convenience and driving joy are similar across ICE & EVs, this finding suggests that Gen Z might value high-tech features more than a car's sheer performance.

Building on this correlation analysis, we reduced these 6 attributes into 2 factors using principal components analysis with varimax rotation. There were only 2 latent factors with an eigenvalue greater than 1. The first one – "lifestyle value" – had loadings for convenience, enjoyment, prestige, and performance, while the second factor – "futuristic appeal" – had loadings for environmental friendliness and high-tech perception.

Rotated Component Matrix[a]

	Component 1	Component 2
Convenience	.822	.007
Enjoyable	.816	.025
Environment	-.260	.817
Prestige	.724	.300
Performance	.512	-.158
HighTech	.308	.848

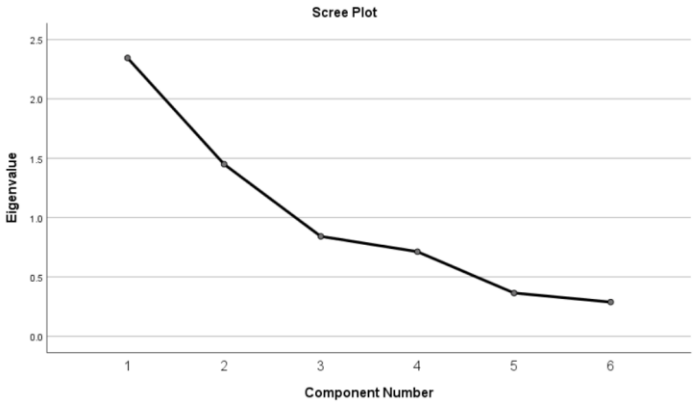


Figure 12: Rotated component matrix and scree plot showing two dominant factors, lifestyle value and futuristic appeal, emerging from principal components analysis.

Upon mapping the rankings obtained for different types onto these factors, we obtained a perceptual map of car categories. Interestingly, the 4 categories are neatly sorted into a nearly 2x2 framework, with lifestyle value being linked to the form factor of the car and drivetrain being linked to its futuristic appeal. SUVs were ranked highly on lifestyle value, while EVs were ranked highly on futuristic appeal.

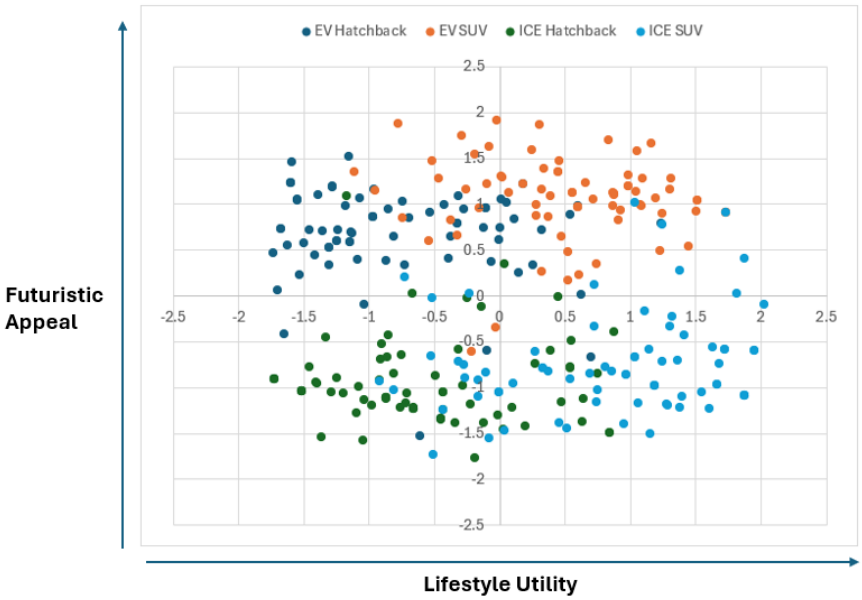


Figure 13: Perceptual Positioning of EV and ICE Hatchbacks and SUVs on Lifestyle Utility and Futuristic Appeal Dimensions

The natural next question was how individuals' overall attitudes towards cars shape their relative perceptions of EVs. For this, we ran a correlation analysis between the respondents' attitudes and the ranks they gave to EVs on the 5 attributes. Interestingly, there were only 4 correlations that emerged as statistically significant. Individuals who valued cars for their travel flexibility were likelier to better recognize the performance given by EVs. Those who regarded cars as the primary driver of air pollution or enjoyed driving in cars more strongly noticed the environmental friendliness of EVs. However, those who valued cars for their comfort tended to regard EVs more poorly in terms of their prestige.

Table 4: Correlation Matrix Between Respondents' Car Attitudes and Perceived EV Attributes

	EV_Avg_Convenience	EV_Avg_Enjoyable	EV_Avg_Environment	EV_Avg_Prestige	EV_Avg_Performance	EV_Avg_HighTech
Convenience1	0.021	0.070	-0.147	-0.052	-0.231	-0.174
Convenience2	-0.021	0.137	0.018	0.243	0.068	-0.064
Enjoyment1	0.136	0.172	-0.300	-0.098	0.104	-0.181
Enjoyment2	0.142	0.121	-0.084	0.137	-0.012	-0.071
Environment1	-0.096	-0.101	-0.235	-0.070	-0.033	-0.129
Environment2	0.046	-0.044	0.135	0.036	0.043	0.082
Prestige1	0.043	-0.057	0.124	-0.084	0.067	-0.017
Prestige2	0.048	-0.026	0.024	0.024	0.013	-0.091
City1	-0.174	-0.204	-0.020	-0.206	-0.043	-0.188
City2	0.059	0.101	-0.071	0.213	0.069	0.044
Social1	0.005	-0.047	0.005	0.010	-0.073	-0.180
Social2	-0.073	0.060	-0.024	0.071	0.011	-0.121
Utility1	-0.037	0.075	-0.123	0.103	0.112	0.076
Utility2	-0.057	0.023	0.128	0.076	0.072	0.054

Regressing these variables onto openness to purchase yielded two significant predictors: aversion to public transport and concern for air pollution, which together explained 12% of the variance. While the predictors are logically obvious, the small proportion of variance they explain indicates that other structural barriers, such as charging infrastructure, charging time, and range, may still be the main determinants of openness to considering EVs.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.287[a]	.083	.070	.78460	.083	6.577	1	73	.012
2	.384[b]	.147	.124	.76170	.065	5.454	1	72	.022

a. Predictors: (Constant), City1

b. Predictors: (Constant), City1, Environment1

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.082	.240		12.816	.000
	City1	.186	.073	.287	2.565	.012
2	(Constant)	2.342	.393		5.954	.000
	City1	.173	.071	.267	2.441	.017
	Environment1	.196	.084	.255	2.335	.022

a. Dependent Variable: EV_Openness

Next, we regressed these independent variables onto a preference for EVs – whether EVs would be the respondent's 1st choice when considering car purchases. Here, there was only 1 statistically significant predictor – the perceived convenience of EVs. This further reinforces the hypothesis stated above that structural factors, such as charging infrastructure, still dominate the decision-making process and are the key underpinning of whether EVs even reach the choice set for prospective consumers. Interestingly, perceived convenience of EVs is the main predictor, even among Gen Z consumers who may not yet have deeply considered operational factors in a car purchase, where such factors would be expected to surface.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.438[a]	.192	.181	.90142	.192	17.315	1	73	.000

a. Predictors: (Constant), EV_Avg_Convenience

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.707	.467		10.082	.000
	EV_Avg_Convenience	-.725	.174	-.438	-4.161	.000

a. Dependent Variable: EV_Preference

3.7.7. Comparative Positioning of EV Brands

A factor analysis of relative rankings across various attribute-level evaluations of EV brands yielded no meaningful results for perceptions within EV brands, with all 5 attributes loading onto a single factor.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.176	43.515	43.515	2.176	43.515	43.515
2	.994	19.880	63.395			
3	.747	14.943	78.338			
4	.617	12.338	90.675			
5	.466	9.325	100.000			

Extraction Method: Principal Component Analysis.

Figure 14: Total variance explained

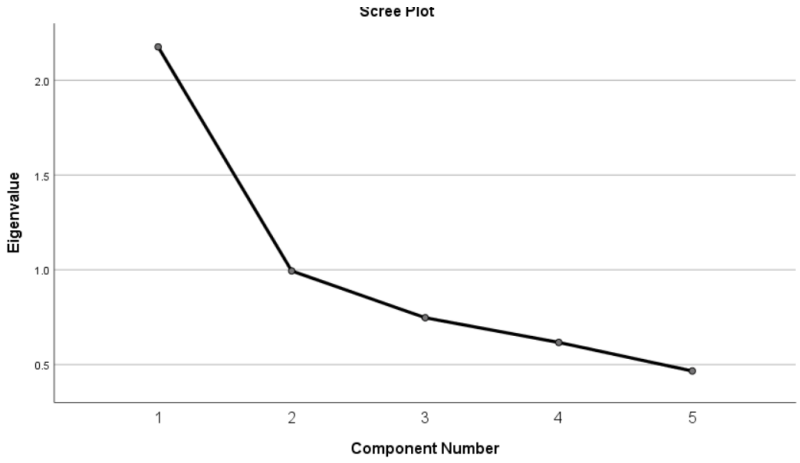


Figure 15: Scree plot indicating a dominant single-factor structure for EV brand perceptions.

Further, even when considering the 2nd factor, the resultant perceptual map did not yield distinct brand positions. This can have one of two implications – either the brands have not yet established distinct positions within the EV category, or the Gen Z sample is not yet aware of specific brands or models within the EV space.

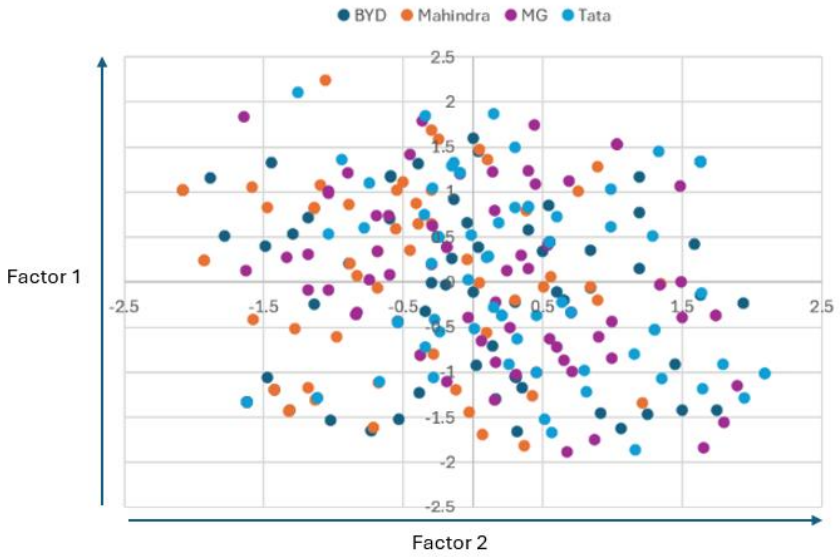


Figure 16: Perceptual map of EV brands showing weak differentiation and overlapping brand positions.

The real answer is likely to be a combination of the two. For mass-market brands like BYD, Mahindra, MG, and Tata, EVs themselves are a brand-definer – their EV models' whole positioning is that they are EVs, and there is little effort yet to position within the EV space, given the nascent stage of this category. As the category matures & competition intensifies, brands will be compelled to carve out distinct positions to capture market share.

Secondly, while Gen Z has a broad awareness of EVs, they lack perceptual impressions of specific EV brands in India. This does not bode well for EV manufacturers, given that intent to purchase a car was strongly predicted by childhood attraction to cars and the finding that Gen Z already strongly influences their families' car purchase decisions. Gen Z's lack of familiarity with EV brand positioning suggests these brands are unlikely to command as much mind space when making purchase decisions.

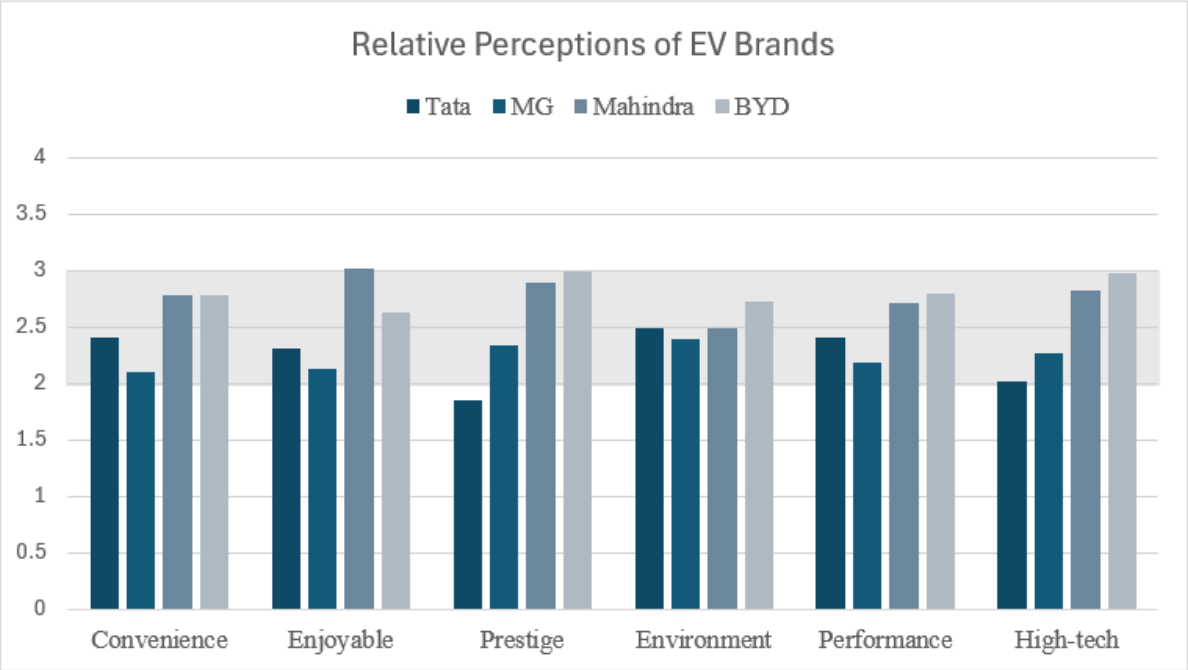


Figure 17: Relative Perceptions of EV Brands

A plot of the mean ranks for each brand across the 5 attributes also shows this. Barring prestige, scores on all other attributes remained clustered around the mean of the overall range = 2.5 ± 0.5. Prestige and perceptions of technological superiority were the only attributes that witnessed any notable variance.

3.8. Summary Overview

In overview, the consumer decision-making model for EV purchases can be broken into 5 stages: vehicle purchase intent, car purchase intent, EV purchase openness, EV purchase preference, and EV brand positions. Each of these stages was found to be associated with different predictors. Car types had a very clear perceptual map of competitive positions, but car brands did not.

3.9. Synthesized Insights: Stated Preferences Versus Organic Skepticism

By synthesizing survey data with social media sentiment analysis, a significant perception-reality gap emerges across different digital platforms and consumer demographics. While professional YouTube reviews and influencer content focus on technical parameters such as battery range and interior design, organic conversations on platforms like Reddit convey more genuine user sentiment about infrastructure failures, software malfunctions, and deep-seated skepticism toward manufacturer assertions. This creates a software paradox: younger consumers are drawn to the high-tech nature of electric vehicles, yet organic discourse reveals that software glitches and digital malfunctions are the primary drivers of negative sentiment and brand distrust. Furthermore, a sustainability paradox exists: environmental concerns are frequently cited in surveys, yet large-scale sentiment data indicate that functional utility, value-for-money, and "perceived convenience" remain the primary focal points for the Indian consumer. This suggests that while consumers are open to green mobility, their final purchase intent is driven by individualistic utility rather than collective environmental idealism.

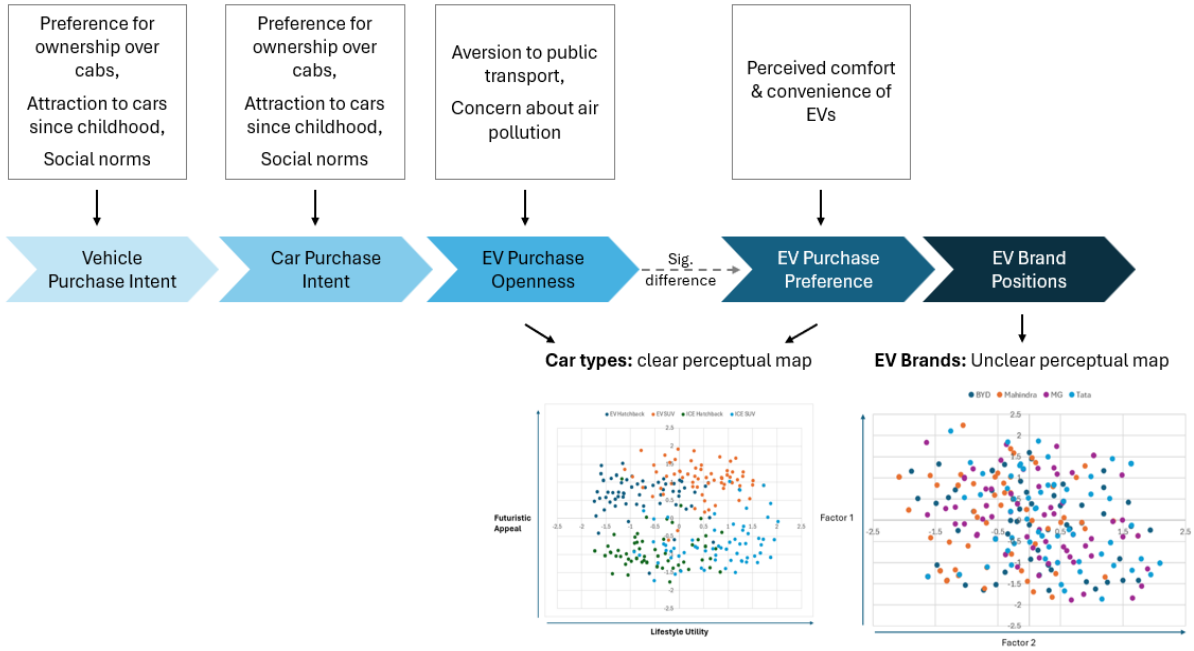


Figure 18: Conceptual framework linking ownership preferences, EV purchase intent, and brand positioning

3.10. Business Implications

The findings from this study have several strategic implications for both government policymakers and auto manufacturers to drive EV adoption in India.

3.10.1. Government Policy

1. **Prioritize Infrastructure Development:** Our study indicates that a key difference between openness to EVs and preference for EVs is the perceived convenience of EVs. While environmental attitudes fostered openness to EVs, only convenience could predict their entry into consumers' choice sets. As such, the government needs to aggressively support and prioritize the development of nationwide EV charging networks, especially focused on Tier-1 and Tier-2 cities. Mere subsidies and consumer education awareness are unlikely to help bridge the gap from awareness to preference. The tipping point in EV adoption will likely come only when charging networks are comparable to petrol station networks, giving EVs comparable convenience and flexibility as cars. To this end, the government can utilize Public-Private Partnerships (PPP) to accelerate infrastructure deployment, ensuring adequate station density to alleviate "range anxiety."

2. **Consumer Education:** Even though >50% of Gen Z are actively involved in family car purchase decisions, their environmental attitudes do not predict purchase intent for either cars or EVs. This implies that while consumers may be aware, they may not yet have internalized the significance of climate risks. As such, it is critical that the government launch targeted educational campaigns in schools and colleges, such as through EV demo days and integration of EV topics into curricula. This will help reinforce climate concerns, foster attraction to EVs at a childhood stage, and create multiplier effects through families.

3.10.2. Auto Manufacturers

1. **Brand Differentiation:** One of the most striking findings from our study was that Gen Z consumers do not perceive any distinct brand positioning across the major EV manufacturers. While this could be because the EV category is still nascent and being an EV itself is a differentiation, this is unlikely to last as the market matures. As such, it is critical for brands to actively craft distinctive brand personas for their EV lineups. For instance, BYD could position itself as a tech-forward luxury brand. SUV brands can capitalize on the aspirational/prestigious perceptions of EV SUVs.

2. **Marketing Strategy Realignment:** With childhood attraction to cars accounting for 9% of purchase intent variance, manufacturers should actively market EVs to children as cool, fostering future customers. This is complemented by the fact that EVs are already perceived to hold 'futuristic appeal' due to their high-tech features and sleeker designs, and should thus be easier to position as the next 'cool' thing.

3. **Product Development:** The finding that environmental attitudes do not predict purchase intent for cars & EVs highlights that EV brands should not look to having electric drivetrains as their only differentiator. Instead, brands can build competitive advantages through advanced features, more comfortable interiors, and smoother rides, differentiating themselves on the factor that most strongly predicts EV preference – convenience & comfort. Ultimately, brands should focus on selling EVs as great cars to drive, not as eco-friendly alternatives to the mainstream.

4. **Ecosystem Development:** With both driving joy and convenience emerging as key predictors, EV manufacturers should look to expand their value chains beyond just manufacturing to after-sales services by orchestrating charging networks to improve the usability of EVs. This would be similar to the strategy Tesla successfully followed in the US to enable EV adoption, until other manufacturers also caught on.

3.11. Limitations

While the findings are insightful, our study does have certain limitations that can be bridged by follow-on research:

1. **Sample limitations:** We used convenience sampling with a sample size of N=75, most being highly educated students at India's leading management institute. As such, while the findings may be representative of highly educated students from Tier-1 cities, they may not accurately reflect the attitudes and decision-making patterns of the broader Gen Z population of India and its cities.
2. **Correlational research:** Our study utilized a correlational design to identify links between attitudes, EV perceptions, and purchase intent. However, one cannot conclusively establish causal relationships in such a design. Ideally, a longitudinal study is needed.
3. **Self-report responses:** We used self-report measures not just for attitudes but also for purchase intent. Critically, EV perceptions were elicited by displaying participants a set of pictures – each representing a particular car type or brand. However, it is possible that perceptual responses to pictures could differ from those in more involved contexts, as experienced in real life.
4. **Modest explainability:** Finally, many of our regression analyses yielded moderate strength, indicating that there are several factors beyond the scope of this survey that could potentially play larger roles in determining purchase intent.

4. Conclusion

This chapter demonstrates that the transition to private electric vehicle ownership in India is currently characterized by moderate optimism, with approximately 54.8% positive sentiment, but this optimism is mediated by significant structural and psychological barriers. By synthesizing 389,391 Reddit comments and 463 YouTube transcripts, and targeting a study of Generation Z, the analysis identifies a market that has moved beyond basic awareness but remains stalled at the final purchase stage.

The social media analysis reveals a clear contrast between platforms. YouTube reviewers largely maintain a constructive and technical tone, focusing on design, innovation, and aspirational value, whereas Reddit captures the more analytical concerns of actual and prospective users. While positive sentiment centers on the futuristic and high-tech appeal of EVs, negative sentiment is increasingly shaped by concerns around software malfunctions, product quality, and manufacturer over-promises. This digital discourse indicates that although public interest in EVs is rising, consumer trust remains affected by concerns about infrastructure reliability and software performance.

The study also identifies Generation Z as an important emerging force in the EV market, with significant influence on family car purchase decisions and earlier entry into vehicle ownership than previous

generations. A notable generational shift is evident: unlike millennials, Generation Z does not appear to associate car ownership strongly with prestige or social status, and purchase intention is not primarily driven by environmental motivations. Instead, preference for EVs is strongly linked to perceived convenience, particularly ease of charging and operational reliability. The statistically significant gap between openness to EVs and actual preference indicates that structural barriers continue to outweigh consumer willingness.

The synthesis of these findings highlights two important paradoxes. The first is a software paradox: consumers are drawn to the high-tech, futuristic appeal of EVs, while software glitches simultaneously emerge as a major source of distrust and negative sentiment. The second is a sustainability paradox, where environmental benefits are frequently acknowledged, but functional utility and value for money remain the primary drivers of consumer evaluation. Together, these findings suggest that while consumer interest in EVs is strengthening, adoption decisions continue to depend on perceptions of convenience, reliability, and practical value.

Overall, the chapter finds that India's EV market has developed substantial consumer awareness and moderate positive sentiment, but the transition from interest to purchase remains constrained by concerns around infrastructure visibility, charging reliability, and product performance. These factors continue to shape consumer confidence and influence the pace of the market's move toward broader EV adoption.

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Chapter 7

Drivers of EV Adoption in India: Evidence from a Consumer Survey

Chapter Summary

Content:

1. Analyses primary consumer survey data from eight Indian cities to examine the gap between EV adoption intent and actual purchase behavior across four segments: first-time car buyers, existing ICE car owners, current EV users, and ICE two-wheeler riders.
2. Investigates how objective constraints (infrastructure, resale value, repair ecosystem) and subjective factors (risk perception, technological familiarity, usage intensity, and gender differences) shape adoption and post-adoption outcomes.

Findings:

1. India's EV slowdown reflects a crisis of confidence rather than a lack of awareness or intent, with resale value and repair-cost uncertainty emerging as cross-segment structural concerns.
2. Charging friction, ecosystem immaturity, and information anxiety drive both adoption hesitation and potential market exit, with distinct vulnerabilities observed among low-income users, mid-range two-wheeler commuters, and women riders.

Takeaways:

1. Shift policy and market focus from incentivizing purchase to securing the ownership lifecycle through standardized resale frameworks, decentralized repair ecosystems, and credible battery health certification.
2. Improve infrastructure visibility, segment-specific marketing, and safety assurance mechanisms to reduce information anxiety and enable sustained, consumer-led EV adoption.

1. Introduction

The transition toward electric mobility in India stands at a critical intersection where sustained policy momentum must now be matched by large-scale consumer absorption. Despite robust policy frameworks like the National Electric Mobility Mission Plan and successive phases of the FAME scheme, the penetration of electric vehicles (EVs) remains limited, with cars accounting for approximately 2.5% (2024) of sales and two-wheelers reaching 6.3% (2025) in recent years (Amir, 2025; Kumar, 2025). This chapter aims to investigate the gap between stated consumer interest and actual purchase behavior by analyzing primary survey data collected in eight major Indian cities: Mumbai, Delhi, Bangalore, Hyderabad, Pune, Lucknow, Thiruvananthapuram, and Bhubaneswar.

The research design for this chapter was motivated by the observation that adoption intent alone is a weak predictor of consumer behavior in contexts defined by "information anxiety", which is a state where consumers are not merely concerned about technology but are uncertain about the reliability, visibility, and long-term viability of the urban charging ecosystem. To address the above theory, the study in this chapter uses structured questionnaires designed to capture the multidimensional nature of EV barriers, integrating objective material constraints with subjective attitudinal measures. The analysis is organized into four distinct sections to capture the full spectrum of the Indian consumer journey.

Section 3.1 examines carless households as they consider their first vehicle purchase. This segment represents the entry point to motorized mobility, where decisions are primarily "system-led." The analysis explored themes of basic awareness, the symbolic "cool" image of early tech adoption, and the importance of public infrastructure visibility. For these first-time buyers, the central question was whether the broader urban ecosystem is mature enough to support their daily mobility needs without the safety net of prior vehicle ownership.

Section 3.2 focuses on existing ICE or hybrid car owners considering a switch or addition to an EV. In contrast to first-time buyers, this segment follows a "product-led" logic, benchmarking EV performance directly against their current ICE vehicles. The themes explored here included technological familiarity, similarity in repair and maintenance processes, and the comparative driving experience. These consumers evaluate whether an EV functions as a superior replacement for a known technology, placing heavy emphasis on range reliability and resale value.

Section 6 transitions to post-adoption experiences among existing EV owners. Understanding long-term retention is as critical as the initial adoption. This section investigated the factors that differentiate "continuers," who are satisfied and intend to stay with the technology, from "potential discontinuers," who may switch back to ICE vehicles. Key themes include daily usage patterns, satisfaction with home versus public charging costs, and the role of digital resources, such as battery management apps, in mitigating ownership friction. It specifically examined how "ecosystem friction," such as difficulty in finding local mechanics or resale uncertainty, can push even satisfied users toward the exit.

Section 7 analyzes existing ICE two-wheeler users, who represent the backbone of Indian private transport. Given that two-wheelers account for over 70% of registered motorized vehicles in India, this section explored themes of price sensitivity, safety perceptions during seasonal extremes (rain and

heat), and range anxiety among commuters. The analysis highlighted how negative word-of-mouth regarding battery life and repair costs shapes the attitudes of this high-volume segment, identifying the specific psychological and economic thresholds that determine their willingness to transition to electric motorcycles.

2. Exploring Pre-Adoption Attitudes Towards Electric Cars in Urban India

2.1. Context and Motivation

The pace of electrification in India's private passenger vehicle segment is fundamentally constrained by barriers that operate before purchase. Despite sustained policy support through the National Electric Mobility Mission Plan and successive phases of the Faster Adoption and Manufacturing of Electric Vehicles (FAME) scheme, electric car penetration in India remains limited (Jain, 2022; IEA, 2024; IEA, 2021). Multiple studies and policy assessments have shown a persistent gap between stated interest in EVs and actual adoption, indicating that demand-side frictions continue to slow diffusion even as technology improves and costs decline (Murugan & Marisamynathan, 2022; Pamidimukkala et al., 2023; A.G. Kumar et al., 2015).

Peer-reviewed international research shows that adoption intent alone is a weak predictor of purchase behavior, particularly in contexts characterized by uncertainty around charging access, technology reliability, and long-term ownership outcomes (Sierzchula et al., 2014; Langbroek et al., 2016; Alison Spencer et al., 2023). In India, these uncertainties are amplified by heterogeneous urban infrastructure conditions, evolving incentive regimes, limited secondary EV markets, and relatively low everyday visibility of electric cars (Krishna, 2021; Jain, 2022; EV Mechanica, 2023). The pre-adoption stage is where households evaluate EVs relative to internal combustion engine (ICE) vehicles or defer purchase altogether, therefore representing a critical bottleneck in the electric mobility transition.

2.2. Conceptualizing Pre-Adoption Households

Pre-adoption households in urban India are not homogeneous. They include households without prior car ownership, households considering their first vehicle purchase, and households that already own ICE or hybrid vehicles and are evaluating whether to add an EV or replace their current vehicle with one. While these groups differ in baseline experience and reference points, they face a shared decision environment characterized by uncertainty, perceived risk, and incomplete information (Sun et al., 2022; Jain, 2022; A. Kumar & R. Singh, 2023).

Prior studies indicate that first-time car buyers tend to prioritize affordability, perceived ease of use, and social or symbolic attributes of the vehicle, whereas existing car owners more frequently benchmark EVs against ICE vehicles on parameters such as driving range, refueling convenience, reliability, and resale value (N. Gupta & D. Kumar, 2023; Bhat et al, 2024; Consumer Reports, 2020). At the same time, several constraints, including charging accessibility, battery reliability, safety perceptions, and confidence in policy support, appear across both groups and shape adoption

decisions irrespective of ownership status (Krishna, 2021; Murugan & Marisamynathan, 2022; Pamidimukkala et al., 2023).

Evidence from India and other markets suggests that a substantial proportion of households remain in an extended "consideration" phase, delaying adoption even when attitudes towards EVs are broadly favorable (Sierzchula et al., 2014; Alison Spencer et al., 2023; Janice Fernandes, 2024; R. Joshi & H. Mahajan, 2023). This reinforces the need to conceptualize pre-adoption behavior as a continuum rather than a binary state, thereby motivating the integrated treatment of carless households and potential switchers within a single analytical framework.

2.3. Evidence from Literature on Adoption Barriers

2.3.1. Financial and Cost-Related Barriers

Financial considerations remain among the most consistently identified barriers to EV adoption. High upfront purchase costs relative to ICE vehicles are repeatedly cited as a primary deterrent, even in contexts where operating costs are lower, and incentives are available (Sierzchula et al., 2014; Murugan & Marisamynathan, 2022; Pamidimukkala et al., 2023). Indian studies further highlight concerns related to battery replacement costs, insurance premiums, and uncertain resale values, which together elevate perceived financial risk in the absence of mature secondary EV markets (Jain, 2022; A.K. Digalwar and R. George, 2022; N. Dawda, 2024).

Comparative international evidence indicates that while financial incentives and subsidies can positively influence adoption, their effectiveness depends on the stability, clarity, and integration of their design with broader market conditions (Langbroek et al., 2016; Avi Chaim Mersky et al., 2016; Nick Turner, 2024). Policy uncertainty or frequent revisions can dampen consumer confidence, particularly among risk-averse households (S. Dhar, M. Pathak, and P.R. Shukla, 2017; U.S. Energy Information Administration, 2024). These findings underscore the importance of examining perceived financial risk and policy credibility at the pre-adoption stage, rather than focusing solely on affordability.

2.3.2. Charging Infrastructure and Accessibility

Charging infrastructure is identified as the second critical barrier, but recent research increasingly conceptualizes this issue through the lens of accessibility rather than solely in terms of charger counts. Accessibility encompasses objective availability, perceived convenience, and expectations regarding future network expansion (He et al., 2022; N. Gupta & D. Kumar, 2023; Sun et al., 2022). Evidence from dense urban environments indicates that uncertainty about the reliability of public charging and a lack of access to home charging can deter adoption, even among households with modest daily travel requirements (Renaud-Blondeau, P. et al., 2022; Bhat et al, 2024).

In India, uneven spatial deployment of charging infrastructure and limited visibility of public chargers reinforce perceptions of inconvenience and range anxiety, particularly among households without dedicated parking (Krishna, 2021; Sumati Kohli, 2024; N. Dawda, 2024). Policy reviews further suggest that infrastructure expansion must be accompanied by confidence-building measures and clear communication to influence adoption intent (A. Srivastava et al., 2022; IEA, 2024).

2.3.3. Technology, Reliability, and Safety Concerns

Concerns related to technological reliability and safety feature prominently at the pre-adoption stage. Empirical studies in India document apprehension regarding battery degradation, thermal safety, repair complexity, and the perceived immaturity of EV technology (Murugan & Marisamynathan, 2022; Pamidimukkala et al., 2023; V. Singh et al., 2021). These concerns are often magnified by limited exposure to EVs and by anecdotal narratives circulating in the media and on online platforms (EV Mechanica, 2023).

Comparative evidence from international markets highlights the role of trust in vehicle technology and service ecosystems in shaping adoption decisions, particularly among consumers with prior experience of ICE vehicles (Alison Spencer et al., 2023; Janice Fernandes, 2024). In emerging markets, uncertainty regarding after-sales support and battery end-of-life management further increases hesitation (Jain, 2022; IEA, 2024; MD S. Hossain et al., 2023).

2.3.4. Psychological and Behavioral Barriers

Beyond structural constraints, a growing body of literature highlights psychological and behavioral barriers to delaying EV adoption. Fear of being an early adopter, anxiety about making an irreversible purchase decision, and the tendency to postpone adoption in anticipation of future technological improvements have been identified as significant drivers of hesitation (Krishna, 2021; EV Mechanica, 2023; P. K. Tarei, P. Chand, and H. Gupta, 2021). These behavioral frictions persist even among environmentally motivated and financially capable households.

Survey evidence from mature EV markets similarly shows that favorable attitudes towards EVs do not automatically translate into purchase intent or action, highlighting the role of habit, trust, and perceived risk (Alison Spencer et al., 2023; Janice Fernandes, 2024; City of Bellevue, 2024). These findings reinforce the need to integrate behavioral dimensions alongside economic and infrastructural factors in pre-adoption analysis.

2.3.5. Social Influence, Policy Design, and Ecosystem Effects

Social influence and policy considerations further shape how EVs are evaluated within households' reference groups. Peer experiences, word-of-mouth communication, and media narratives influence perceptions of convenience, reliability, and social status, particularly in markets where EV ownership remains relatively rare (Sun et al., 2022; McKinsey, 2023; Andrew Loh et al., 2024). Ecosystem-level analyses emphasize that adoption outcomes are shaped by coordinated developments across OEMs, charging providers, finance, and public policy, rather than isolated interventions (McKinsey, 2022; IEA, 2024; V. Singh et al., 2021).

Comparative policy studies further highlight that successful EV diffusion typically relies on bundled policy packages that combine incentives, infrastructure investment, and regulatory signals discouraging the use of ICE vehicles (A. Srivastava et al., 2022; J. H. M. Langbroek et al., 2016; William Sierzchula et al., 2014).

2.4. Questionnaire Design for Pre-Adoption Households (Potential EV consumers)

Drawing on the above literature, the pre-adoption questionnaire was designed to capture the multi-dimensional nature of EV adoption barriers while maintaining comparability across household types. The instrument integrates objective indicators with attitudinal and perception-based measures, reflecting evidence that adoption decisions are shaped by both material constraints and subjective evaluations (Krishna, 2021; Pamidimukkala et al., 2023; P. Sharma et al., 2023).

Questions on consumer awareness and technological understanding assess familiarity with EV capabilities, charging requirements, and maintenance needs, responding to documented gaps in consumer knowledge in India (McKinsey & Company, 2023; Jain, 2022; Pamidimukkala et al., 2023). A dedicated survey section on financial considerations captures perceptions of purchase price, operating costs, incentives, and resale value, with an explicit focus on perceived financial risk (Sierzchula et al., 2014; Murugan & Marisamynathan, 2022; G. Shrimali, 2021).

The questionnaire includes a detailed charging infrastructure module that covers home-charging feasibility, public-charging accessibility, and confidence in charging around the city, consistent with accessibility-based adoption frameworks (He et al., 2022; Sun et al., 2022; Renaud-Blondeau, P. et al., 2022). Policy awareness and credibility are assessed through questions about knowledge of national- and state-level incentives and expectations regarding policy continuity, reflecting evidence that uncertainty about policy support can dampen adoption intent (Langbroek et al., 2016; Sumati Kohli, 2024; IEA, 2024).

Finally, social and psychological dimensions are explicitly incorporated, including social influence, environmental motivation, safety perceptions, and behavioral tendencies such as postponing purchase. This responds directly to calls in the literature to move beyond narrowly economic explanations and account for emotional and behavioral factors shaping EV adoption (Krishna, 2021; EV Mechanica, 2023; Alison Spencer et al., 2023).

Pre-adoption barriers constitute a critical bottleneck in India's electric mobility transition. While post-adoption satisfaction shapes long-term retention, large-scale adoption cannot occur unless households are willing to cross the initial decision threshold. The literature and survey design jointly indicate that pre-adoption hesitation is driven not only by cost and infrastructure gaps, but also by uncertainty, lack of trust, and behavioral resistance to perceived risk (Krishna, 2021; Pamidimukkala et al., 2023; IEA, 2024).

By systematically examining pre-adoption attitudes across different household contexts, this chapter aims to provide evidence relevant for the calibration of policy incentives, infrastructure planning, and market offerings. Addressing pre-adoption frictions alongside post-adoption challenges is therefore essential for enabling a sustained and inclusive transition to electric mobility in urban India.

3. Description of Data Obtained from Potential EV Consumers

3.1. Carless Households Considering Buying Their First Car

This section presents the collected data thematically for carless households considering their first car purchase. Figure 1 presents the socio-demographic characteristics of the sampled pre-adoption households. The largest proportion of respondents (47.4%) falls within the 30–39 age group. In terms of annual household income, 75.4% report an income of less than INR 10 lakh. Most respondents (80.1%) belong to households with 3–5 members, while 86.0% are male. Regarding educational attainment, 47.7% hold a Bachelor's degree, while 37.4% hold a diploma but no Bachelor's degree. Additionally, 80.5% of respondents are married.

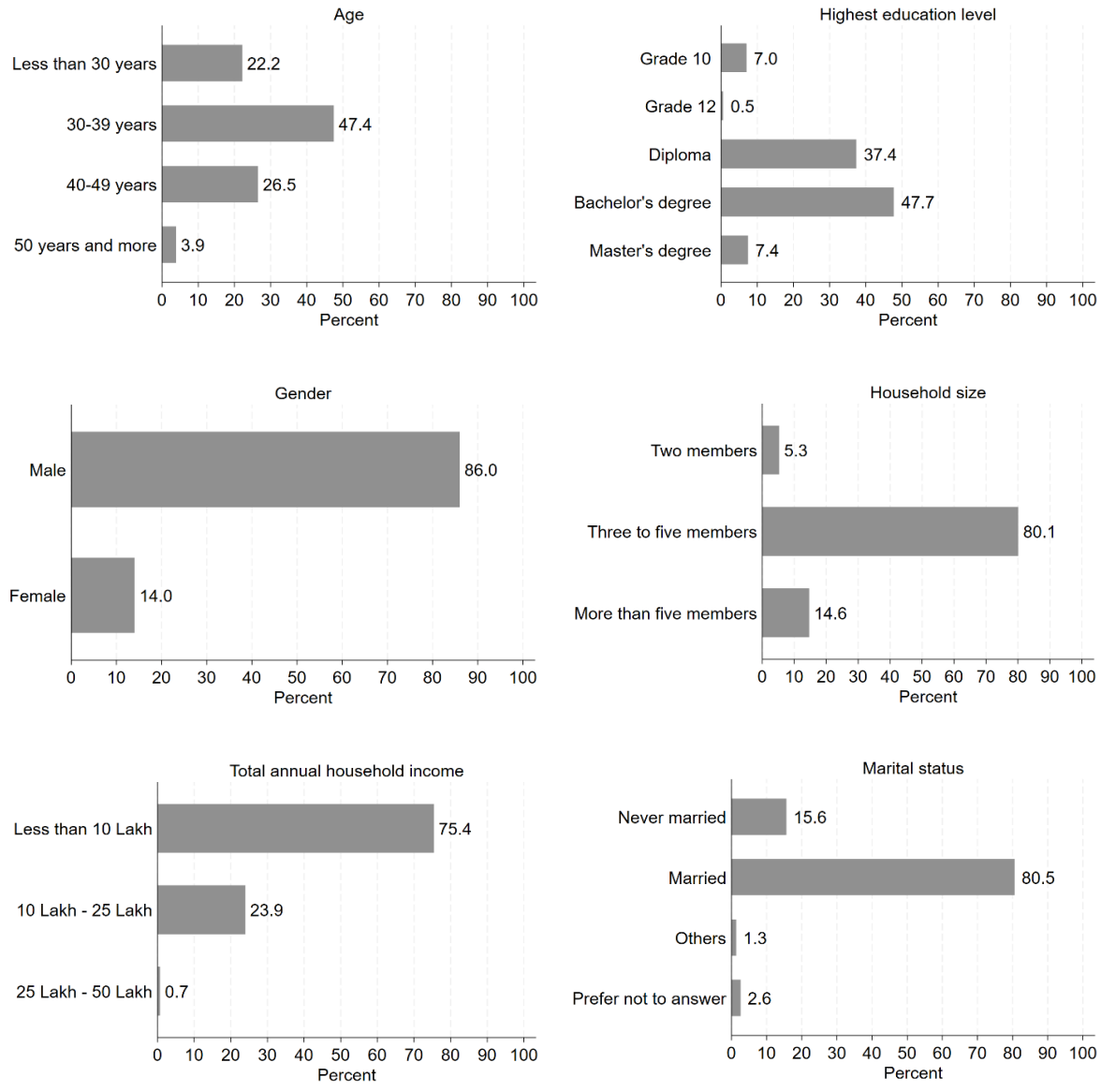


Figure 1: Socio-demographic characteristics of the sampled pre-adoption households

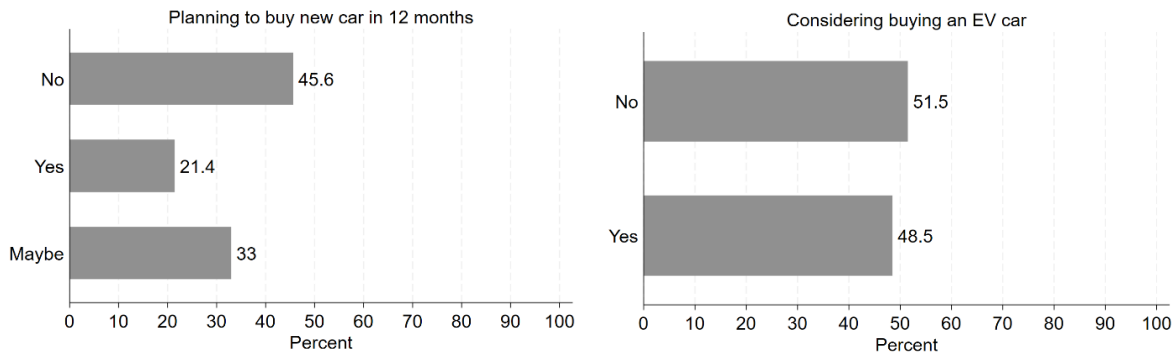


Figure 2: Respondents' car purchase plans in the next 12 months and their consideration of EV cars

Figure 2 shows respondents' car purchase plans in the next 12 months and their consideration of EV cars. It shows that 45.6% of respondents report not planning to buy a new car in the next 12 months. It also shows that 33.0% of respondents report considering buying a new car, while 21.4% report planning to buy one in the next 12 months. Regarding EVs, 51.5% of respondents are not considering buying one, while 48.5% are.

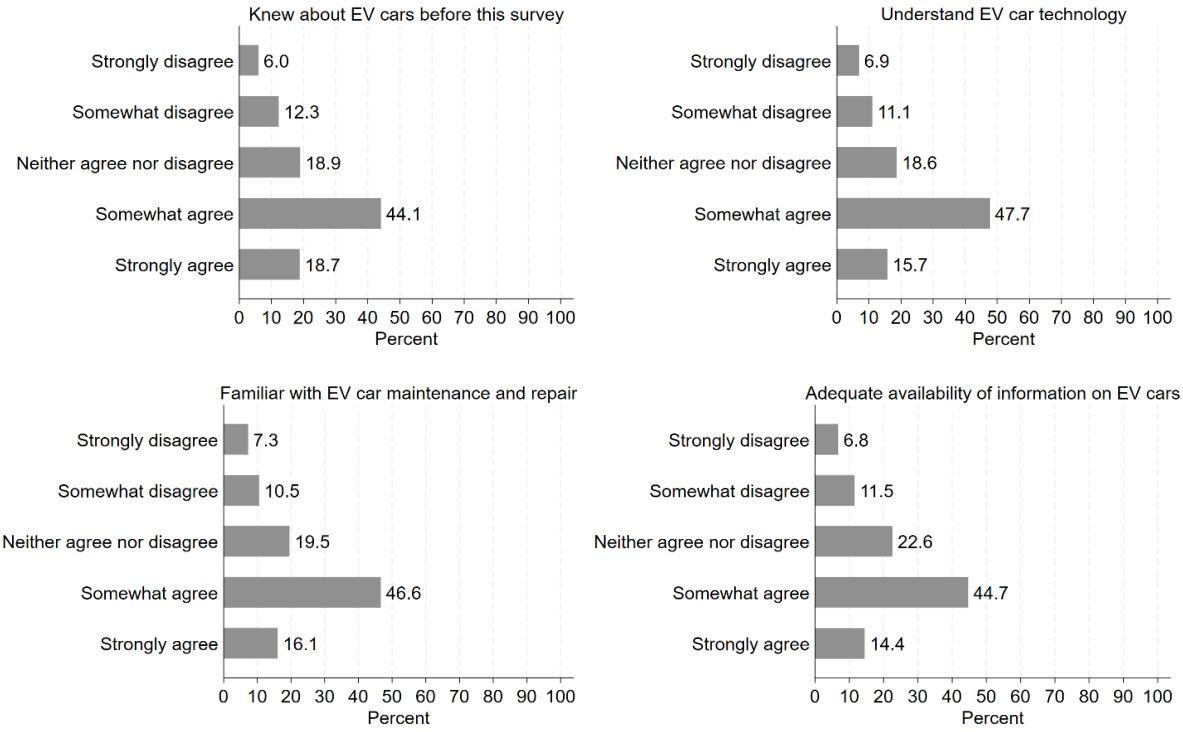


Figure 3: Respondents' awareness and familiarity with EV cars across different dimensions

Figure 3 presents respondents' awareness and familiarity with EVs across different dimensions. It shows that 44.1% of respondents somewhat agree and 18.7% strongly agree that they are aware of EVs. Similarly, 47.7% somewhat agree, and 15.7% strongly agree that they understand EV technology. Regarding maintenance and repair, 46.6% somewhat agree, and 16.1% strongly agree that they are familiar with the relevant processes. Additionally, 44.7% somewhat agree, and 14.4% strongly agree that adequate information on EVs is available.

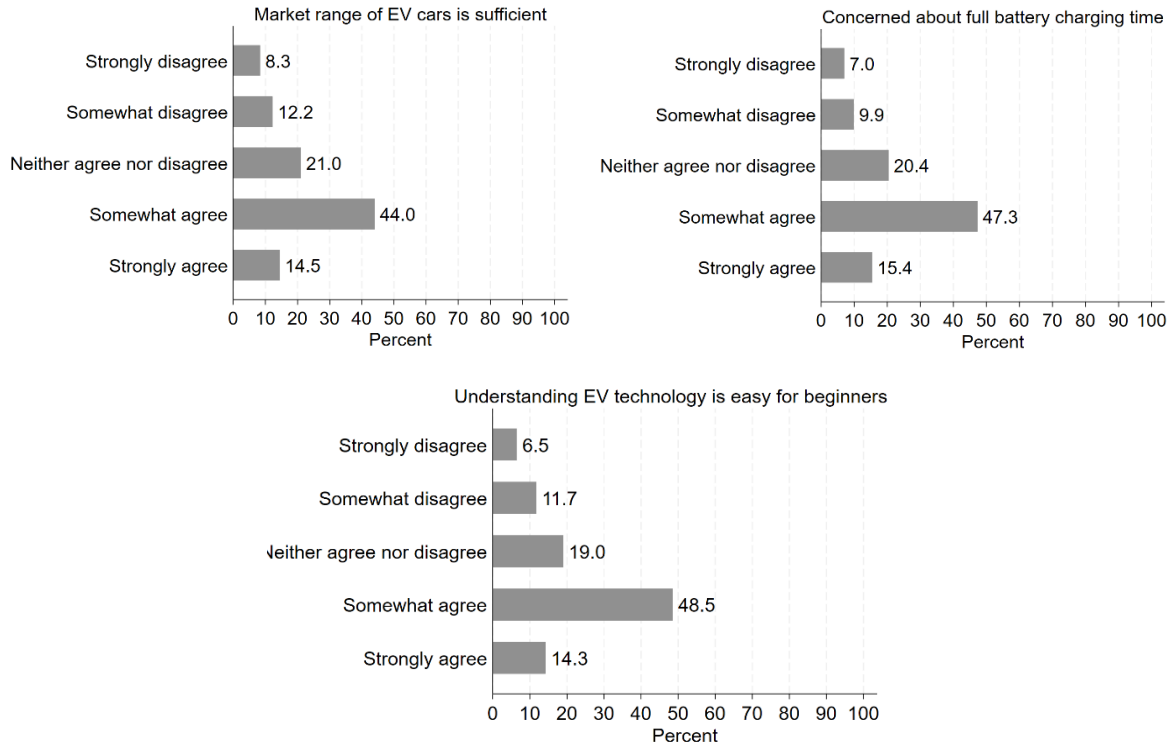


Figure 4: Respondents' perceptions regarding technological adequacy and reliability of EV cars

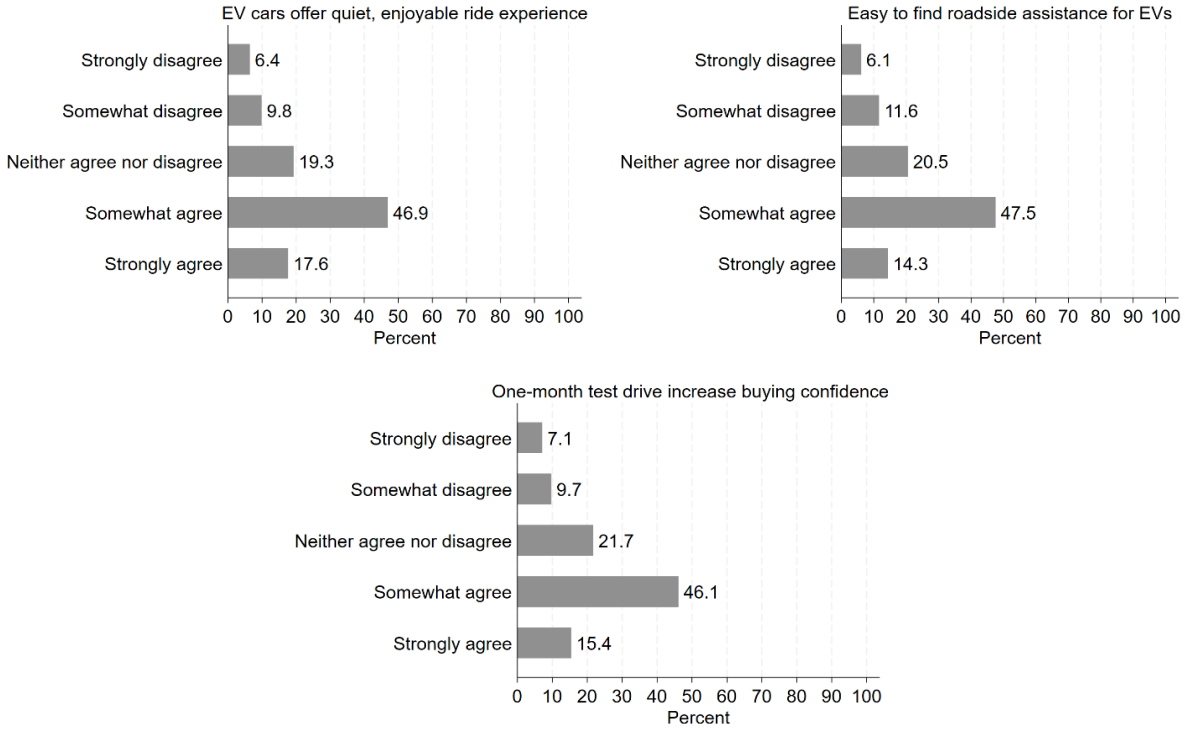


Figure 5: Respondents' perceptions regarding EV driving experience, roadside assistance, and confidence-building mechanisms for EV purchase

Figure 4 shows respondents' perceptions regarding technological adequacy and reliability of EVs. It shows that 44.0% of respondents somewhat agree and 14.5% strongly agree that the range of EVs available in the market is sufficient. In terms of charging, 47.3% of respondents somewhat agree, and

15.4% strongly agree that they are concerned about the time required to fully charge an EV battery. Additionally, 48.5% of the respondents somewhat agree, and 14.3% strongly agree that understanding EV car technology is easier for a first-time buyer.

Figure 5 shows respondents' perceptions regarding EV driving experience, roadside assistance, and confidence-building mechanisms for EV purchase. It shows that 46.9% of respondents somewhat agree and 17.6% strongly agree that EV cars offer a quieter, more enjoyable driving experience. It further shows that 47.5% of the respondents somewhat agree and 14.3% strongly agree that immediate roadside assistance for EV breakdown is easy to find. Additionally, Figure 5 shows that 46.1% of respondents somewhat agree and 15.4% strongly agree that their confidence in EVs would increase if month-long test drives were available.

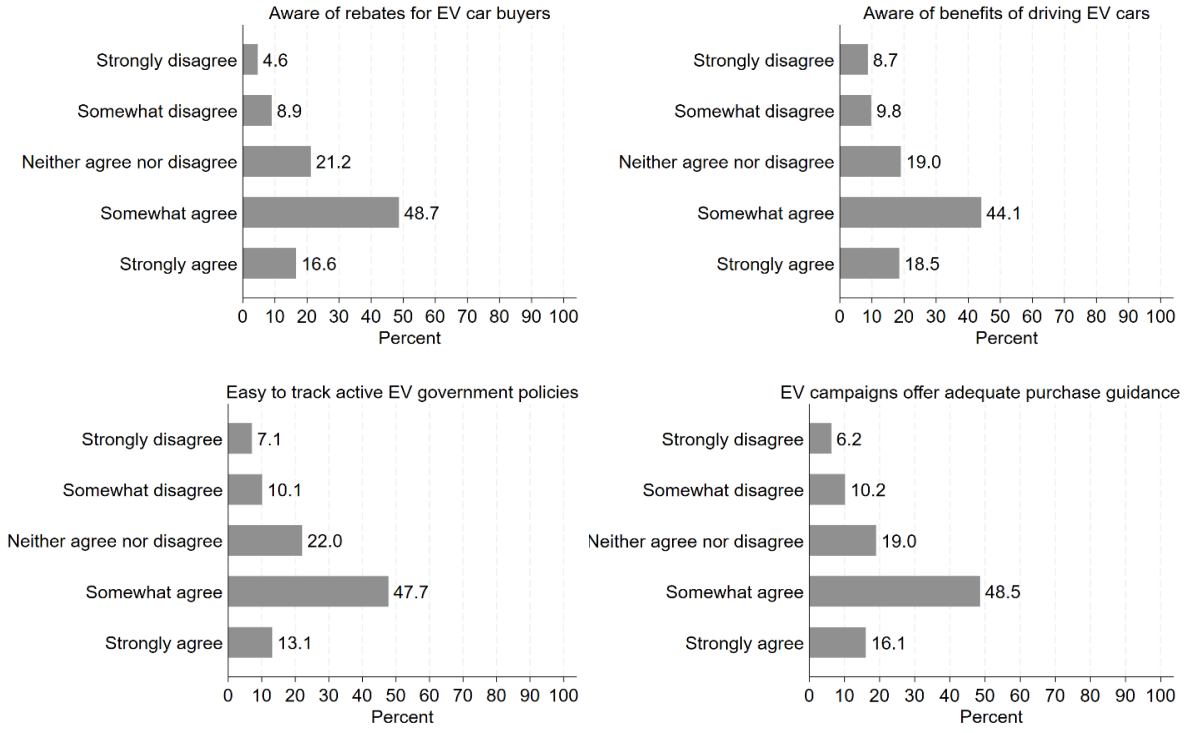


Figure 6: Respondents' awareness regarding government policies, rebates, and promotional information related to EV cars

Figure 6 shows respondents' awareness of government policies, rebates, and promotional information regarding EVs. It shows that 48.7% of the respondents somewhat agree and 16.6% strongly agree that they are aware of rebates available for EV car buyers. It further shows that 44.1% of respondents somewhat agree and 18.5% strongly agree that they are aware of additional benefits available for EVs. Additionally, Figure 6 shows that 47.7% of the respondents somewhat agree and 13.1% strongly agree that tracking EV-related government policies currently in effect is easy. It also shows that 48.5% of the respondents somewhat agree and 16.1% strongly agree that promotional activities for EVs provide adequate information.

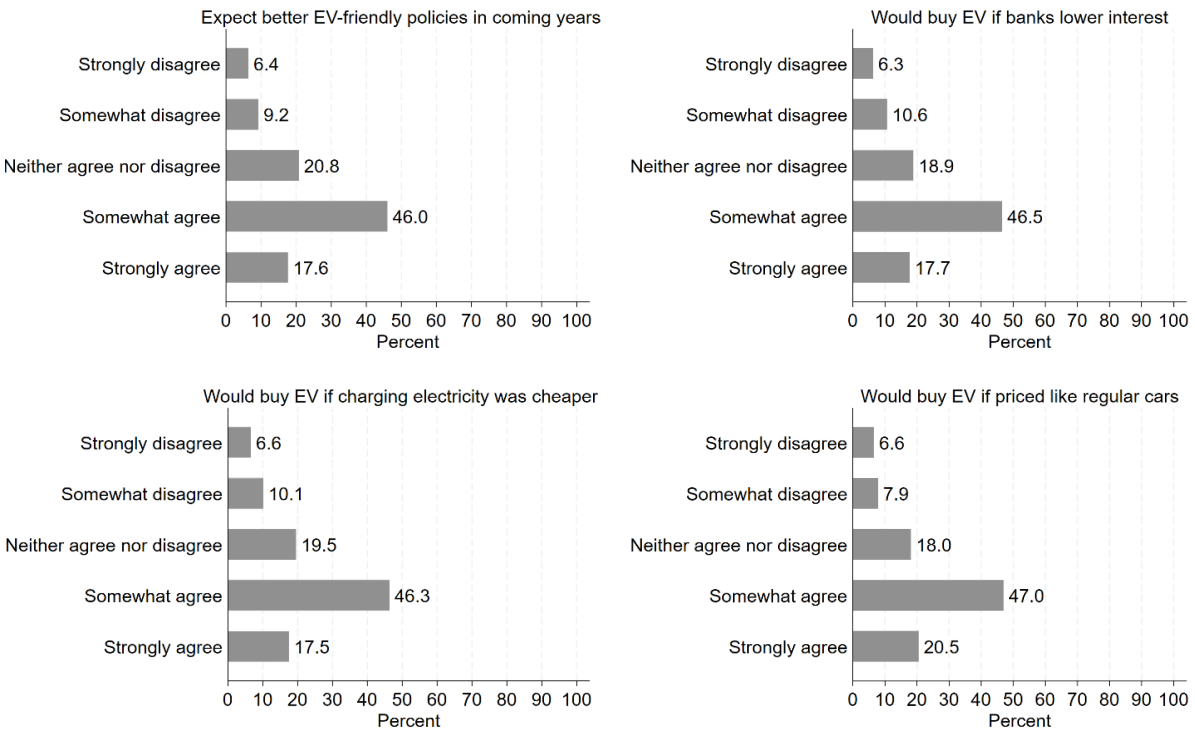


Figure 7: Respondents' expectations regarding improvement in EV-friendly policies and the influence of financial conditions on EV buying decisions

Figure 7 shows respondents' expectations regarding improvement in EV-friendly policies and the influence of financial conditions on EV buying decisions. It shows that 46.0% of respondents somewhat agree and 17.6% strongly agree that EV-friendly policies for buyers will improve in the next few years. It further shows that 46.5% of respondents somewhat agree and 17.7% strongly agree that they would buy an EV if bank loan interest rates were lower. Additionally, Figure 7 shows that 46.3% of respondents somewhat agree and 17.5% strongly agree that they would buy an EV if electricity for charging becomes cheaper. It also shows that 47.0% of respondents somewhat agree and 20.5% strongly agree that they would buy an EV if purchase prices were the same as for ICE cars.

Figure 8 shows respondents' social influence considerations when buying an EV car. It shows that 40.7% of respondents somewhat agree and 17.0% strongly agree that they would buy an EV if friends and family recommended it. It further shows that 43.1% of respondents somewhat agree and 15.2% strongly agree that they would buy an EV if news and media provided positive reviews. Additionally, Figure 8 shows that 42.2% of respondents somewhat agree and 14.1% strongly agree that owning an EV as their first car would give them a modern, "cool" image.

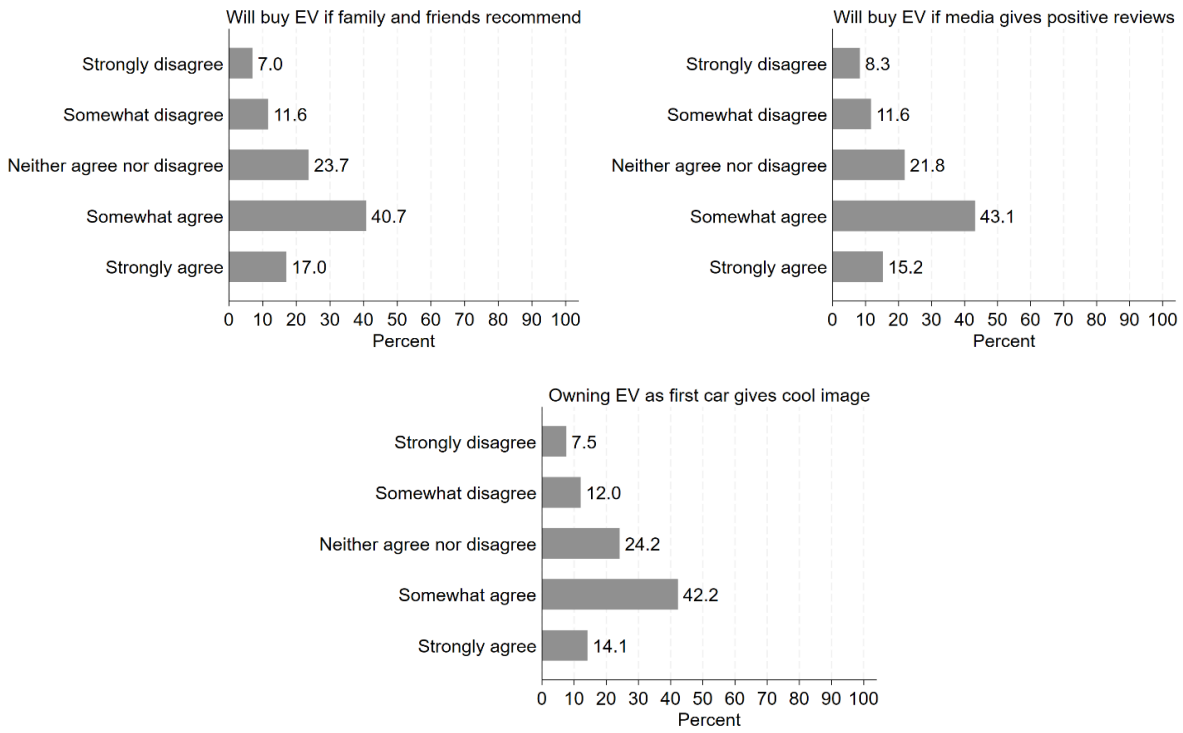


Figure 8: Effects of social influence on respondents' considerations when buying an EV car

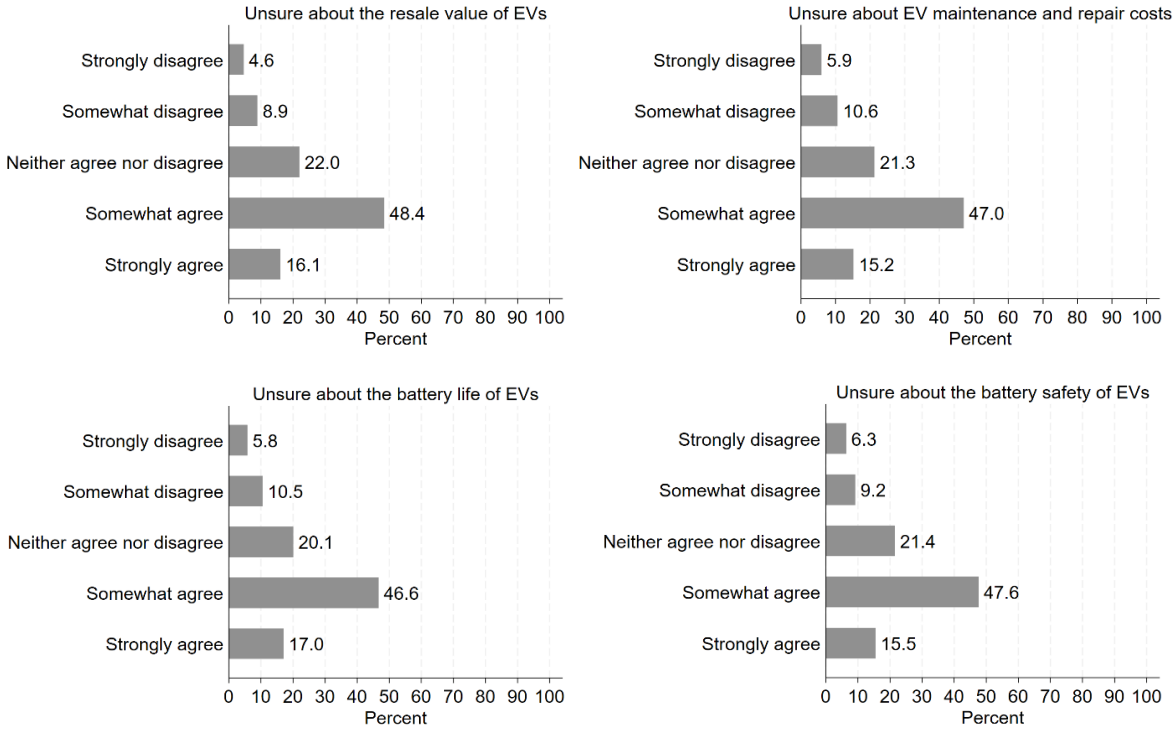


Figure 9: Uncertainty and perceived burden associated with EV ownership are affecting respondents' EV purchase decisions.

Figure 9 shows respondents' uncertainty and perceived burden associated with EV ownership. It shows that 48.4% of respondents somewhat agree and 16.1% strongly agree that they are unsure about the resale value of an EV. It further shows that 47.0% of the respondents somewhat agree and

15.2% strongly agree that they are unsure about the cost of EV repair and maintenance. Additionally, Figure 9 shows that 46.6% of respondents somewhat agree and 17.0% strongly agree that they are unsure about EV battery life. It also shows that 47.6% of respondents somewhat agree and 15.5% strongly agree that they are unsure about the safety of EV batteries.

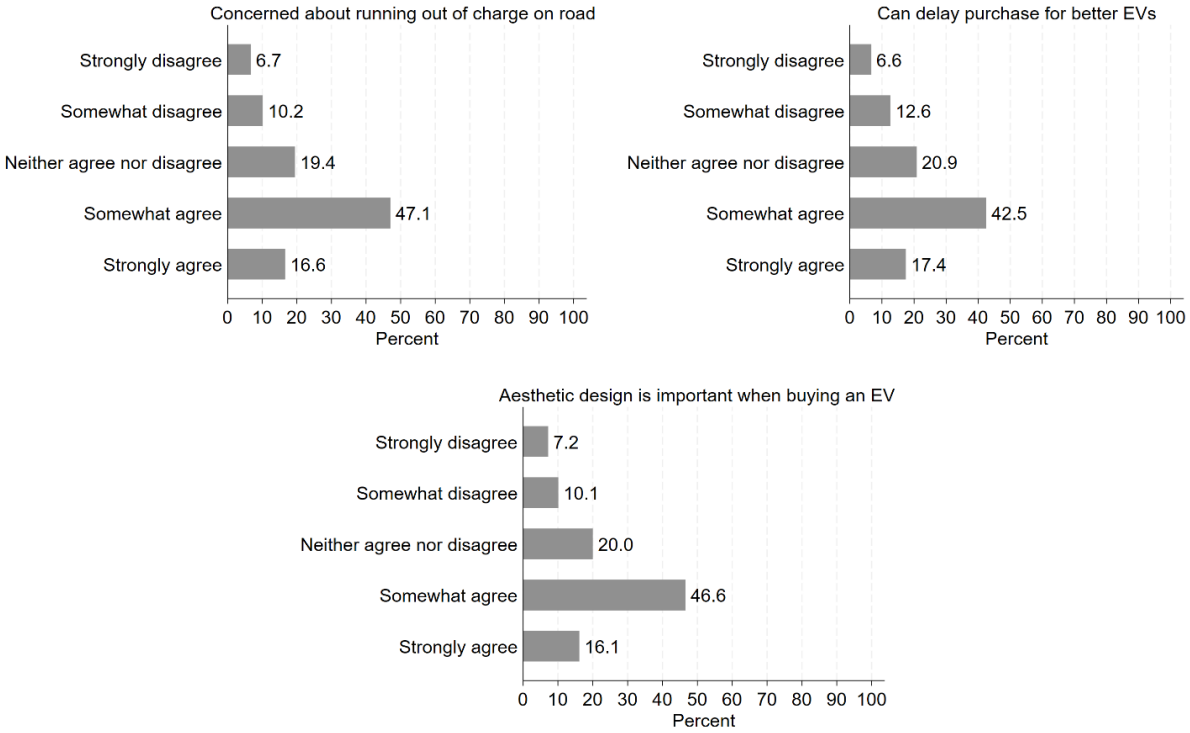


Figure 10: Respondents' views on external factors affecting EV car purchase decisions

Figure 10 shows respondents' views on external factors affecting EV car purchase decisions. It shows that 47.1% of the respondents somewhat agree and 16.6% strongly agree that they are concerned about running out of charge and getting stranded. 42.5% of the respondents somewhat agree, and 17.4% strongly agree that they would delay their car purchase if EVs become cheaper and better in the coming years. Additionally, 46.6% of respondents somewhat agree, and 16.1% strongly agree that aesthetic design is an important factor to consider when buying an EV.

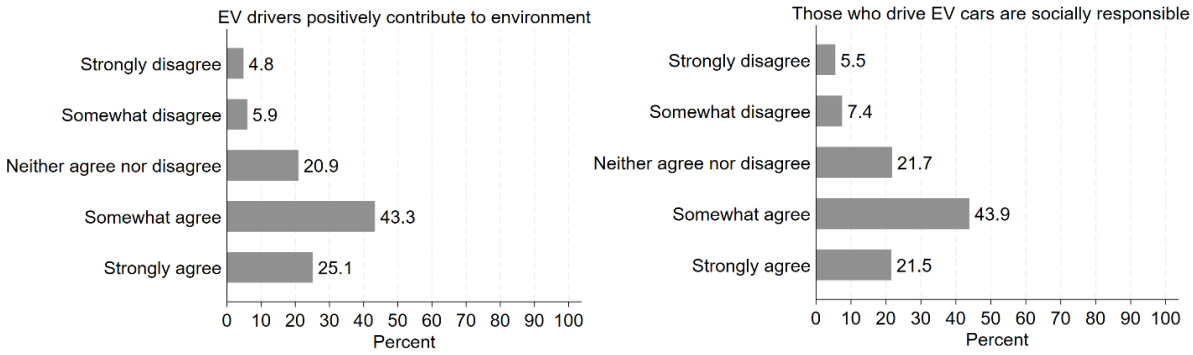


Figure 11: Perceived environmental and social benefits of EVs

Figure 11 shows the perceived environmental and social benefits of EVs. It shows that 43.3% of respondents somewhat agree and 25.1% strongly agree that EV car drivers contribute positively to the

environment, while only 5.9% somewhat disagree and 4.8% strongly disagree. It also shows that 43.9% of respondents somewhat agree and 21.5% strongly agree that EV car drivers are socially responsible, compared to 7.4% who somewhat disagree and 5.5% who strongly disagree.

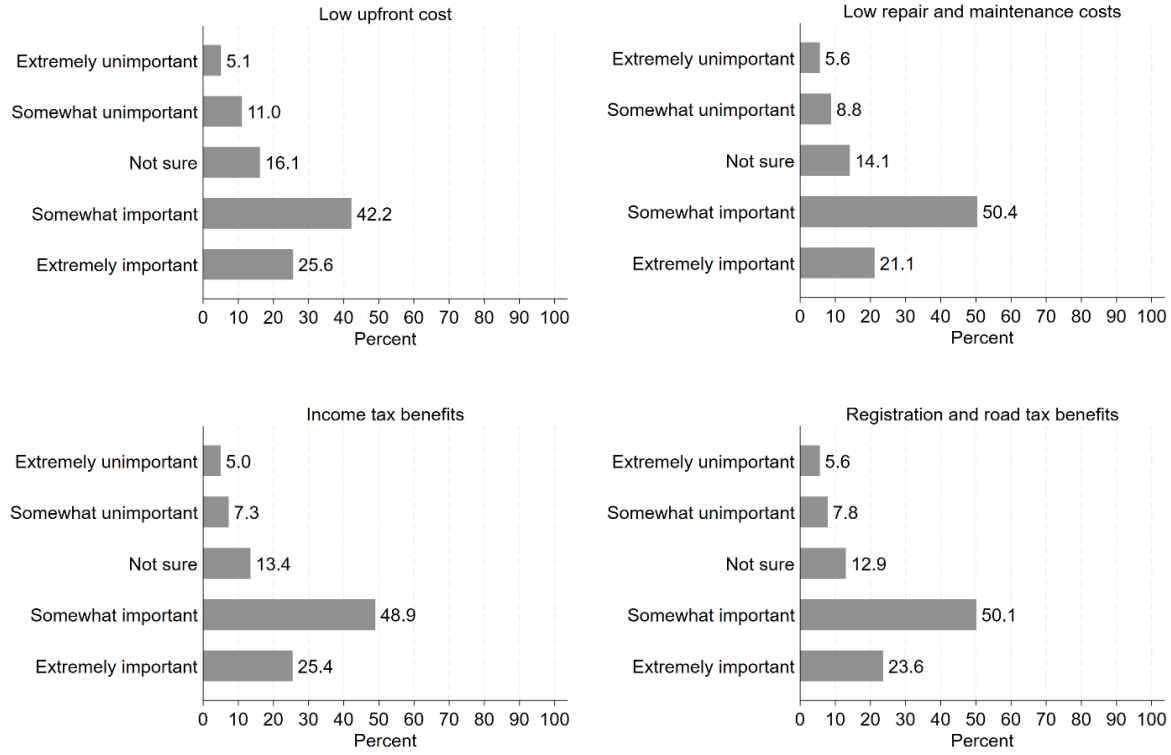
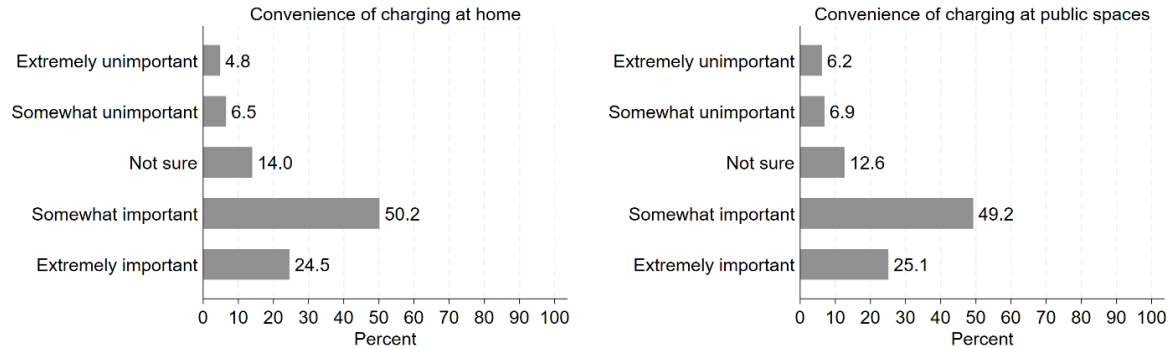


Figure 12: Importance assigned to financial aspects while considering purchasing an EV

Figure 12 highlights the importance of financial factors when considering the purchase of an EV. For a low upfront cost, 42.2% of respondents reported it as somewhat important, 25.6% as extremely important, and 5.1% as extremely unimportant. For low repair and maintenance costs, 50.4% of respondents reported it as somewhat important, 21.1% as extremely important, and 5.6% as extremely unimportant. For income tax benefits, 48.9% of respondents reported it as somewhat important, 25.4% as extremely important, and 5.0% as extremely unimportant. For registration and road tax benefits, 50.1% of respondents reported it as somewhat important, 23.6% as extremely important, and 5.6% as extremely unimportant.



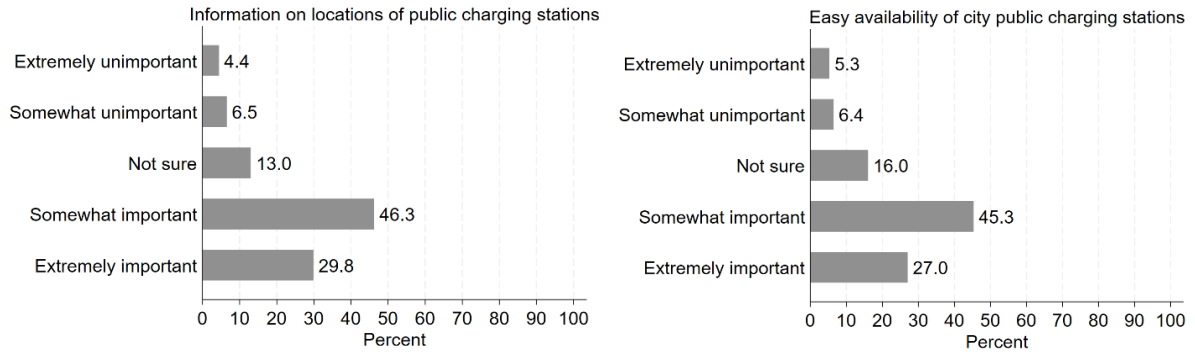


Figure 13: Importance of charging infrastructure aspects while considering purchasing an EV

Figure 13 shows the importance placed on charging infrastructure when purchasing an EV. For the convenience of charging at home, 50.2% reported it as somewhat important, 24.5% as extremely important, and 4.8% as extremely unimportant. For the convenience of charging in public spaces, 49.2% of respondents reported it as somewhat important, 25.1% as extremely important, and 6.2% as extremely unimportant. For information on the locations of public charging stations, 46.3% of respondents reported it as somewhat important, 29.8% as extremely important, and 4.4% as extremely unimportant. For easy access to public charging stations around the city, 45.3% of respondents reported it as somewhat important, 27.0% as extremely important, and 5.3% as extremely unimportant.

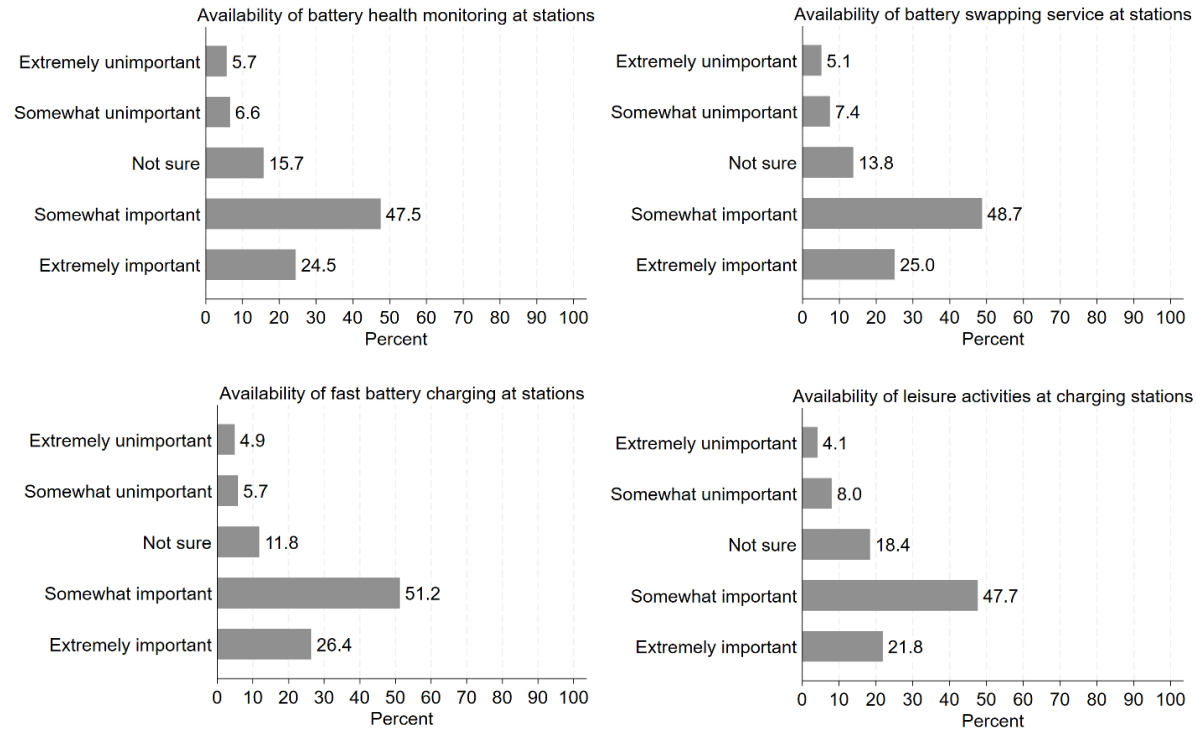


Figure 14: Importance of additional charging infrastructure aspects while considering purchasing an EV

Figure 14 presents additional aspects of charging infrastructure considered when purchasing an EV. Regarding the availability of battery health monitoring services at charging stations, 47.5% of respondents reported it as somewhat important, 24.5% as extremely important, and 5.7% as

extremely unimportant. Regarding the availability of battery swapping service at charging stations, 48.7% of respondents reported it as somewhat important, 25.0% as extremely important, and 5.1% as extremely unimportant. Regarding the availability of fast battery charging at charging stations, 51.2% of respondents reported it as somewhat important, 26.4% as extremely important, and 4.9% as extremely unimportant. Regarding the availability of leisure activities at charging stations, 47.7% of respondents reported it as somewhat important, 21.8% as extremely important, and 4.1% as extremely unimportant.

3.2. Households Owning an ICE/Hybrid Car and Considering Switching to/Adding an EV Car

This section describes the collected data thematically for households that already own an ICE/hybrid car and are considering switching to or adding an EV. Figure 15 shows that the largest percentage of respondents belongs to the 40–49-year age group, at 37.5%. It also shows that 54.8% of the sampled households report a total annual household income between 10 lakh and 25 lakh INR. It further shows that 77.7% of respondents belong to households with 3–5 members. Figure 15 also shows that 89.6% of the respondents are male. Additionally, it shows that 50.8% of respondents hold a Bachelor's degree, while 29.5% report holding a diploma but no Bachelor's degree. 85.4% of the respondents are married.

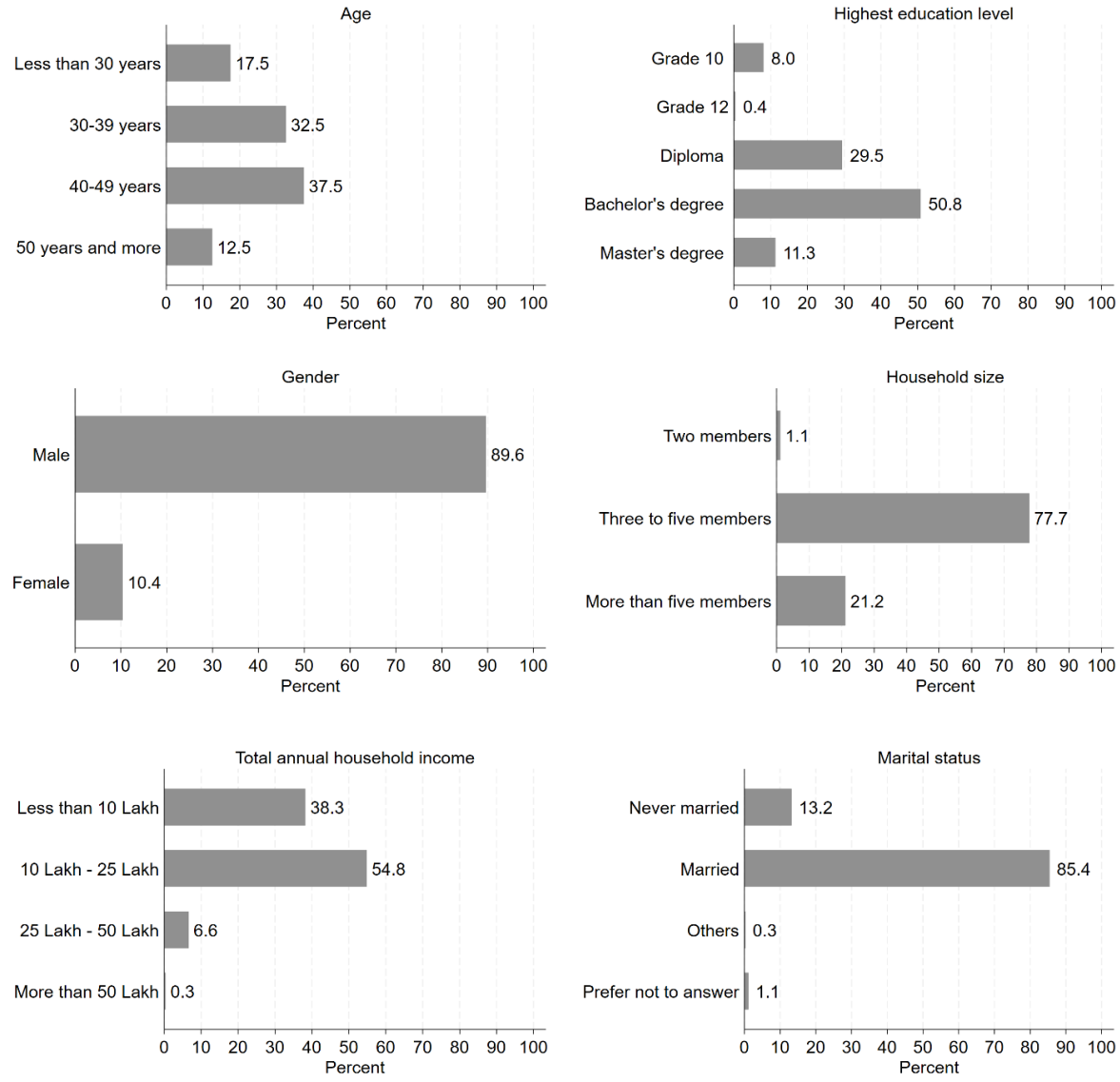


Figure 15: Socio-demographic characteristics of the sampled pre-adoption households

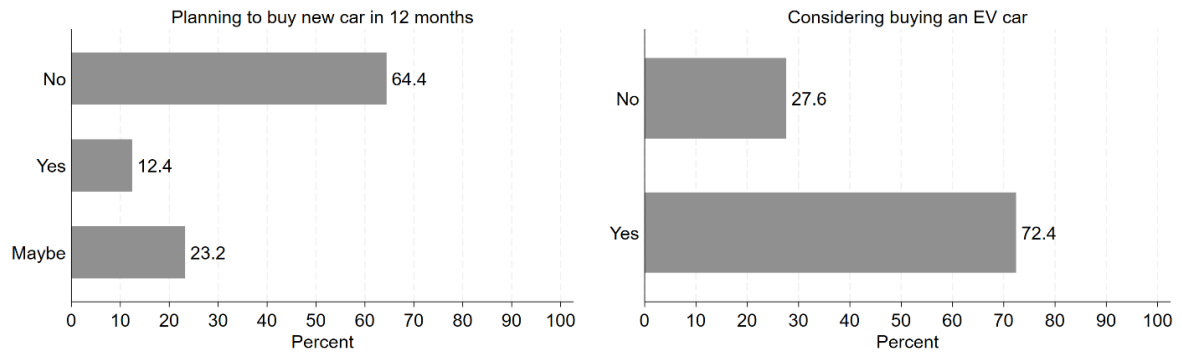


Figure 16: Respondents' car purchase plans in the next 12 months and their consideration of EV cars

Figure 16 shows the characteristics of the sampled households' purchase intentions. It shows that 64.4% of respondents report they do not plan to buy a new car in the next 12 months. It also shows that 72.4% of respondents report considering buying an EV.

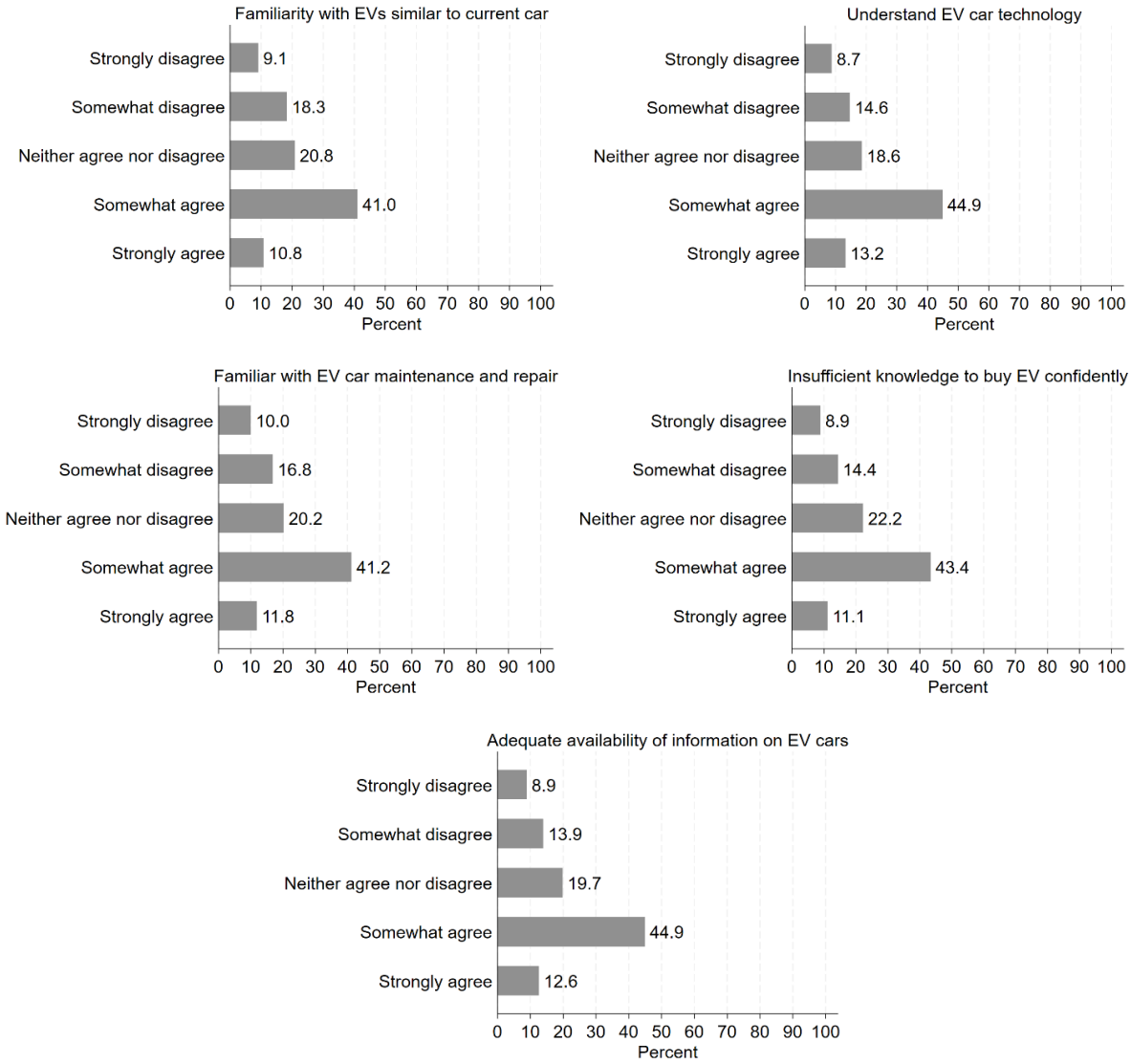


Figure 17: Respondents' perceptions regarding familiarity, understanding, and information adequacy related to EV cars

Figure 17 shows respondents' perceptions of familiarity, understanding, and information adequacy regarding EV cars. It shows that 41.0% of respondents somewhat agree and 10.8% strongly agree that they are familiar with EVs compared to their current car. It also shows that 44.9% somewhat agree and 13.2% strongly agree that they understand EV car technology. 41.2% somewhat agree, and 11.8% strongly agree that EV car maintenance and repair are familiar to them. 43.4% somewhat agree, and 11.1% strongly agree that their current knowledge of EVs is insufficient to buy one with confidence. Further, 44.9% somewhat agree, and 12.6% strongly agree that the information available about EVs is adequate.

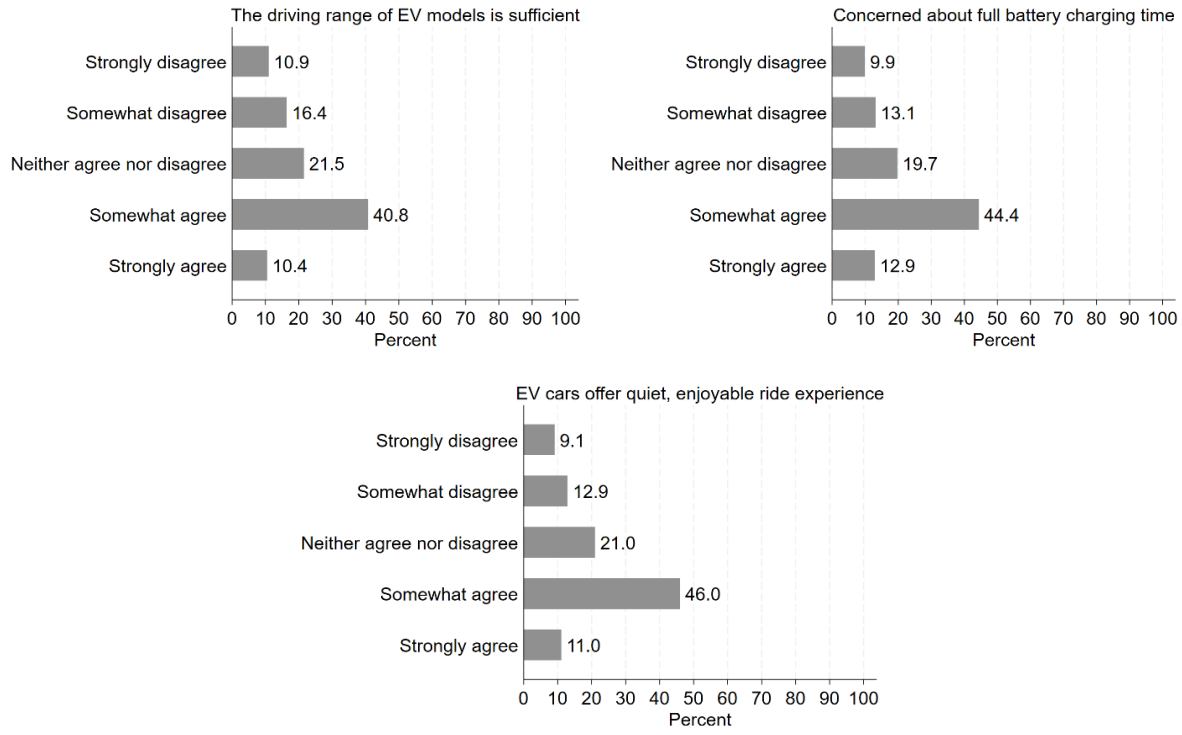


Figure 18: Respondents' perceptions regarding the reliability and performance of EV car technology

Figure 18 shows respondents' perceptions regarding the reliability and performance of EV car technology. Figure 18 shows that 40.8% of respondents somewhat agree and 10.4% strongly agree that the driving range of EVs currently available on the market is sufficient. It also shows that 44.4% somewhat agree and 12.9% strongly agree that they are concerned about the time it takes to fully charge an EV battery. Additionally, 46.0% somewhat agree, and 11.0% strongly agree that an EV offers a quieter, equally enjoyable driving experience than their current car.

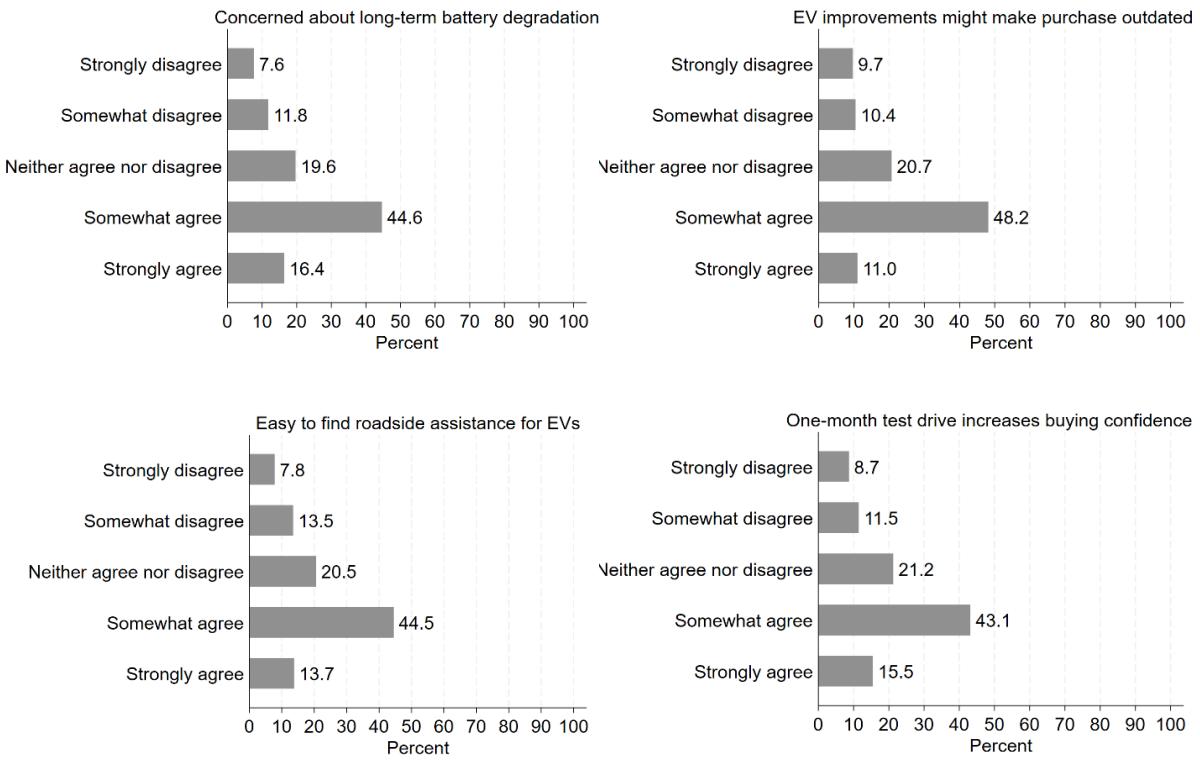


Figure 19: Respondents' perceptions regarding deterrents and confidence boosters associated with purchasing an EV car

Figure 19 shows respondents' perceptions regarding deterrents and confidence boosters. 44.6% somewhat agree, and 16.4% strongly agree that they are concerned about battery degradation over the years in EVs. 48.2% somewhat agree, and 11.0% strongly agree that rapid EV car technology updates will make a purchased EV car outdated. 44.5% somewhat agree, and 13.7% strongly agree that they are concerned about the ease of finding immediate roadside assistance for an EV car breakdown. 43.1% somewhat agree, and 15.5% strongly agree that a chance to test an EV car will increase their confidence in buying one.

Figure 20 shows respondents' levels of awareness and familiarity with government policies and promotional support for EVs. It shows that 46.7% of respondents somewhat agree and 14.6% strongly agree that they are aware of rebates available to EV car buyers. 42.6% of respondents somewhat agree, and 11.3% strongly agree that they are familiar with the additional benefits of driving an EV. 43.8% respondents somewhat agree, and 10.9% respondents strongly agree that they find it easy to track EV-related government policies currently in effect. Additionally, it shows that 44.2% of respondents somewhat agree and 14.4% strongly agree that promotional campaigns about EVs provide adequate guidance for purchase.

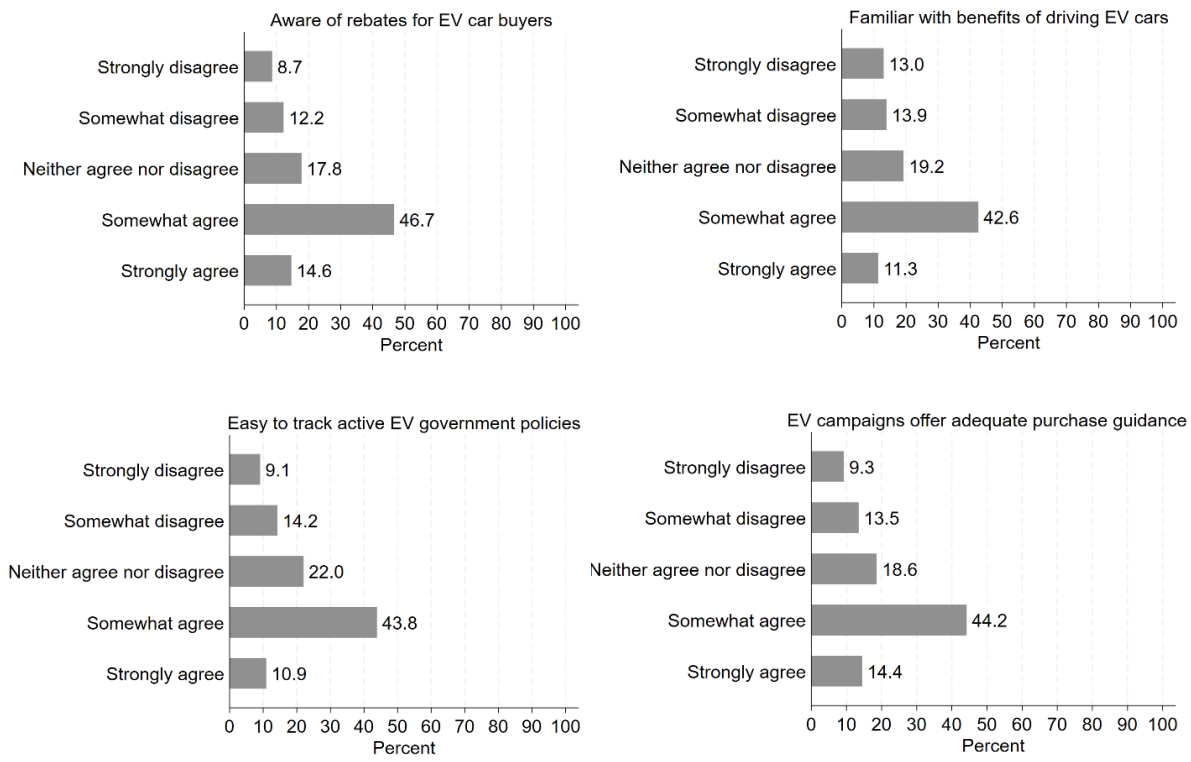
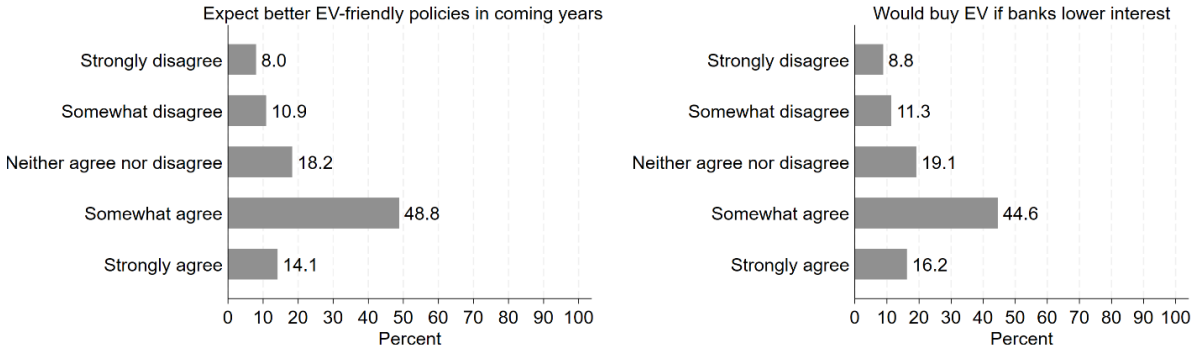


Figure 20: Level of awareness and familiarity with government policies and promotional support related to EVs among respondents

Figure 21 shows expectations for improvements in EV-friendly policies and the influence of financial conditions on EV buying decisions. It shows that 48.8% of respondents somewhat agree and 14.1% strongly agree that EV-friendly policies for buyers are expected to improve in the next few years. 44.6% somewhat agree, and 16.2% strongly agree that they would buy an EV if bank loan interest rates were lower. 42.7% somewhat agree, and 16.0% strongly agree that they would buy an EV if charging electricity becomes cheaper. Additionally, 44.1% somewhat agree, and 15.7% strongly agree that they would purchase an EV if the purchase price were the same as that of a regular car.



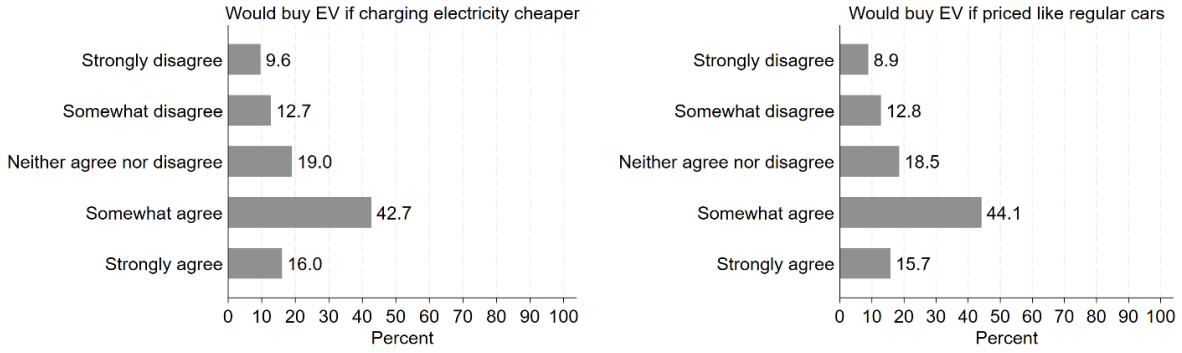
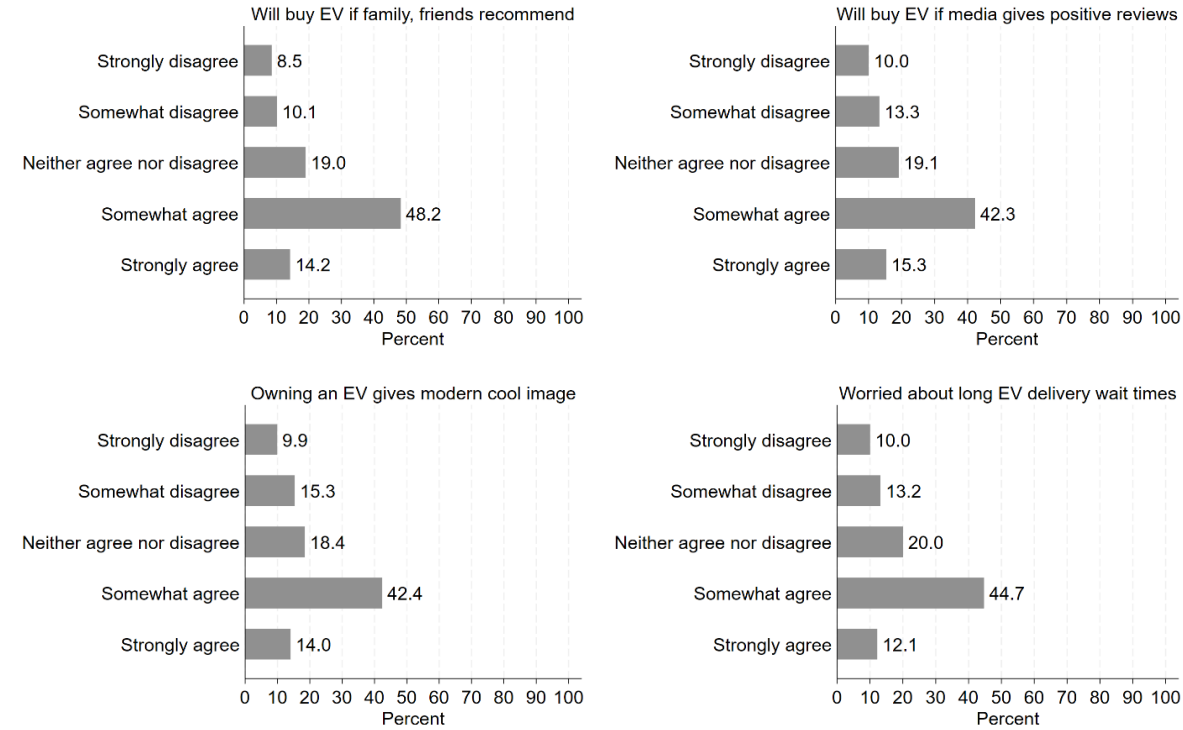


Figure 21: Expectations regarding improvement in EV-friendly policies and the influence of financial conditions on EV buying decisions

Figure 22 shows the social influences and logistical concerns associated with purchasing an EV. It shows that 48.2% of respondents somewhat agree and 14.2% strongly agree that they would buy an EV car if friends and family recommend it. 42.3% somewhat agree, and 15.3% strongly agree that they would buy an EV car if news and social media give positive reviews. 42.4% somewhat agree, and 14.0% strongly agree that owning an EV car would give a modern 'cool' image. Additionally, Figure 22 shows that 44.7% somewhat agree and 12.1% strongly agree that they are concerned about the long wait times for EV deliveries. Regarding the repair ecosystem, 44.7% somewhat agree, and 16.6% strongly agree that they are worried that a local mechanic might not know how to repair an EV.



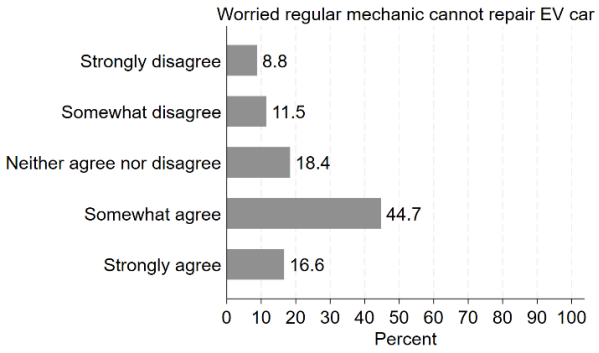


Figure 22: Social influence and logistical concerns affecting the purchase decision for an EV

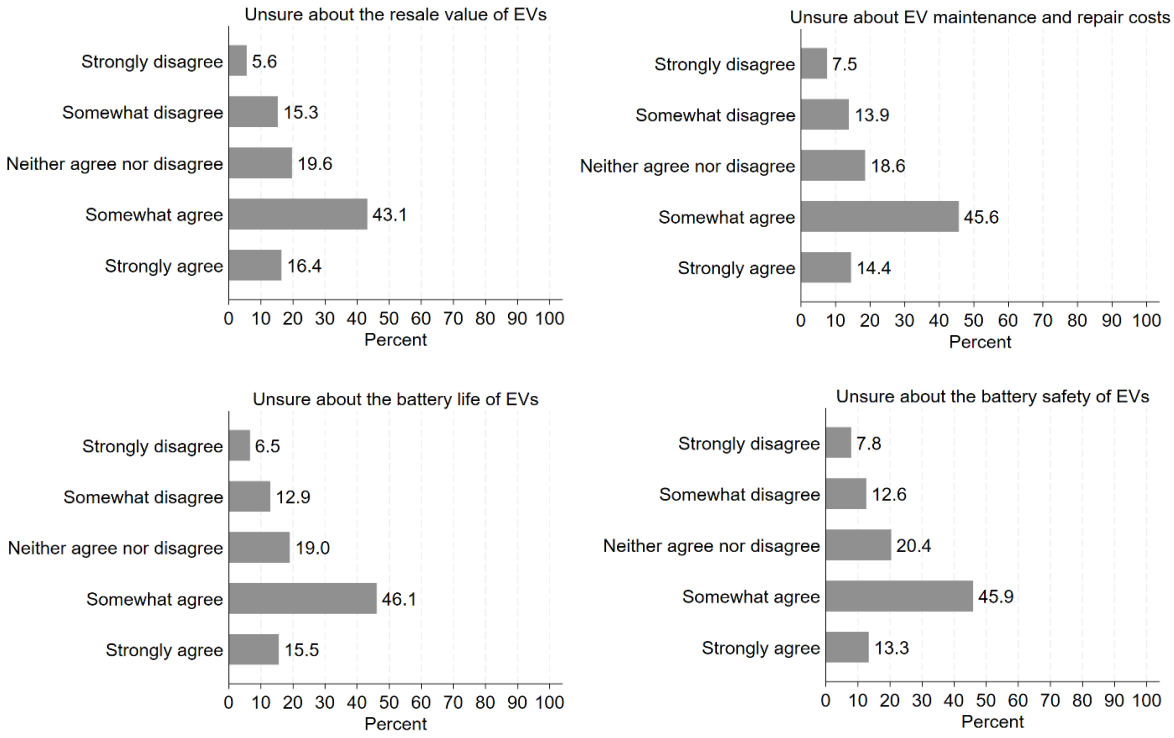


Figure 23 Uncertainty and perceived burden associated with EV ownership

Figure 23 shows the uncertainty and perceived burden associated with EV ownership. It shows that 43.1% of respondents somewhat agree and 16.4% strongly agree that they are unsure about the resale value of an EV car. 45.6% somewhat agree, and 14.4% strongly agree that they are unsure about how much EV car repair and maintenance would cost. 46.1% somewhat agree, and 15.5% strongly agree that they are unsure about the battery life of an EV car. Additionally, 45.9% somewhat agree, and 13.3% strongly agree that they are unsure about the safety of EV batteries.

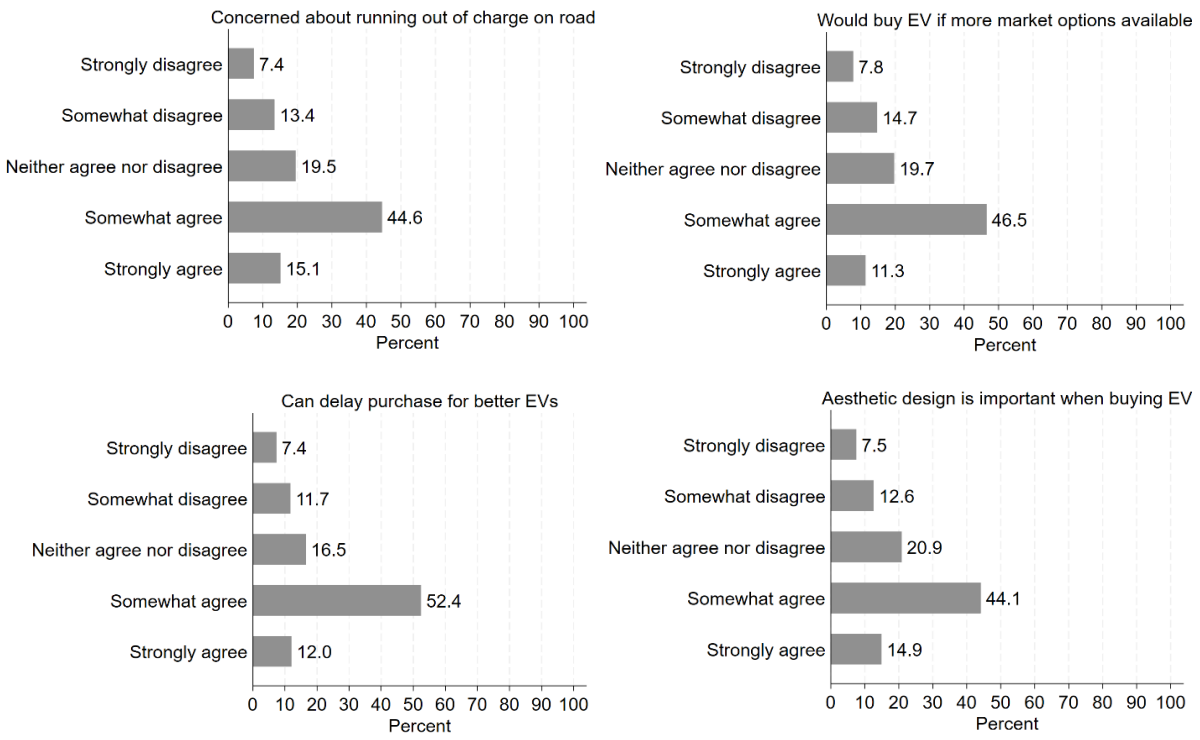


Figure 24: External factors affecting EV car purchase decisions

Figure 24 shows the external factors that affect EV purchase decisions. It shows that 44.6% of respondents somewhat agree and 15.1% strongly agree that they are concerned about running out of charge and getting stranded. 46.5% somewhat agree, and 11.3% strongly agree that they would buy an EV if more options were available in the market. 52.4% somewhat agree, and 12.0% strongly agree that they would delay purchasing an EV if EVs become cheaper and better in the coming years. Additionally, 44.1% somewhat agree, and 14.9% strongly agree that aesthetic design is an important consideration when buying an EV.

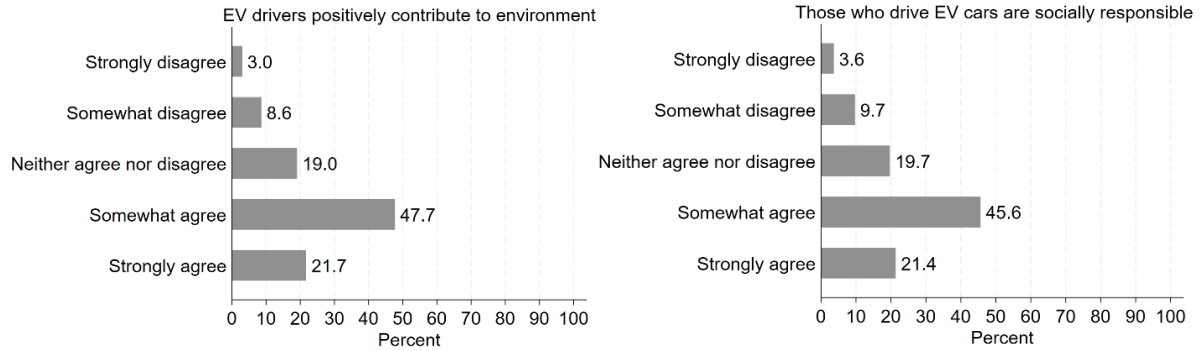


Figure 25: Perceived environmental and social benefits of EVs

Figure 25 shows the perceived environmental and social benefits of EVs. It shows that 47.7% of respondents somewhat agree and 21.7% strongly agree that EV drivers contribute positively to the environment. It also shows that 45.6% somewhat agree and 21.4% strongly agree that EV drivers are socially responsible.

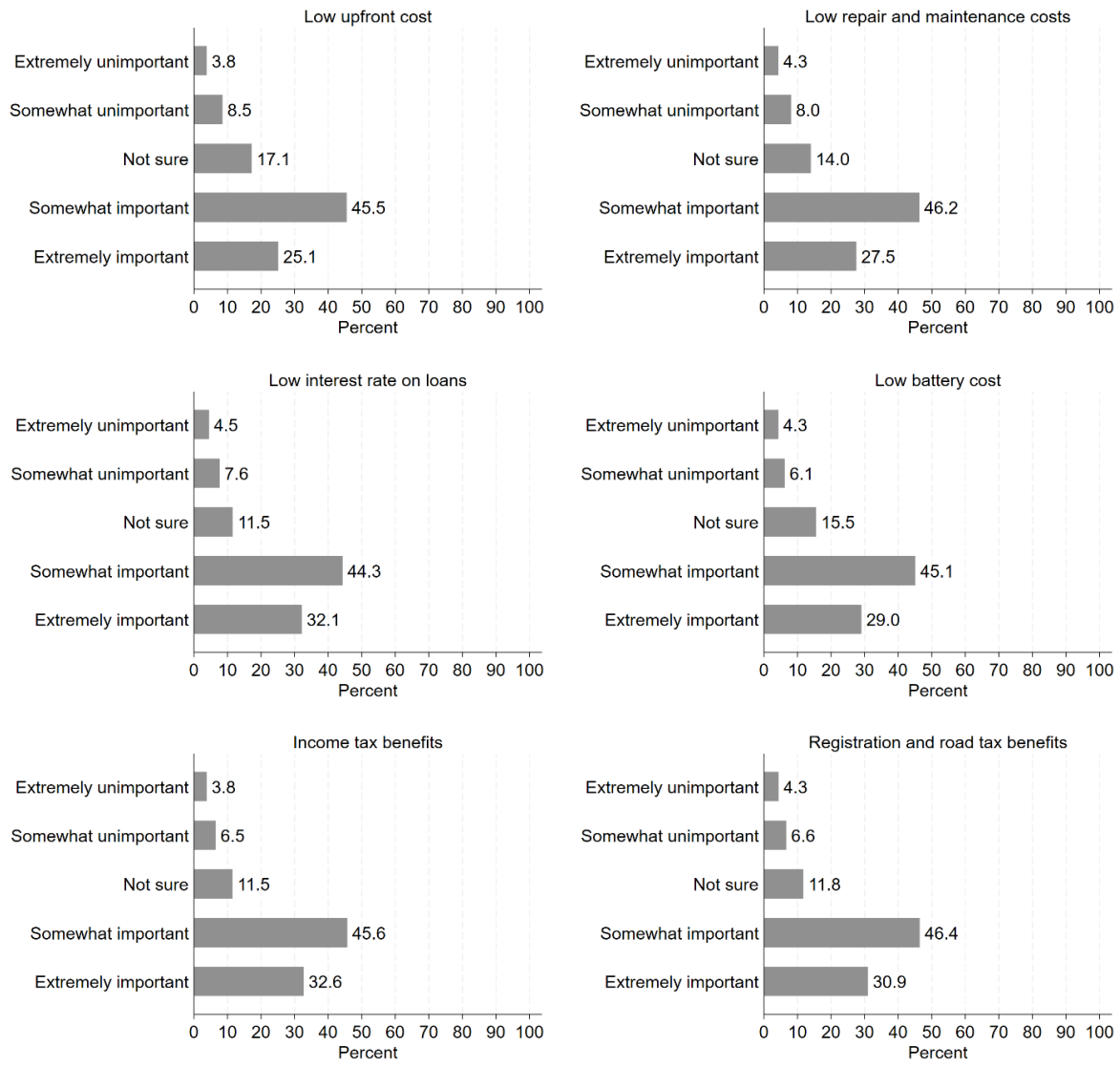


Figure 26: Importance of financial aspects while considering buying an EV

Figure 26 highlights the importance of financial considerations when buying an EV. It shows that 45.5% of respondents consider a low upfront cost to be somewhat important, and 25.1% extremely important. It also shows that 46.2% consider low repair and maintenance costs somewhat important, and 27.5% extremely important. 44.3% consider a low loan interest rate somewhat important, and 32.1% extremely important. 45.1% consider low battery cost somewhat important, and 29.0% extremely important. It also shows that 45.6% consider income tax benefits somewhat important, and 32.6% extremely important. 46.4% consider registration and road tax benefits somewhat important, and 30.9% regard them as extremely important.

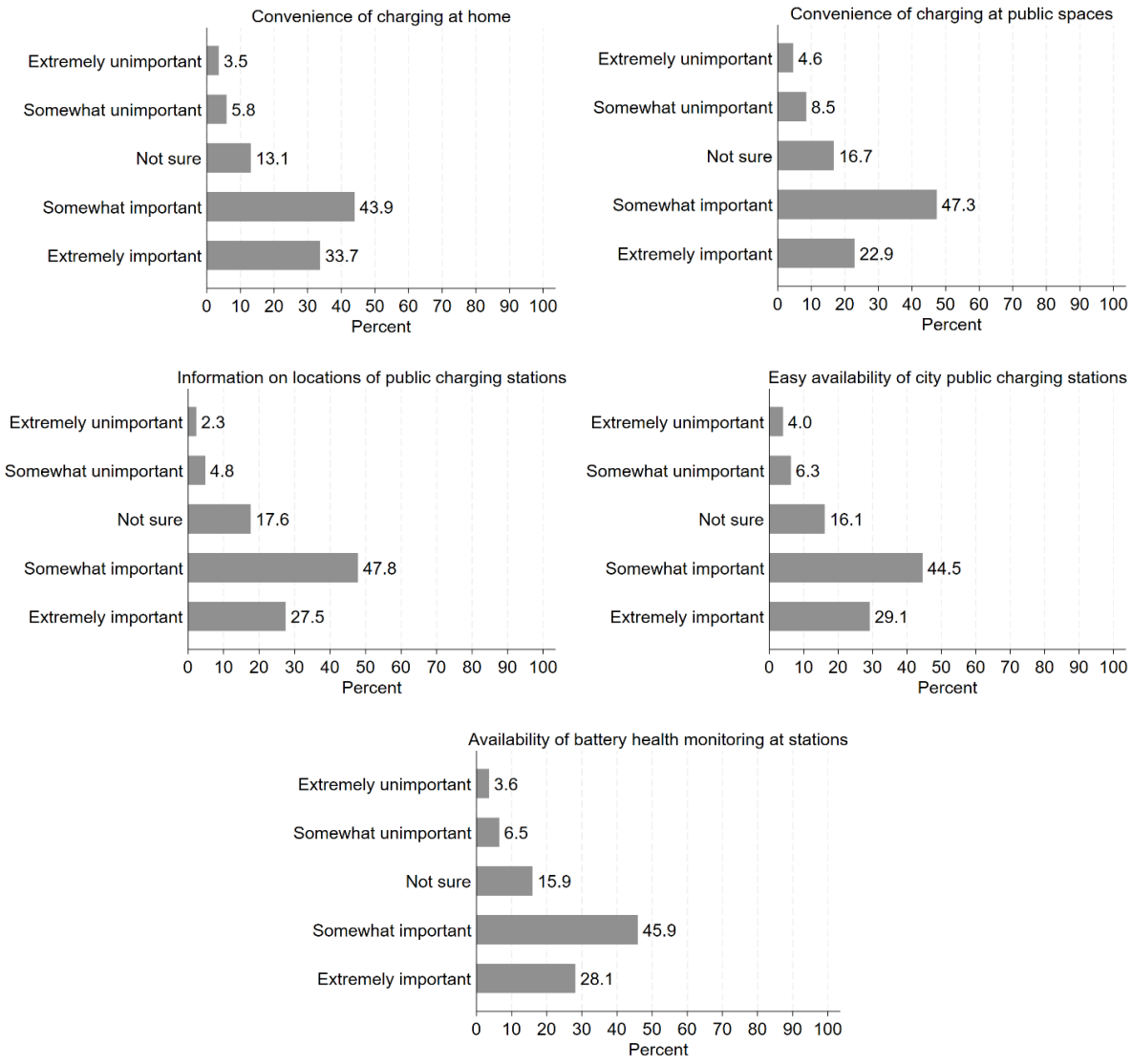


Figure 27: Importance of charging aspects while considering buying an EV

Figure 27 highlights the importance of charging considerations when buying an EV. It shows that 43.9% of respondents consider the convenience of charging at home somewhat important, and 33.7% consider it extremely important. It also shows that 47.3% consider the convenience of charging in public spaces somewhat important, while 22.9% consider it extremely important. 47.8% consider information on the locations of public charging stations somewhat important, and 27.5% consider it extremely important. Additionally, 44.5% consider the easy availability of public charging stations around the city somewhat important, and 29.1% consider it extremely important. It also shows that 45.9% consider the availability of a battery health-monitoring service at charging stations somewhat important, and 28.1% consider it extremely important.

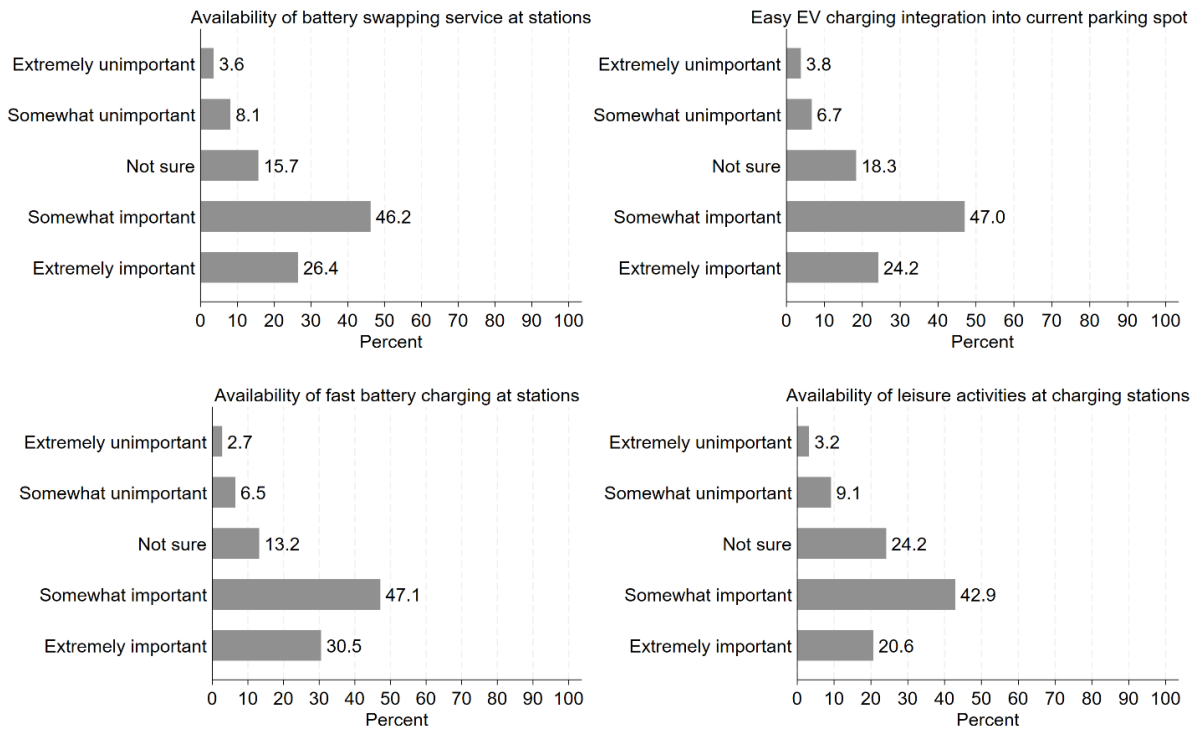


Figure 28: Importance of additional charging aspects while considering buying an EV

Figure 28 highlights the importance of additional charging considerations when buying an EV. It shows that 46.2% of respondents consider the availability of battery-swapping services at charging stations to be somewhat important, and 26.4% to be extremely important. 47.0% consider the easy integration of EV charging into my current parking spot somewhat important, and 24.2% extremely important. 47.1% consider the availability of fast battery charging at charging stations to be somewhat important, and 30.5% to be extremely important. Additionally, 42.9% consider the availability of leisure activities at charging stations to be somewhat important, and 20.6% consider it extremely important.

3.3. Cross-Tabulation of Data Obtained from Potential EV Consumers

3.3.1. Carless Households Considering Buying Their First Car

This section presents a cross-tabulation of the data by selected themes for carless households, focusing on their first car purchase.

a. The Charging Aspects

Figure 29 shows the perceived concern about EV charging time across different vehicle purchase plans. It shows that 74.3% (55.8% + 18.5%) of respondents considering an EV purchase, somewhat (55.8%) or strongly (18.5%) agree that they are concerned about the time it takes to fully charge the battery. In comparison, a relatively lower share of persons not considering an EV purchase somewhat/strongly agree that they are concerned about charging time.

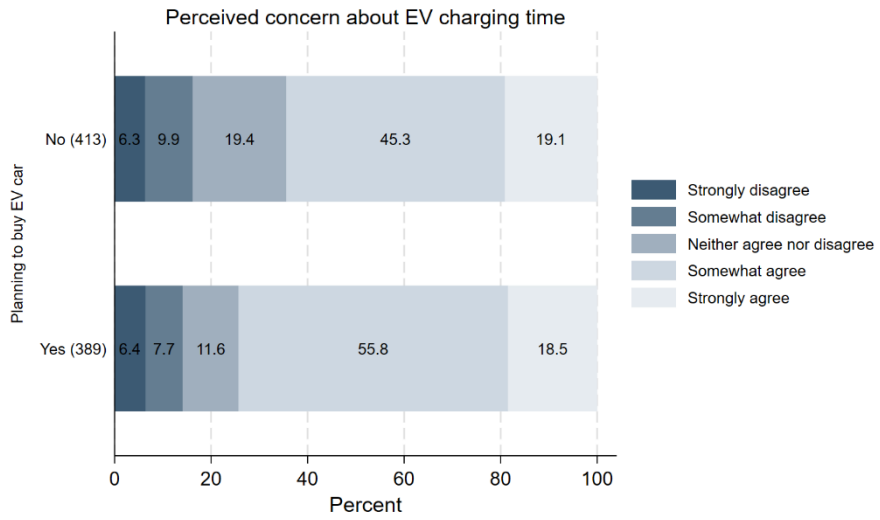


Figure 29: Perceived concern about EV charging time among EV considerers and non-considerers

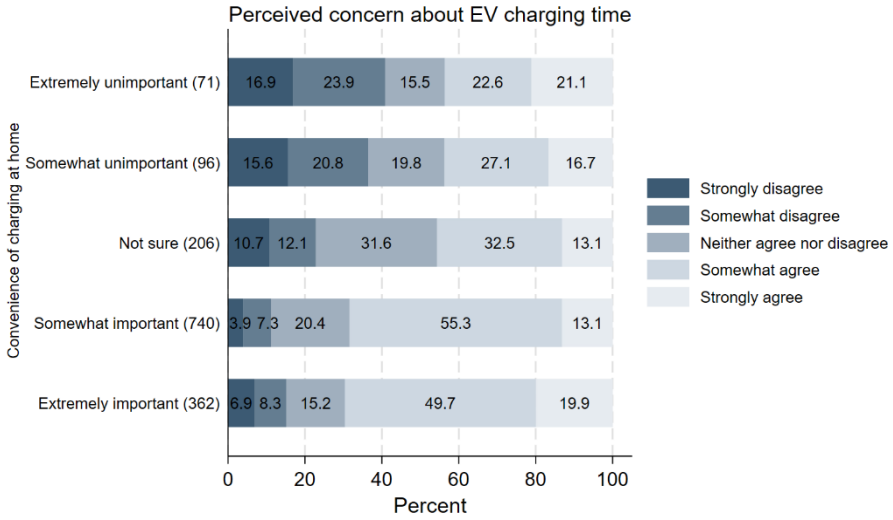


Figure 30: Importance of home charging for respondents

Figure 30 shows that 69.6% of respondents who rate the convenience of charging at home as extremely important, somewhat (49.7%), or strongly (19.9%) agree that they are concerned about the time it takes to fully charge the battery. In comparison, a relatively lower share of persons who rate home charging convenience as unimportant somewhat/strongly agree with this concern.

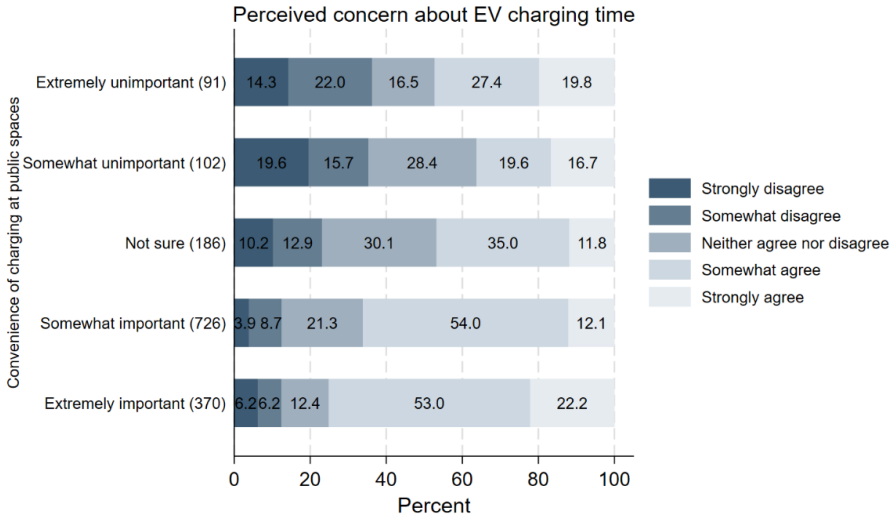


Figure 31: Importance of public charging for respondents

Figure 31 shows that 75.2% of respondents who rate the convenience of charging at public spaces as extremely important, somewhat (53.0%), or strongly (22.2%) agree that they are concerned about the time it takes to fully charge the battery.

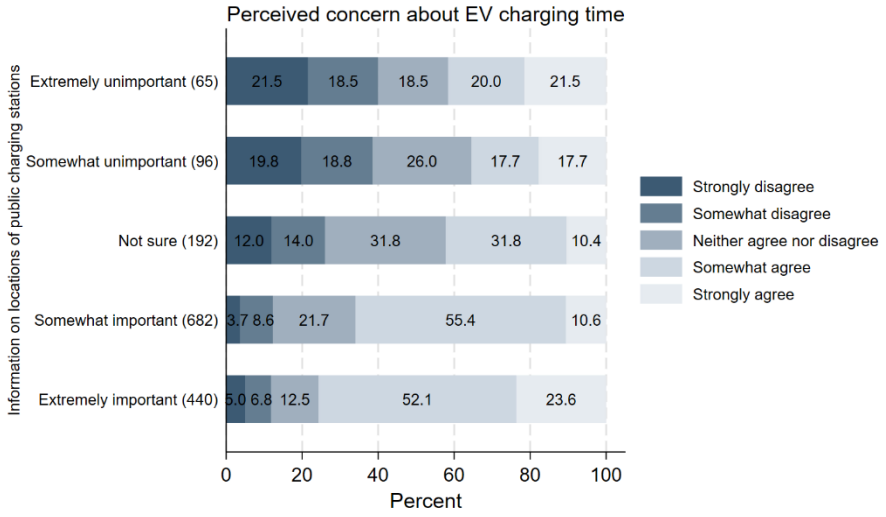


Figure 32: Importance of information on locations for public charging for respondents

Figure 32 shows that 75.7% of respondents who rate information on the locations of public charging stations as extremely important, somewhat (52.1%), or strongly (23.6%) agree that they are concerned about the time it takes to fully charge the battery.

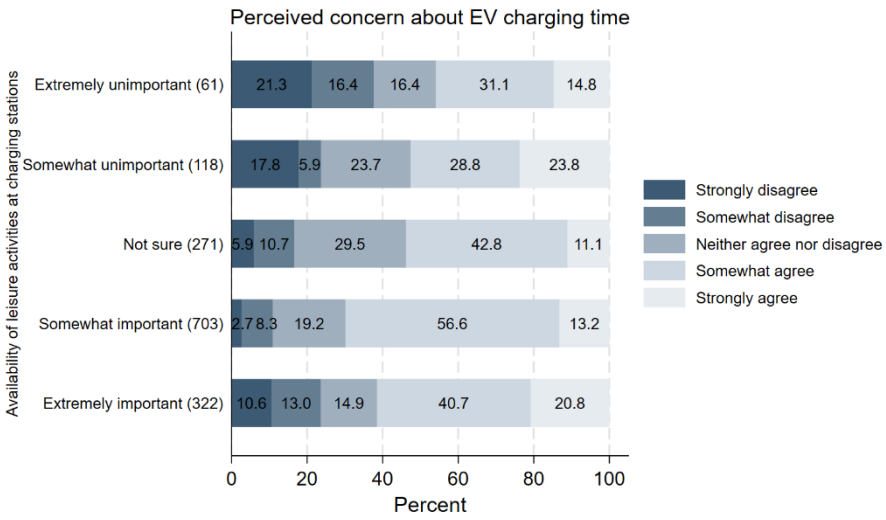


Figure 33: Importance of leisure activities at public charging stations for respondents

Figure 33 shows that 69.8% (56.6% + 13.2%) of respondents who rate the availability of leisure activities at charging stations as somewhat important, somewhat (56.6%) or strongly (13.2%), agree they are concerned about the time it takes to fully charge the battery.

b. The Information of EVs

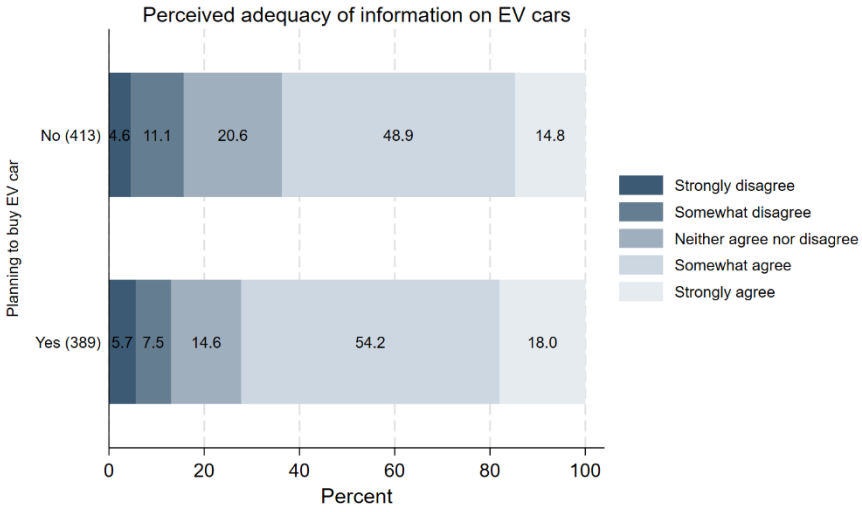


Figure 34: Perceived adequacy of information about EVs among EV considerers and non-considerers

Figure 34 shows the perceived adequacy of information on EV cars across different vehicle purchase plans. It shows that 72.2% (54.2% + 18.0%) of respondents considering an EV purchase, somewhat (54.2%) or strongly (18.0%) agree that the availability of information on EVs is adequate.

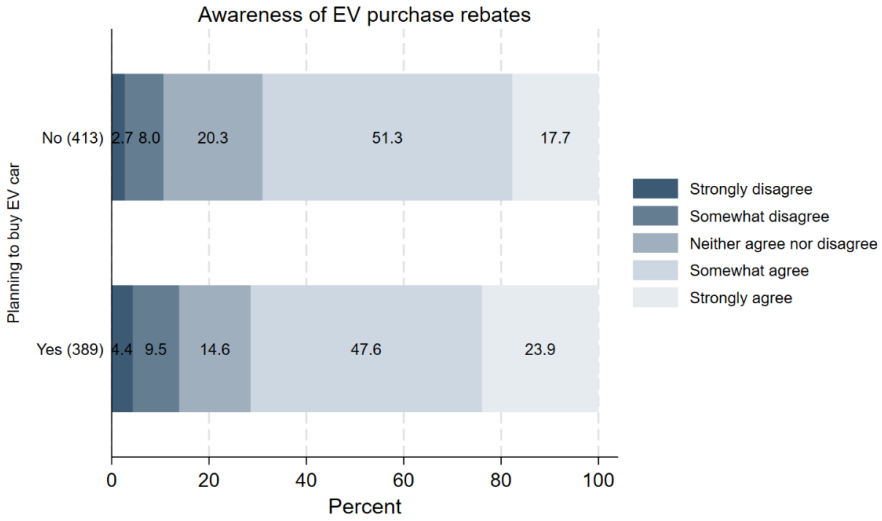


Figure 35: Perceived awareness of EV purchase rebates among EV considerers and non-considerers

Figure 35 shows the perceived awareness of EV purchase rebates across different vehicle purchase plans. Figure 35 shows that 71.5% (47.6% + 23.9%) of respondents considering an EV purchase, somewhat (47.6%) or strongly (23.9%) agree they are aware of the rebates available for EV buyers. In comparison, a relatively lower share of persons not considering an EV purchase somewhat/strongly agree that they are aware of EV purchase rebates.

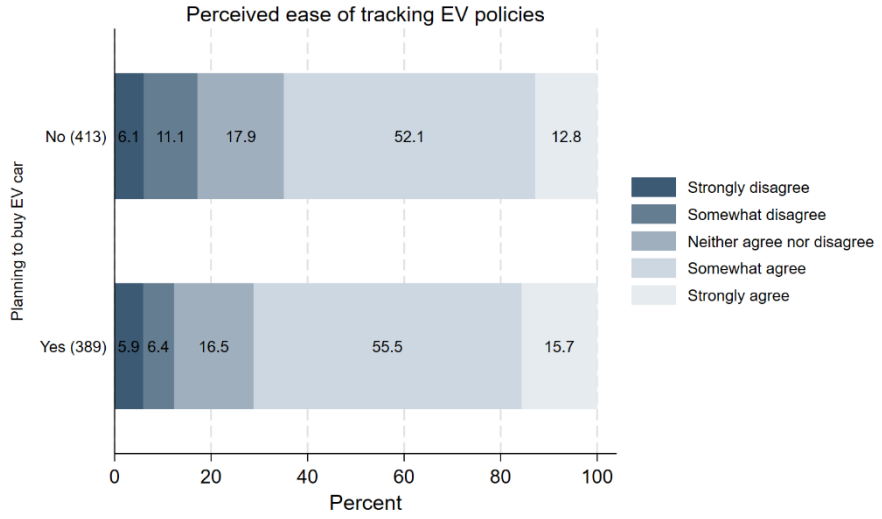


Figure 36: Perceived ease of tracking EV policies among EV considerers and non-considerers

Figure 36 shows the perceived ease of tracking EV policies across different vehicle purchase plans. It shows that 71.2% (55.5% + 15.7%) of respondents considering an EV purchase somewhat (55.5%) or strongly (15.7%) agree that it is easy to track which EV-related government policies they qualify for. In comparison, a relatively lower share of persons not considering an EV purchase somewhat/strongly agree that it is easy to track government policies.

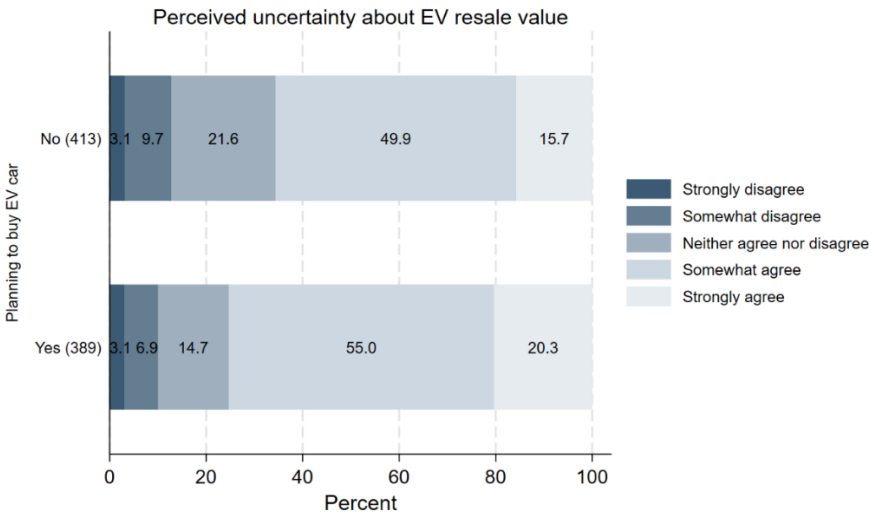


Figure 37: Perceived uncertainty about EV resale among EV considerers and non-considerers

Figure 37 shows the perceived uncertainty about EV resale value across different vehicle purchase plans. Figure 37 shows that 75.3% (55.0% + 20.3%) of respondents considering an EV purchase somewhat (55.0%) or strongly (20.3%) agree that they are unsure about the resale value of an EV. In comparison, a relatively lower share of persons not considering an EV purchase somewhat/strongly agree that they are unsure about the resale value.

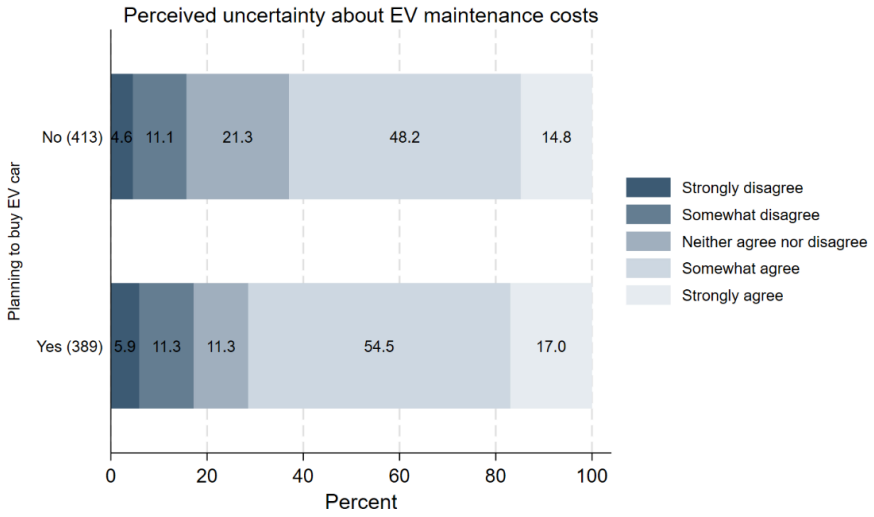


Figure 38: Perceived uncertainty about EV maintenance costs among EV considerers and non-considerers

Figure 38 shows the perceived uncertainty about EV maintenance costs across different vehicle purchase plans. Figure 38 shows that 71.5% (54.5% + 17.0%) of respondents considering an EV purchase somewhat (54.5%) or strongly (17.0%) agree they are unsure about how much EV car maintenance and repair would cost. In comparison, a relatively lower share of persons not considering an EV purchase somewhat/strongly agree that they are unsure about maintenance and repair costs.

1.3.1.1. The CASE Framework

In this subsection, a strategic CASE framework is proposed as a means of understanding consumer preferences regarding certain aspects when purchasing an EV. The CASE (Cost, Aesthetic, Social, and Environmental) dimensions are assumed to influence consumer intentions to adopt EVs. Through this framework, we aim to evaluate how financial parity, design preferences, perceived social responsibility, and environmental consciousness collectively shape potential buyers' decision-making.

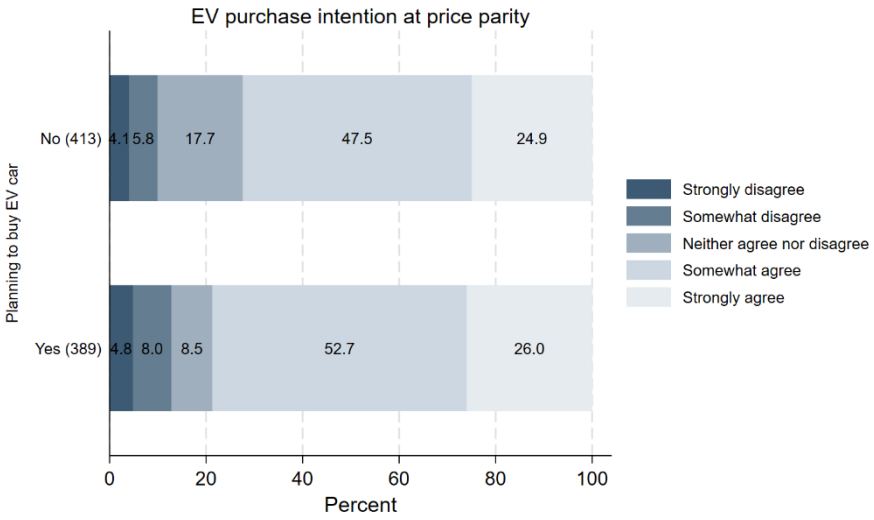


Figure 39: EV purchase intention at price parity among EV considerers and non-considerers

Figure 39 shows the EV purchase intention at price parity across different vehicle purchase plans. Figure 39 shows that 78.7% (52.7% + 26.0%) of respondents who are considering an EV purchase somewhat (52.7%) or strongly (26.0%) agree they would purchase an EV if purchase prices were the same as for regular cars. In comparison, a relatively lower share of persons in the group who do not consider an EV purchase somewhat/strongly agree with the purchase intention at price parity.

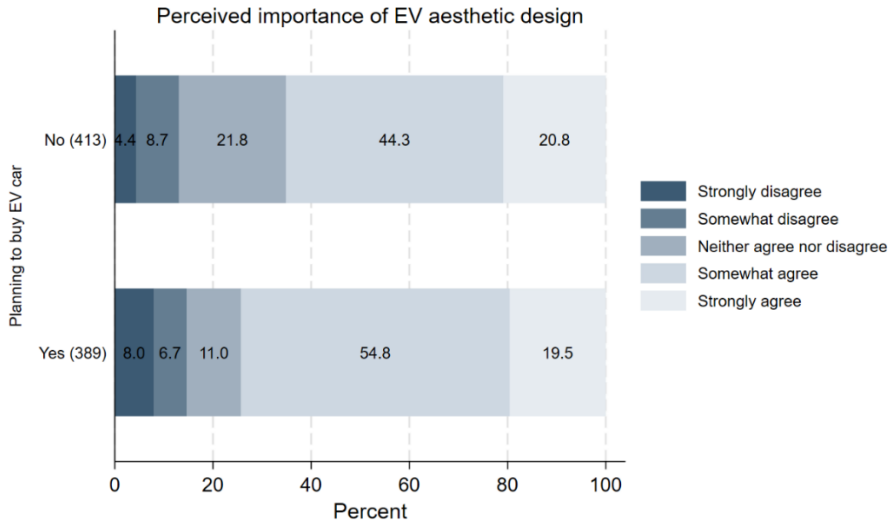


Figure 40: Perceived importance of EV aesthetic design among EV considerers and non-considerers

Figure 40 shows the perceived importance of EV aesthetic design across different vehicle purchase plans. Figure 40 shows that 74.3% (54.8% + 19.5%) of respondents who are considering an EV purchase

somewhat (54.8%) or strongly (19.5%) agree that aesthetic design is an important consideration when buying an EV. In comparison, a relatively lower share of persons belonging to the group, not considering an EV purchase, somewhat/strongly agree that aesthetic design is an important consideration.

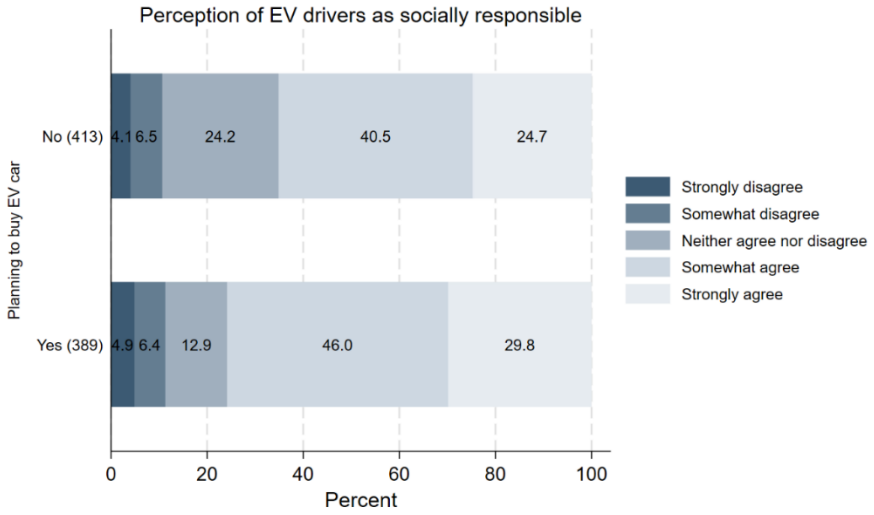


Figure 41: Perception of EV drivers as socially responsible among EV considerers and non-considerers

Figure 41 shows EV drivers' perception of being socially responsible across different vehicle purchase plans. Figure 41 shows that 75.8% (46.0% + 29.8%) of respondents considering an EV purchase, somewhat (46.0%) or strongly (29.8%) agree that EV drivers are socially responsible. In comparison, a relatively lower share of persons in the group who are not considering an EV purchase somewhat/strongly agree that EV drivers are socially responsible.

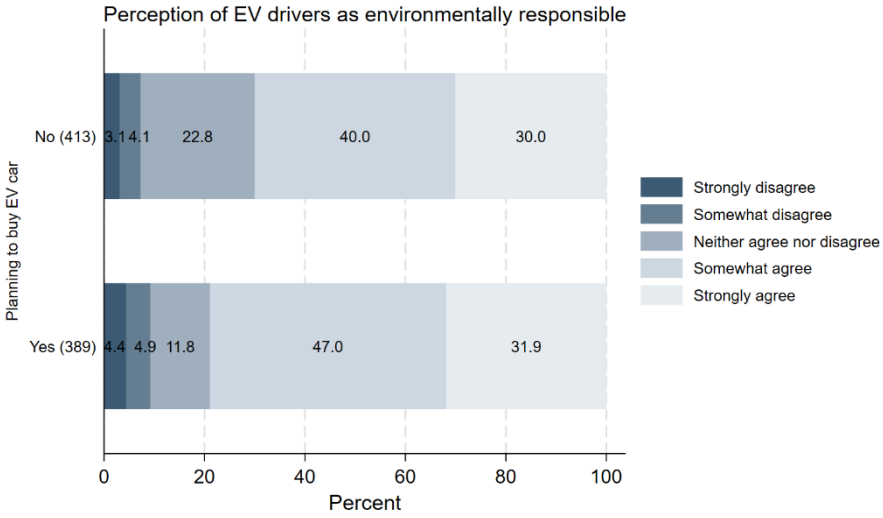


Figure 42: Perception of EV drivers as environmentally responsible among EV considerers and non-considerers

Figure 42 shows EV drivers' perceptions of environmental responsibility across different vehicle purchase plans. It shows that 78.9% (47.0% + 31.9%) of respondents considering an EV purchase somewhat (47.0%) or strongly (31.9%) agree that EV drivers contribute positively to the environment.

In comparison, a relatively lower share of persons in the group who do not plan to purchase an EV somewhat/strongly agree that EV drivers are environmentally responsible.

c. The Cool Modern Image

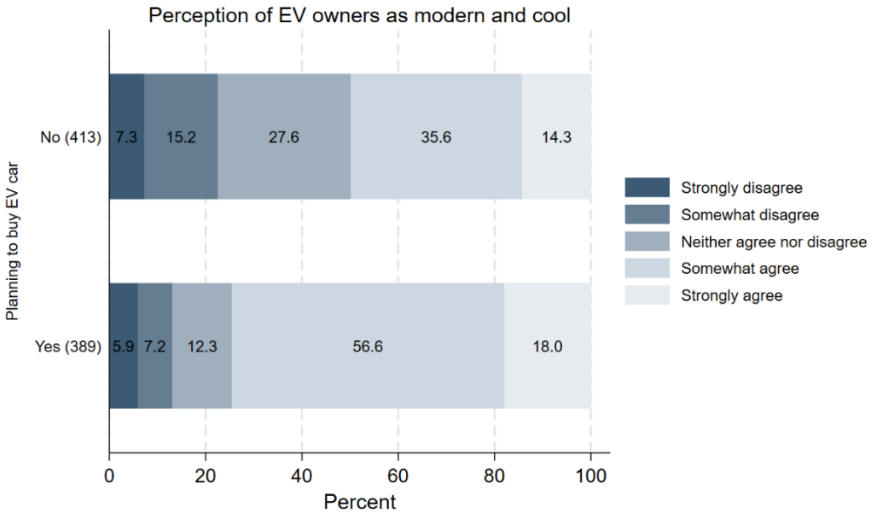


Figure 43: Perception of EVs as modern and cool among EV considerers and non-considerers

Figure 43 shows that EV owners perceive their vehicles as modern and cool across different vehicle purchase plans. It shows that 74.6% (56.6% + 18.0%) of respondents who are considering an EV purchase somewhat (56.6%) or strongly (18.0%) agree that owning an EV would give a modern "cool" image. In comparison, a relatively lower share of persons in the group who are not considering an EV purchase somewhat/strongly agree that EV owners are modern and cool.

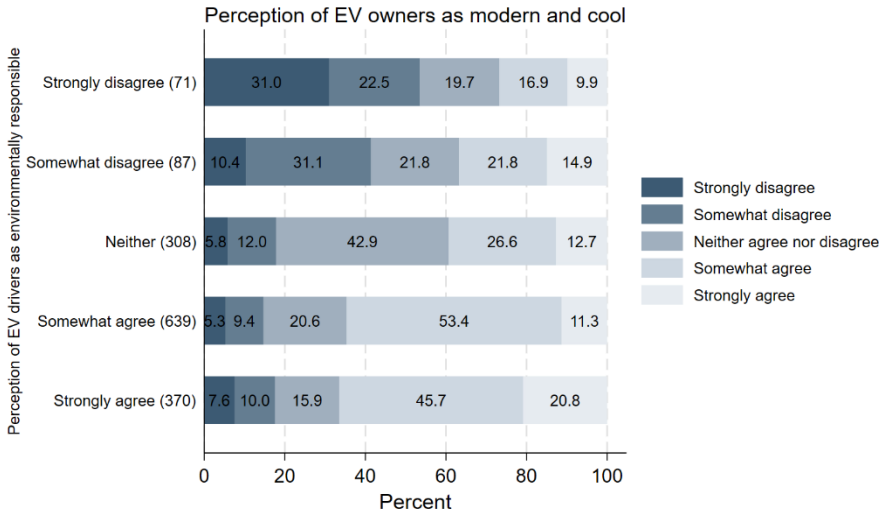


Figure 44: Perception of EVs as modern and cool among respondents due to perceived environmental benefits

Figure 44 shows that EV owners are perceived as modern and cool across different levels of environmental responsibility. It shows that 66.5% (45.7% + 20.8%) of respondents who strongly agree that EV drivers contribute positively to the environment somewhat (45.7%) or strongly (20.8%) agree

that owning an EV car would give a modern "cool" image. In comparison, a relatively lower share of persons who do not agree that EV drivers are environmentally responsible somewhat/strongly agree with the modern "cool" perception.

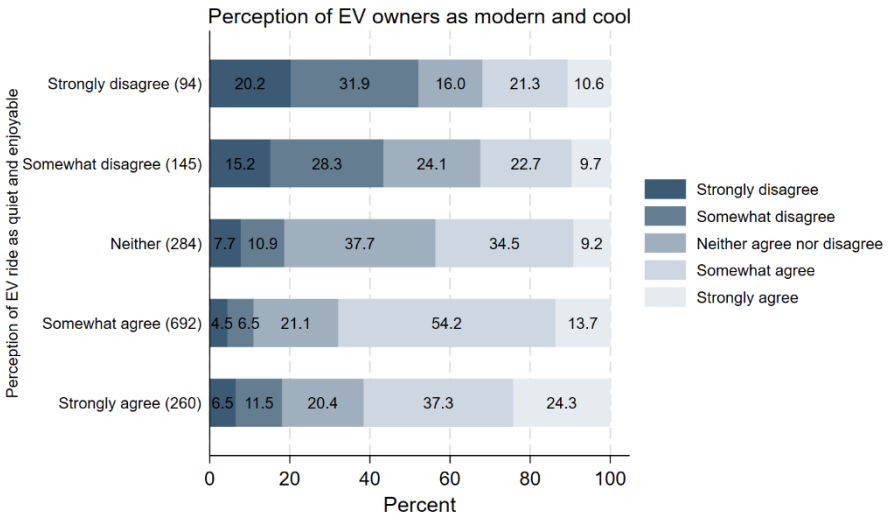


Figure 45: Perception of EVs as modern and cool among respondents due to perceived driving pleasure

Figure 45 shows that EV owners are perceived as modern and cool across different levels of perception of the EV driving experience. It shows that 67.9% (54.2% + 13.7%) of respondents who somewhat agree that an EV ride is quiet and enjoyable, somewhat agree (54.2%) or strongly agree (13.7%) that owning an EV would give a modern "cool" image. In comparison, a relatively lower share of persons who do not agree that an EV ride is quiet and enjoyable somewhat/strongly agree with the modern "cool" perception.

d. The Demographic Focus

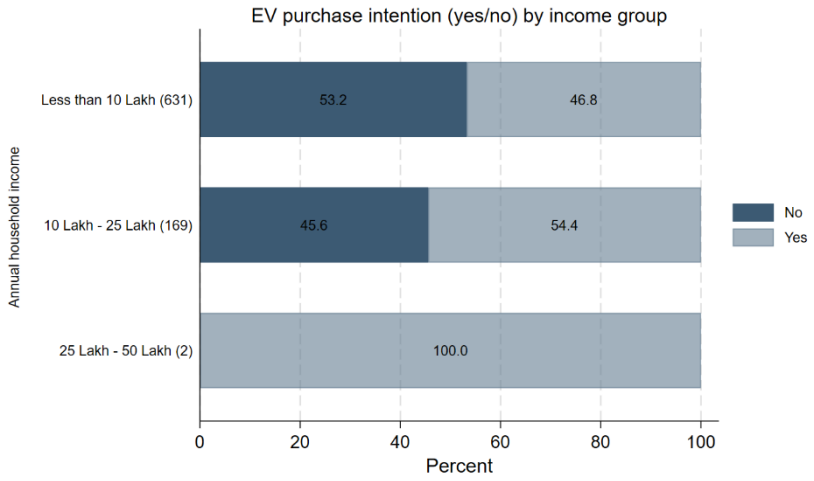


Figure 46: EV purchase intention across different household income levels

Figure 46 shows EV purchase intention by household income level. It shows that 54.4% of respondents in the middle-income group (10 Lakh-25 Lakh) intend to purchase an EV. In comparison, a similar share

of persons in the low-income group (less than 10 Lakh), at 46.8%, report an intention to purchase an EV.

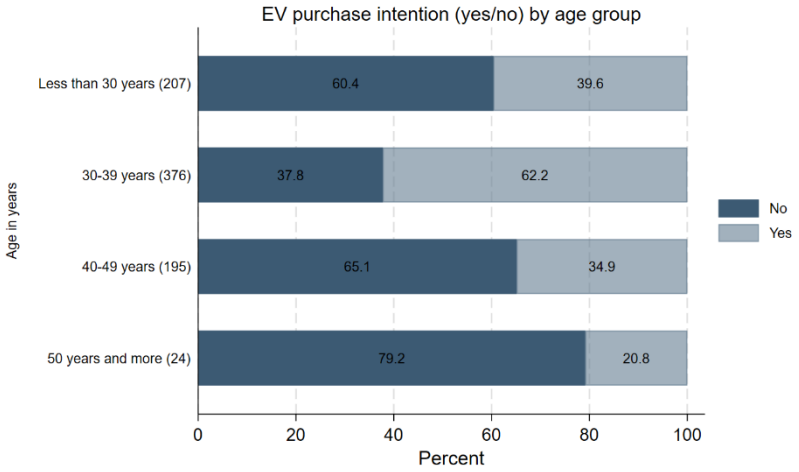


Figure 47: EV purchase intention across different age groups

Figure 47 shows EV purchase intention by age group. It shows that 62.2% of respondents in the 30-39 age group report an intention to purchase an EV. In comparison, a lower share of persons in the other age groups report an intention to purchase an EV.

3.3.2. Households Owning an ICE/Hybrid Car and Considering Switching to/Adding an EV Car

This section presents a cross-tabulation of the data across selected themes for households that already own an ICE/hybrid car and are considering switching to or adding an EV.

a. The Lifestyle Change Aspects and Car Comparison Story

Figure 48 shows the likelihood of purchasing an EV at the same price as an ICE car across different vehicle purchase plans. Figure 48 shows that 76.5% (51.7% + 24.8%) of respondents who are considering an EV purchase somewhat (51.7%) or strongly (24.8%) agree they would buy an EV if it were priced the same as their current ICE vehicle. In comparison, a relatively lower share of persons who are not considering an EV purchase somewhat/strongly agree with the purchase intention at price parity.

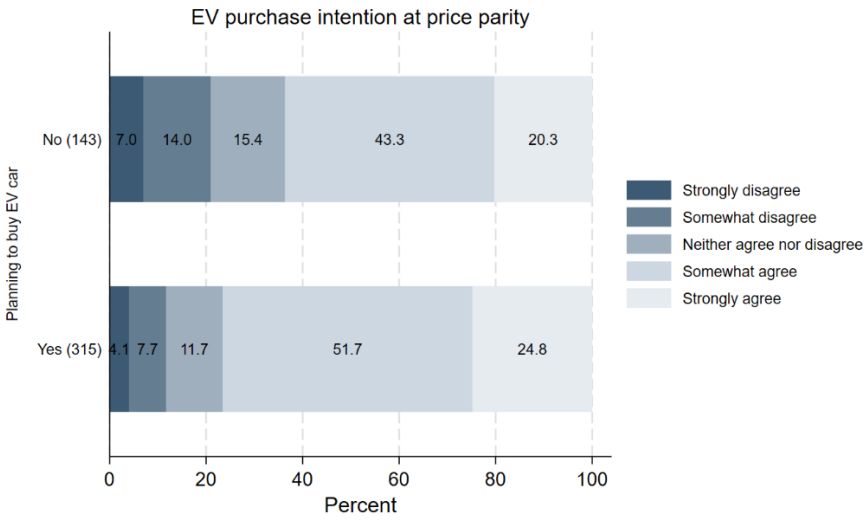


Figure 48: Likelihood of purchasing an EV if priced the same as an ICE car among EV considerers and non-considerers

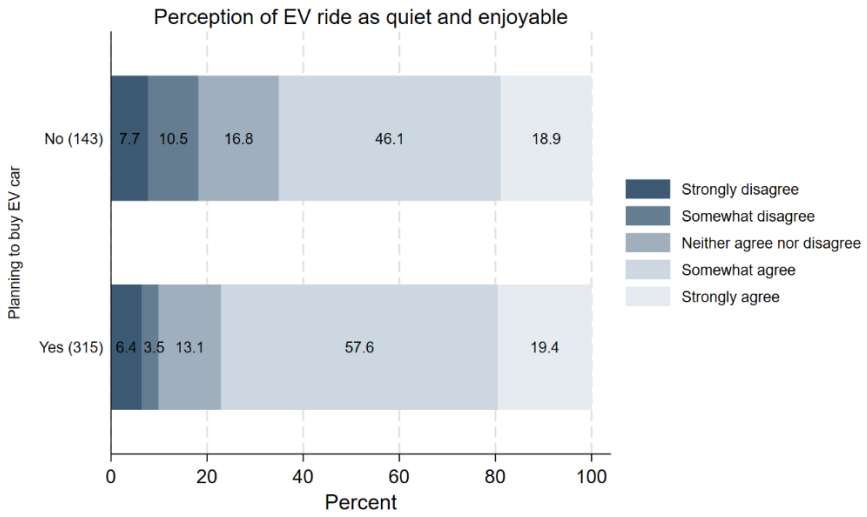


Figure 49: Perceived influence of driving experience on EV purchase among EV considerers and non-considerers

Figure 49 shows the influence of driving experience on the likelihood of purchasing an EV across different vehicle purchase plans. It shows that 77.0% (57.6% + 19.4%) of respondents who are considering an EV purchase somewhat (57.6%) or strongly (19.4%) agree they would buy an EV if the driving experience were better than that of their current ICE vehicle. In comparison, a relatively lower share of persons who are not considering an EV purchase somewhat/strongly agree that they would buy an EV because of improved driving pleasure.

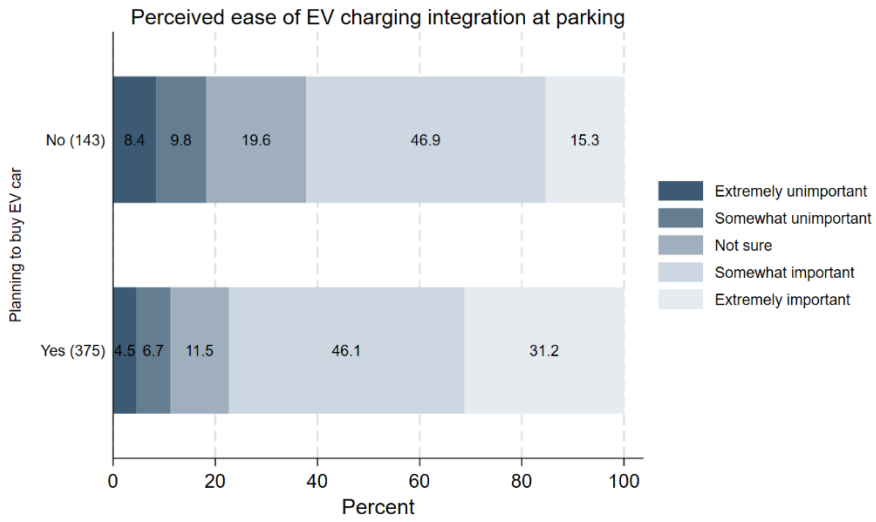


Figure 50: Perceived importance of parking spot charging integration among EV considerers and non-considerers

Figure 50 illustrates the importance of integrating parking spot charging across different vehicle purchase plans. It shows that 77.3% (46.1% + 31.2%) of respondents considering an EV purchase rate easy integration of charging into their current parking spot as somewhat (46.1%) or extremely (31.2%) important. In comparison, a relatively lower share of persons not considering an EV purchase rate parking spot charging integration as somewhat/extremely important.

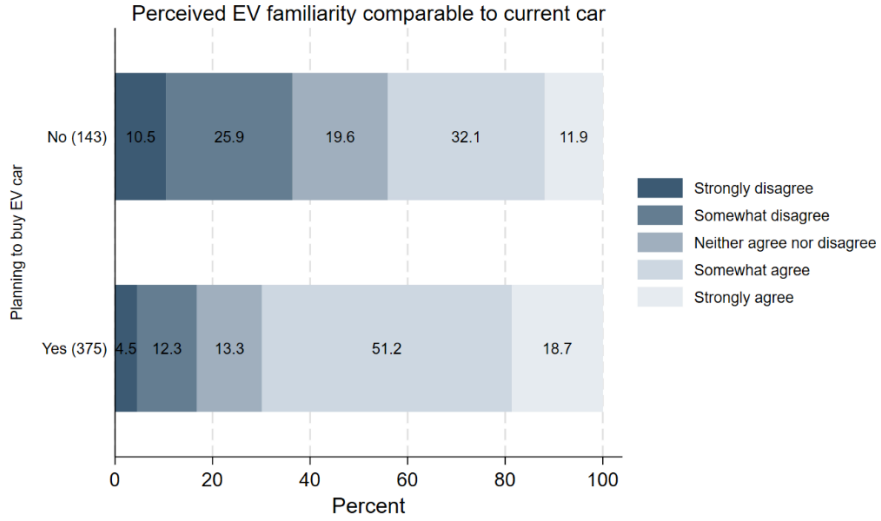


Figure 51: Perceived importance of technological familiarity on EV purchase among EV considerers and non-considerers

Figure 51 shows the importance of technological familiarity on EV purchase likelihood across different vehicle purchase plans. It shows that 69.9% (51.2% + 18.7%) of respondents who are considering an EV purchase somewhat (51.2%) or strongly (18.7%) agree they would buy an EV if their tech familiarity were similar to that of their current ICE vehicle. In comparison, a relatively lower share of persons not considering an EV purchase somewhat/strongly agree they would purchase an EV based on tech familiarity.

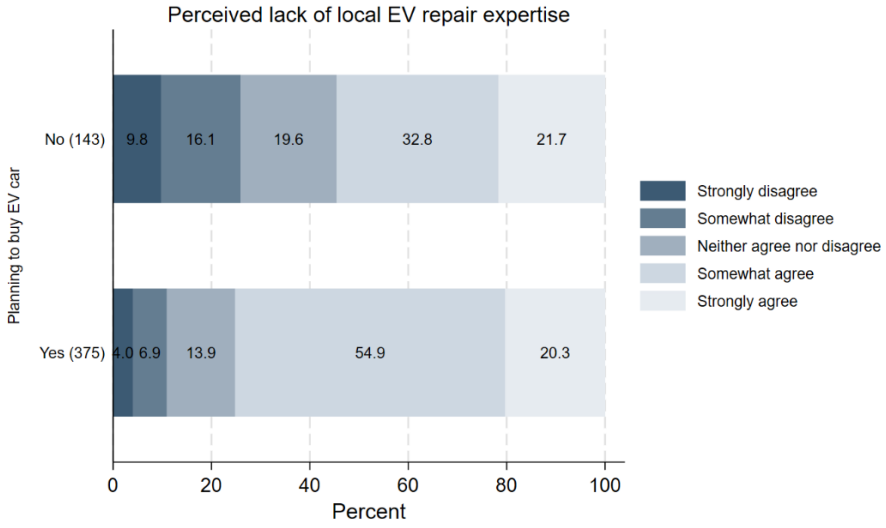


Figure 52: Perceived lack of local EV maintenance support among EV considerers and non-considerers

Figure 52 shows the impact of repair and maintenance process similarity on EV purchase likelihood across different vehicle purchase plans. It shows that 75.2% (54.9% + 20.3%) of respondents who are considering an EV purchase somewhat (54.9%) or strongly (20.3%) agree they would buy an EV if the repair and maintenance process were similar to that of their current ICE vehicle. In comparison, a relatively lower share of persons who are not considering an EV purchase somewhat/strongly agree that they would purchase an EV based on familiar maintenance processes.

b. The Repair and Maintenance Factors

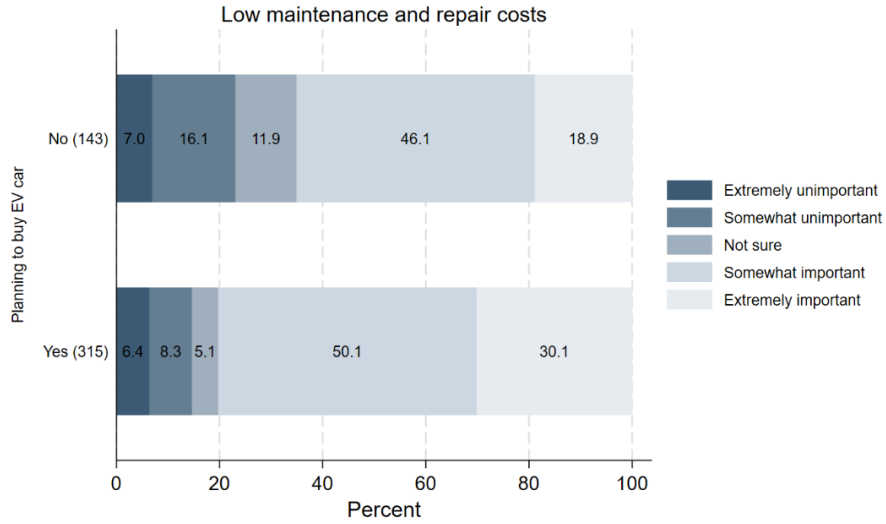


Figure 53: Perceived importance of low maintenance and repair costs among EV considerers and non-considerers

Figure 53 shows the importance of low maintenance and repair costs across different vehicle purchase plans. Figure 53 shows that 80.2% (50.1% + 30.1%) of respondents who are considering an EV purchase rate low maintenance and repair costs as somewhat (50.1%) or extremely (30.1%) important. In

comparison, a relatively lower share of persons not considering an EV purchase rate low maintenance and repair costs as somewhat/extremely important.

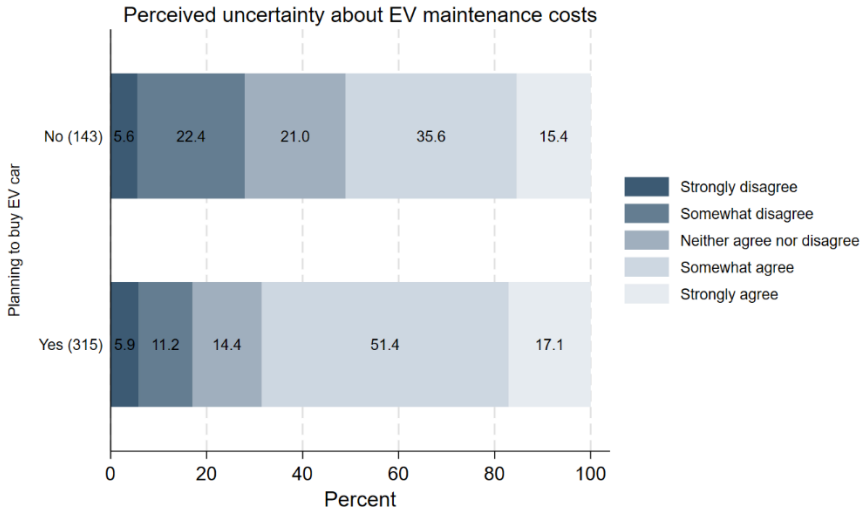


Figure 54: Perceived uncertainty about EV maintenance costs among EV considerers and non-considerers

Figure 55 shows the perceived uncertainty about EV maintenance costs across different vehicle purchase plans. Figure 55 shows that 68.5% (51.4% + 17.1%) of respondents considering an EV purchase somewhat (51.4%) or strongly (17.1%) agree they are unsure about how much EV car maintenance and repair would cost. In comparison, a relatively lower share of persons not considering an EV purchase somewhat/strongly agree that there is uncertainty about maintenance costs.

c. The CASE Framework

This section presents the results for the CASE framework proposed in the previous section. Figure 56 shows the EV purchase intention at price parity across different vehicle purchase plans. It shows that 76.5% (51.7% + 24.8%) of respondents, considering an EV purchase, somewhat (51.7%) or strongly (24.8%), agree they would purchase an EV if purchase prices were the same as for regular cars. In comparison, a relatively lower share of persons in the group who do not consider an EV purchase somewhat/strongly agree with the purchase intention at price parity.

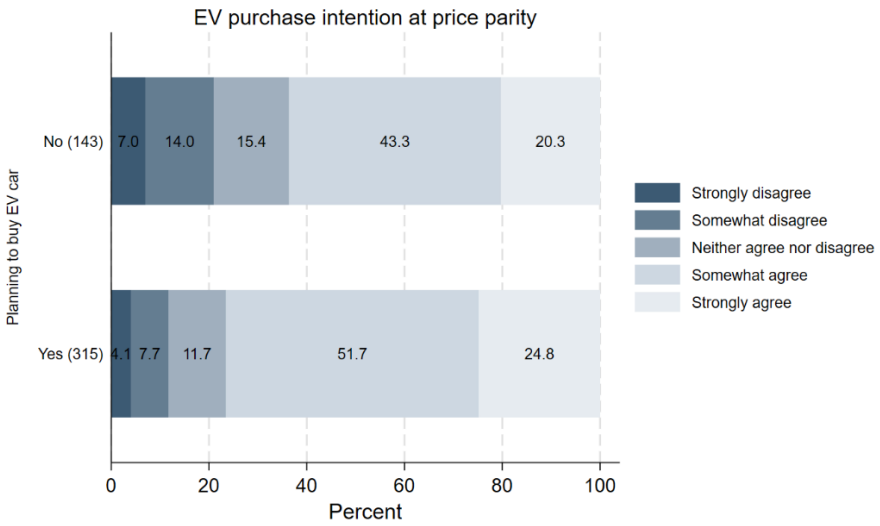


Figure 55: Likelihood of purchasing an EV if priced the same as an ICE car among EV considerers and non-considerers

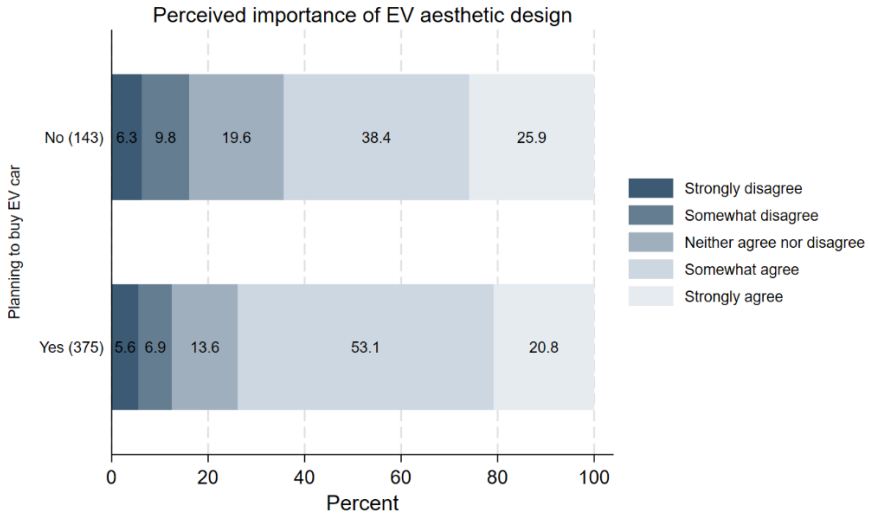


Figure 56: Perceived importance of EV aesthetic design among EV considerers and non-considerers

Figure 57 shows the perceived importance of EV aesthetic design across different vehicle purchase plans. It shows that 73.9% (53.1% + 20.8%) of respondents considering an EV purchase somewhat (53.1%) or strongly (20.8%) agree that aesthetic design is an important consideration when buying an EV. In comparison, a relatively lower share of persons not considering an EV purchase somewhat/strongly agree that aesthetic design is an important consideration.

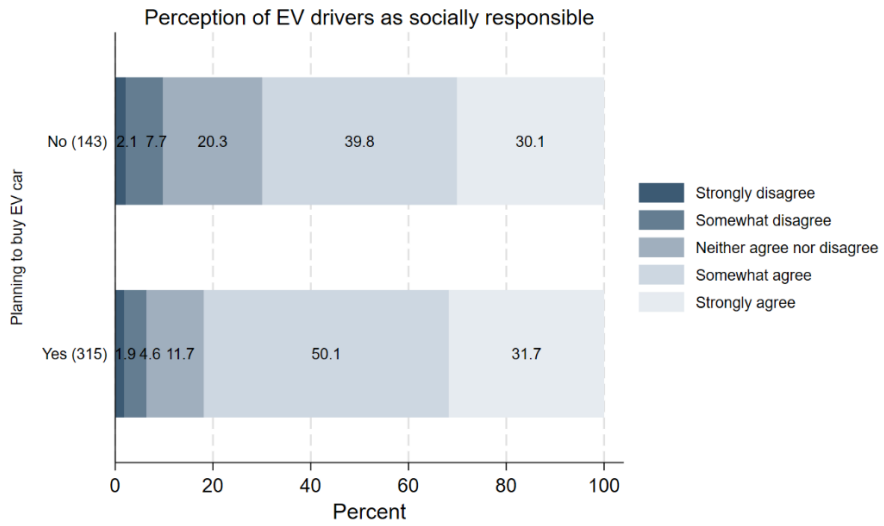


Figure 57: Perception of EV drivers as socially responsible among EV considerers and non-considerers

Figure 58 shows EV drivers' perception of being socially responsible across different vehicle purchase plans. It shows that 81.8% (50.1% + 31.7%) of respondents considering an EV purchase somewhat (50.1%) or strongly (31.7%) agree that EV drivers are socially responsible. In comparison, a relatively lower share of persons not considering an EV purchase somewhat/strongly agree with the perception of EV drivers as socially responsible.

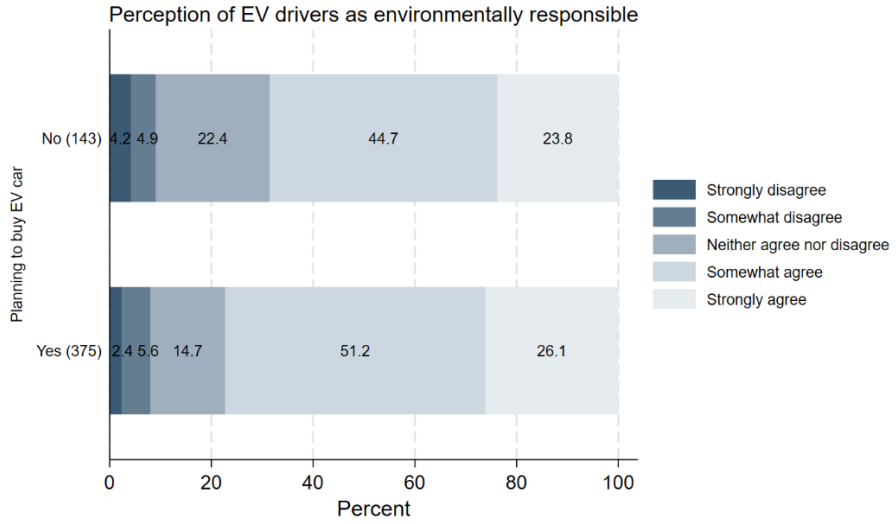


Figure 58: Perception of EV drivers as environmentally responsible among EV considerers and non-considerers

Figure 59 shows EV drivers' perception of being environmentally responsible across different vehicle purchase plans. Figure 59 shows that 77.3% (51.2% + 26.1%) of respondents considering an EV purchase somewhat (51.2%) or strongly (26.1%) agree that EV drivers contribute positively to the environment. In comparison, a relatively lower share of persons not considering an EV purchase somewhat/strongly agree with the perception of EV drivers as environmentally responsible.

d. The Cool Modern Image

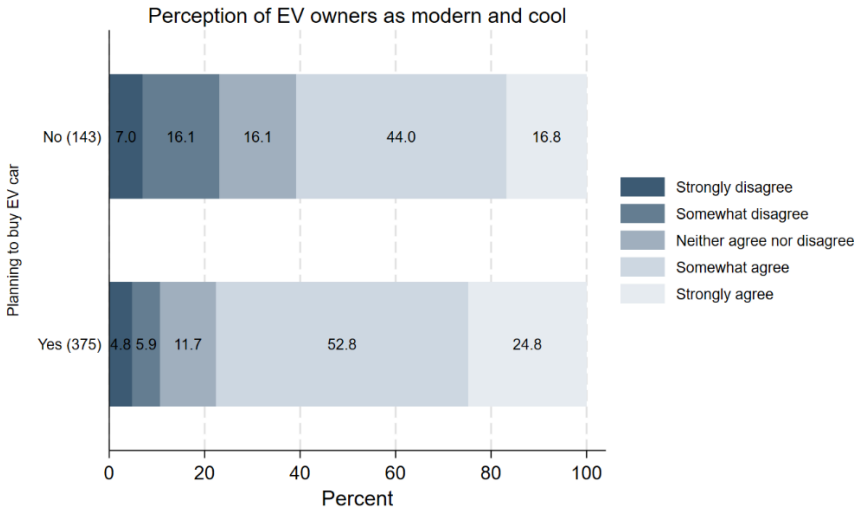


Figure 59: Perception of EV owners as modern and cool among EV considerers and non-considerers

Figure 60 shows that EV owners perceive their vehicles as modern and cool across different vehicle purchase plans. It shows that 77.6% (52.8% + 24.8%) of respondents who are considering an EV purchase somewhat (52.8%) or strongly (24.8%) agree that owning an EV would give a modern "cool" image. In comparison, a relatively lower share of persons not considering an EV purchase somewhat/strongly agree with the perception of EV owners as modern and cool.

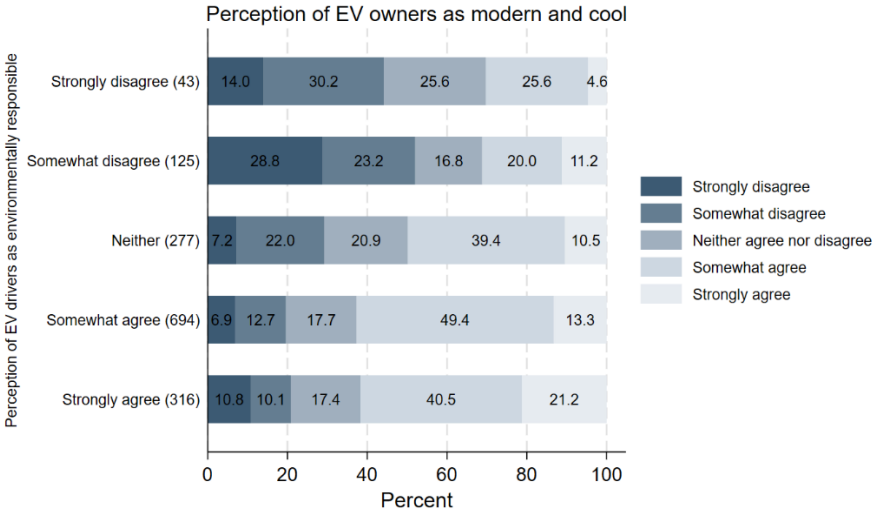


Figure 60: Perception of EVs as modern and cool among EV respondents due to perceived environmental benefits

Figure 61 shows that EV owners are perceived as modern and cool across different levels of environmental responsibility. It shows that 62.7% (49.4% + 13.3%) of respondents who somewhat agree that EV drivers contribute positively to the environment somewhat (49.4%) or strongly (13.3%) agree that owning an EV would give a modern "cool" image. In comparison, a relatively lower share of persons who do not agree that EV drivers are environmentally responsible somewhat/strongly agree with the modern "cool" perception.

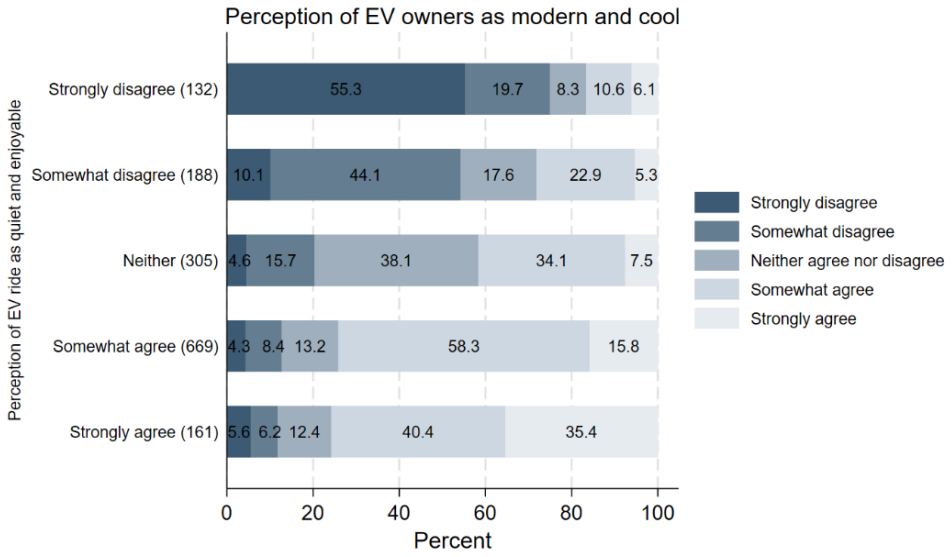


Figure 61: Perception of EVs as modern and cool among respondents due to perceived driving pleasure

Figure 62 shows the perception of EV owners as modern and cool across different levels of perception regarding the EV driving experience. It shows that 74.1% (58.3% + 15.8%) of respondents who somewhat agree that an EV ride is quiet and enjoyable somewhat agree (58.3%) or strongly agree (15.8%) that owning an EV would give a modern "cool" image. In comparison, a relatively lower share of persons who do not somewhat agree that an EV ride is quiet and enjoyable somewhat/strongly agree with the modern "cool" perception.

e. The Demographic Focus

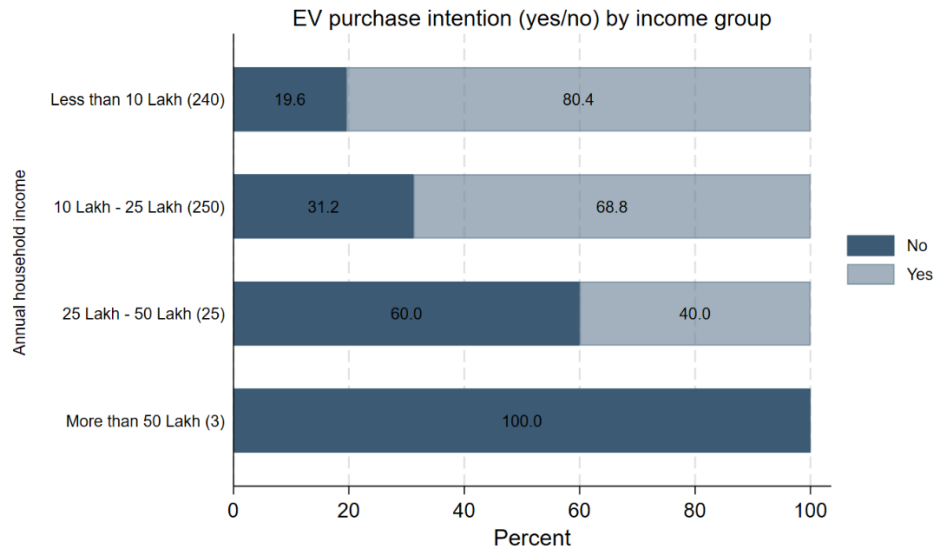


Figure 62: EV purchase intention across different household income levels

Figure 63 shows EV purchase intention by household income for ICE car-owning households. It shows that 80.4% of respondents in the low-income group (less than 10 Lakh) intend to purchase an EV. In comparison, a lower share of persons in the other income groups report an intention to purchase an EV.

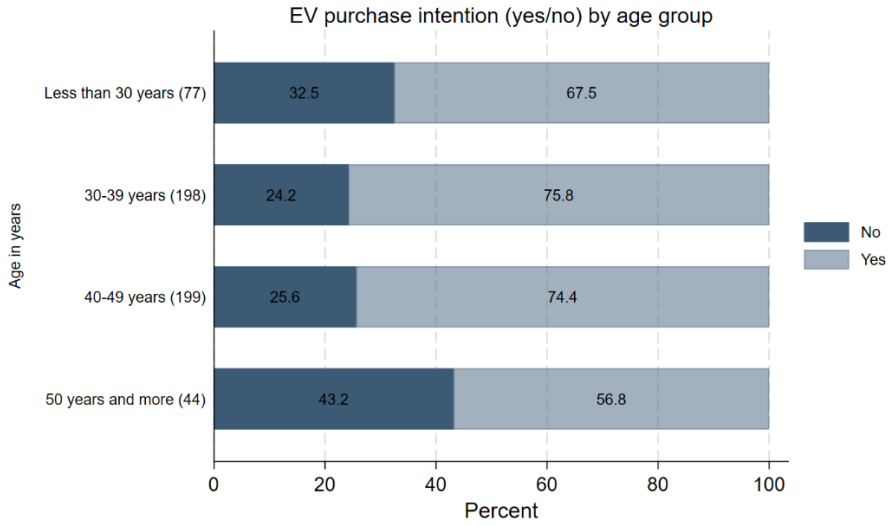


Figure 63: EV purchase intention across different age groups

Figure 64 shows EV purchase intention by age for ICE car-owning households. It shows that 75.8% of respondents aged 30-39 intend to purchase an EV. Similarly, 74.4% of respondents aged 40-49 intend to purchase an EV. In comparison, a lower share of persons in the other age groups report an intention to purchase an EV.

4. Key Insights about Potential EV Car Consumers in India

Pre-adoption households in urban India do not represent a single, homogeneous block of potential consumers. Instead, the findings suggest a stratified pre-adoption story where ownership status, income, and age fundamentally shape the cognitive evaluation of electric vehicles. While a shared environment of uncertainty exists, the journey towards EV adoption diverges early based on whether a household is entering the market for the first time or considering a switch from an existing ICE vehicle.

Information gaps, rather than a lack of intent or policy awareness, constitute the primary bottleneck for adoption. The data reveal that while awareness of government rebates and policies is high and relatively uniform across groups, a significant "translation gap" persists regarding product-level details. EV considerers in both groups report higher levels of uncertainty about resale value and maintenance processes than non-considerers. This suggests that while policy incentives facilitate initial interest, the transition to a purchase decision is stalled by a lack of trust in the long-term ownership uncertainty. This stacked uncertainty appears to shape hesitation in decision-making more strongly than any single barrier in isolation. The results, therefore, suggest that EV adoption barriers in the current Indian

context are better interpreted as multi-dimensional risk perceptions rather than isolated economic constraints.

Cross-tabulations show that respondents considering purchasing an EV often report equal or higher levels of concern across several dimensions than non-considerers in both carless and ICE-owning households. This pattern suggests that interest in EVs does not eliminate perceived risk. Instead, it increases evaluative scrutiny. Consideration appears to trigger deeper assessment of technology reliability, charging convenience, resale uncertainty, and policy adequacy. This indicates that the transition from interest to adoption is mediated by risk resolution rather than by awareness generation alone.

The EV adoption journey diverges significantly based on current ownership status. For carless households, the decision is primarily "system-led," dominated by concerns over charging availability, public infrastructure visibility, and information certainty. First-time buyers are evaluating whether the broader urban ecosystem will support their daily mobility. In contrast, for existing ICE owners, the decision is "product-led." These consumers benchmark EVs against their current vehicles on parameters of running costs, aesthetic design, performance, and resale value. For them, the transition is an experience-based evaluation of whether an EV is a superior replacement for a known technology.

Charging friction remains the most substantial psychological barrier, particularly for those already considering an EV. Concern about charging time is higher among EV considerers than non-considerers, suggesting that greater engagement with the idea of ownership heightens sensitivity to infrastructure gaps. Within the "Charging Aspects," a clear hierarchy emerged. While home charging and leisure activities were rated as important, potential EV consumers place a significantly higher emphasis on public charging visibility and information. This suggests that "range anxiety" is effectively "information anxiety" and the fear is not just running out of charge, but the inability to locate reliable public charging stations.

The meaning of "EV value" is rapidly evolving from a purely economic or ethical product to an aspirational one. Under the CASE framework (Cost, Aesthetic, Social, and Environmental), cost remains a dominant constraint. However, the gaps between considerers and non-considerers are widest in areas of social image and aesthetic design. Similar observation is noted in the "Cool Story," where nearly 75% of considerers in both carless and ICE-owning households view EVs as a modern status symbol. Notably, this "coolness" is increasingly driven by product-related factors, such as driving pleasure and tech image, rather than by environmental morality alone. This signals a transition in the Indian market from ethical or economical adoption to aspirational consumption.

Finally, demographic factors act as specific triggers for different segments. In carless households, age is the primary differentiator, with those in the 30-39 age group showing a unique "bulge" in consideration (62%). For existing ICE owners, income is the dominant factor, with lower-income households (<10 Lakh) showing the highest consideration (80%), likely driven by a combination of frustration with current ICE operating costs and an aspiration for a more modern, cost-effective vehicle. Ultimately, India’s EV transition is no longer lagging behind consumer intent. It is lagging in execution clarity. The challenge for policymakers and OEMs has shifted from convincing consumers of the EV’s benefits to supporting confident decision-making by providing demystified product information and reliable infrastructure.

5. Segmentation of Potential EV Car Consumers in India

5.1. Carless Households Considering Buying Their First Car

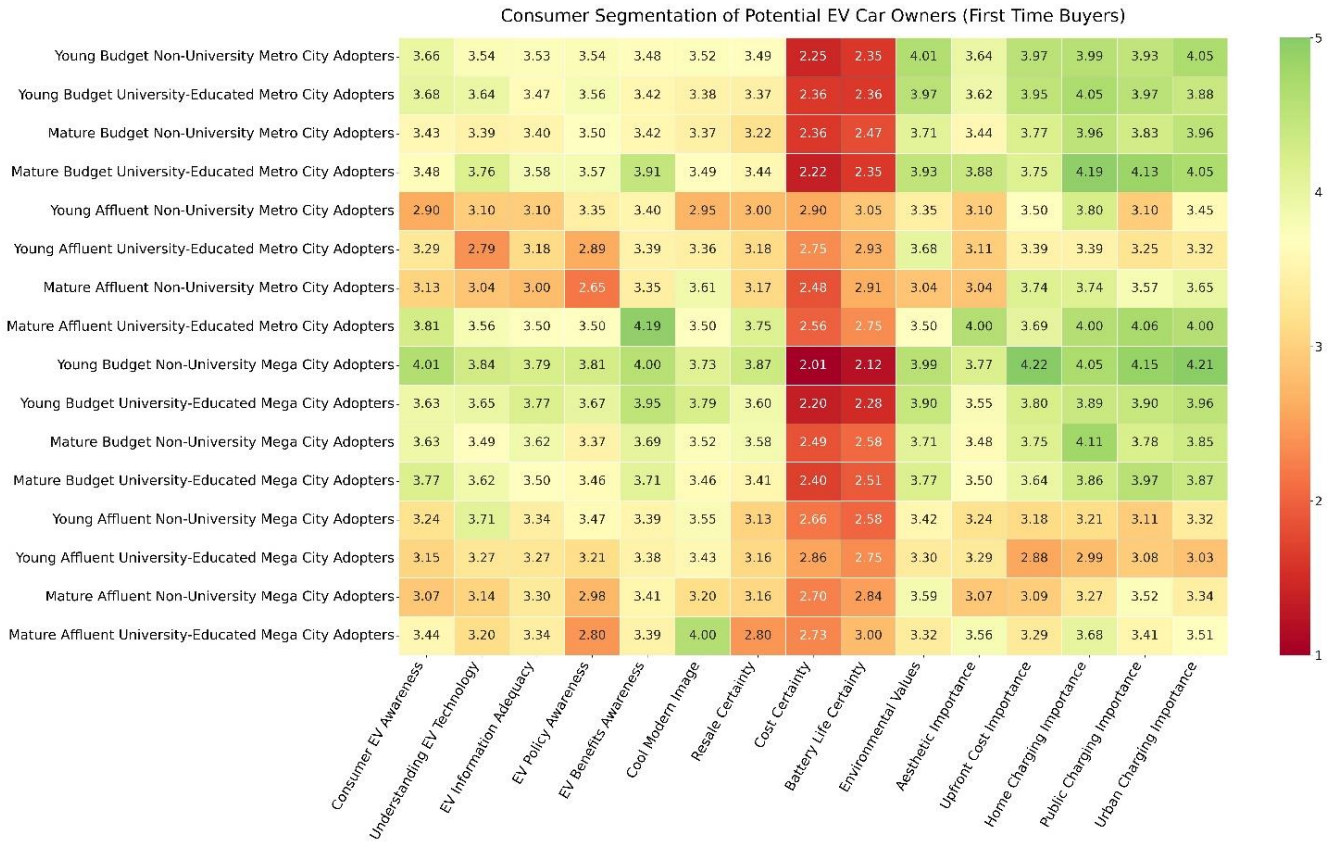


Figure 64: Consumer segmentation heatmap for first-time buyers showing mean Likert scores (1–5 scale) across demographic segments

This section presents customer segmentation based on data collected across selected themes from carless households considering their first car purchase. Figure 65 presents the consumer segmentation heatmap for first-time buyers. The values represent mean Likert scores (1–5 scale) for each construct across consumer segments, with higher values indicating greater awareness and importance. The consumer segments were pre-defined from the data based on 4 criteria:

Age: Young (below 40 years old); Mature (40 years old and above)

Income: Budget (less than 10 lakh per annum); Affluent (10 lakh and above per annum)

Education: University-Educated (Bachelor's or Master's); Non-University (Levels below Bachelor's)

City-Type: Mega-city (Mumbai, Delhi); Metro City (Bangalore, Hyderabad, Pune, Lucknow, Thiruvananthapuram, Bhubaneswar)

Note: Here, Public Charging refers to charging infrastructure available at publicly accessible or shared locations, such as malls, commercial complexes, workplace parking, and other public or semi-public

spaces. Meanwhile, urban charging refers to charging infrastructure across the city, including the availability and distribution of charging stations. Cost certainty refers to repair cost certainty.

Figure 65 shows that environmental values remain consistently high across all segments. For instance, Young Budget Non-University Mega-city adopters report a mean of 3.99, Mature Budget University-Educated Mega-city adopters report 3.77, and Young Budget Non-University Metro adopters report 4.01. It also shows that the importance of charging remains high. The importance of home charging ranges from 3.86 to 4.19 across 12 of the segments, while the importance of public charging ranges overall from 3.08 to 4.15. The importance of urban charging similarly remains higher, generally above 3.85 for most budget Mega-city segments.

Figure 65 further shows that perceived EV modernity remains strong across segments, with means ranging from 3.37 (Mature Budget Non-University Metro) to 4.00 (Mature Affluent University-Educated Mega-city). This indicates a relatively stable perception of EVs as technologically current across demographic groups. However, it also shows moderate deviation in awareness-related constructs. Perceived consumer awareness ranges from 2.90 (Young Affluent Non-University Metro) to 4.01 (Young Budget Non-University Mega-city). EV policy awareness ranges from 2.65 (Mature Affluent Non-University Metro) to 3.81 (Young Budget Non-University Mega-city). EV benefits awareness ranges from 3.35 (Mature Affluent Non-University Metro) to 4.19 (Mature Budget University-Educated Metro). It also shows that university-educated mega-city segments consistently score higher on awareness constructs than non-university metro-affluent segments.

Regarding uncertainty variables, Figure 65 shows that repair cost certainty remains relatively low across segments. Means range from 2.01 (Young Budget Non-University Mega-city) to 2.90 (Young Affluent Non-University Metro). Battery life certainty similarly ranges from 2.12 (Young Budget Non-University Mega-city) to 3.05 (Young Affluent Non-University Metro). Resale certainty ranges between 2.80 and 3.87 across segments, indicating moderate but not uniformly strong certainty.

Segment-wise, Young Budget Mega-city adopters consistently report higher scores across awareness, environmental values, charging importance, and EV modernity than other segments. In contrast, Mature Affluent Non-University Metro adopters show comparatively lower consumer awareness (3.13), policy awareness (2.65), and moderate uncertainty confidence levels.

5.2. Households Owning an ICE/Hybrid Car and Considering Switching to/Adding an EV Car

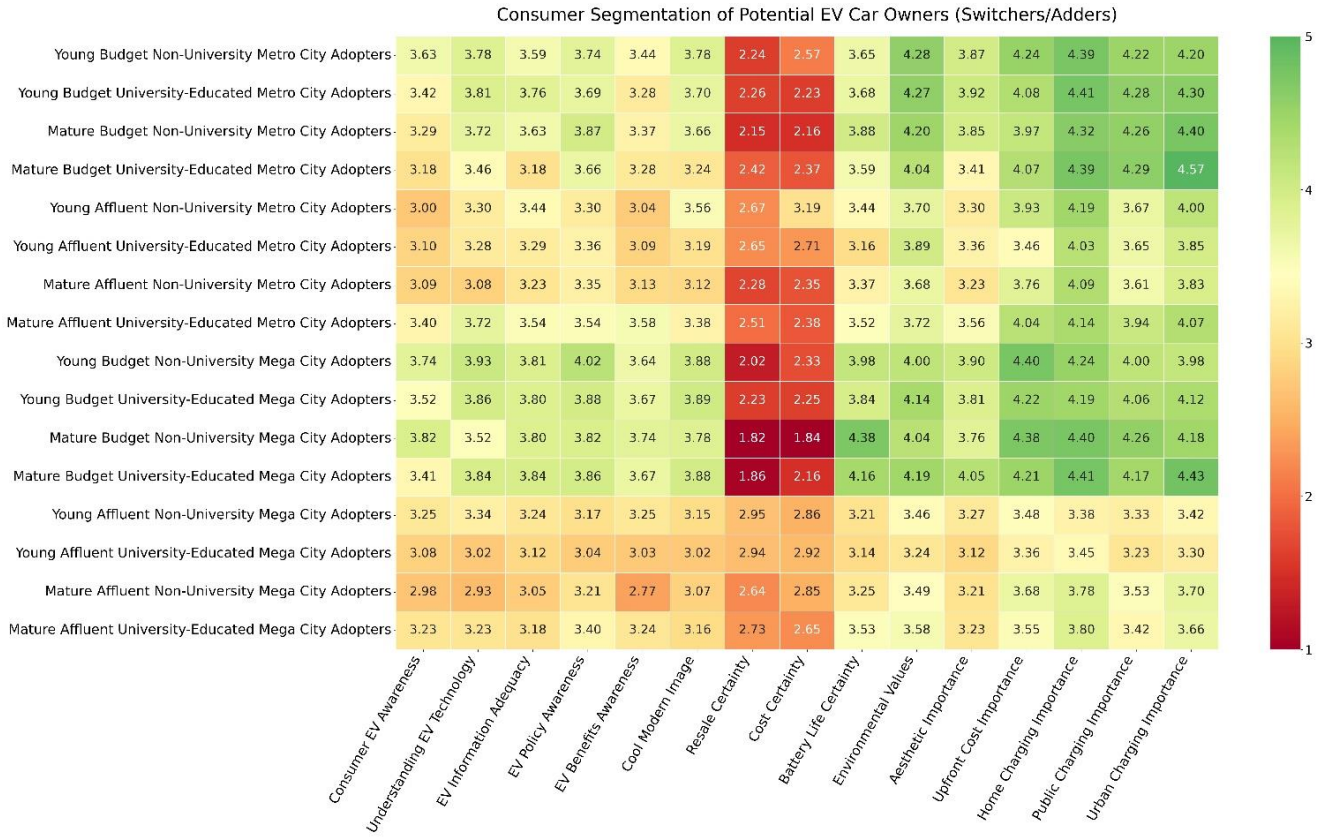


Figure 65: Consumer segmentation heatmap for switchers/adders showing mean Likert scores (1–5 scale) across demographic segments

Figure 66 presents the segmentation heatmap for households that already own an ICE/hybrid car and are considering switching to/adding an EV, constructed using the same methodology and reverse-coding logic as in the previous sub-section.

Figure 66 shows that environmental values remain high across segments, with most means above 3.70. For example, Young Budget Non-University Mega-city adopters report 4.00, Mature Budget University-Educated Mega-city adopters report 4.19, and Young Budget Non-University Metro adopters report 4.28. It also shows that the importance of charging remains high across all segments. Public charging importance ranges between 3.23 and 4.29 across segments, while home charging importance frequently exceeds 4.00 among budget mega-city groups and all metro city groups.

Figure 66 further shows that EV's modern image remains strong, with means ranging from 3.02 (Young Affluent University-educated Mega-city) to 3.89 (Young Budget University-educated Mega-city). Additionally, the importance of upfront cost remains relatively high across, frequently reported above 3.80. Awareness-related construction again shows differentiation. Consumer awareness ranges from 2.98 (Mature Affluent Non-University Mega-city) to 3.82 (Mature Budget Non-University Mega-city). EV policy awareness ranges from 3.17 (Young Affluent Non-University Mega-city) to 4.02 (Young

Budget Non-University Mega-city). EV benefits awareness similarly remains stronger among university-educated mega-city segments.

Regarding uncertainty variables, Figure 66 shows that repair cost certainty remains comparatively lower, particularly among mega-city budget groups (1.84–2.33). Battery life certainty ranges from 3.14 (Young Affluent University-educated Mega-city) to 4.38 (Mature Budget Non-University Mega-city), indicating improved confidence among specific metro budget segments. Resale certainty is low overall, ranging from 1.82 to 2.95 across segments.

Segment-wise, Figure 66 shows that Young Budget Mega-city and Mature Budget Mega-city adopters consistently report higher environmental values (around 4.00–4.19), higher importance of charging (above 4.20 in multiple cases), and relatively stronger awareness than affluent metro segments. In contrast, Mature Affluent Non-University Metro adopters show lower awareness (2.98–3.21 range) and comparatively moderate uncertainty confidence.

5.3. Insights and Targeted Implications from Consumer Segmentation Analysis of Potential EV Car Consumers

The combined analysis of Figures 65 and 66 shows that environmental alignment remains a strong construct across both first-time buyers and switchers/adders. For first-time buyers, environmental values fall within the 3.71–3.99 range across most budget mega-city segments. For switchers/adders, environmental values frequently exceed 4.00, like among Young Budget Non-University Mega-city adopters (4.00) and Mature Budget University-Educated Mega-city adopters (4.19). It is evident that the importance of charging, particularly public and home charging, remains high and, in many cases, above 4.00 across mega-city budget segments for both first-time buyers and switchers/adders. This suggests that charging infrastructure remains a significant consideration in EV purchase decisions within the sampled population.

However, awareness-related constructs are unevenly distributed. In first-time car buyers, consumer awareness ranges from 2.90 (Young Affluent Non-University Metro) to 4.01 (Young Budget Non-University Mega-city), while EV policy awareness ranges from 2.65 to 3.81 across segments. In terms of switchers/adders, similar variation persists, with policy awareness ranging from 3.17 (Mature Affluent Non-University Mega-city) to 4.02 (Young Budget Non-University Mega-city). Additionally, awareness of EV benefits often remains higher among university-educated mega-city segments than among non-university, metro-city affluent groups. This shows that informational asymmetry continues to segment the market primarily by education and geography.

It further observed that certainty-related constructs remain comparatively weaker than environmental and charging variables. For first-time car buyers, repair cost certainty ranges from 2.01 to 2.90 across segments, and battery life certainty ranges from 2.12 to 3.05. For switchers/adders, repair cost certainty remains between 1.84 and 2.92 across several mega-city segments, while battery life certainty ranges from 3.14 to 4.38, depending on the group. It is also seen that resale certainty remains low, generally between 1.81 and 2.95. This indicates that systemic uncertainty, particularly regarding repair and resale value, continues to create friction for adoption.

Segment-level comparisons further show that Young and Mature Budget Mega-city segments consistently exhibit high environmental values, strong importance of charging (often 4.20 or above for switchers/adders), and comparatively higher awareness levels. In contrast, Mature Affluent Non-University Metro segments report comparatively lower scores on consumer awareness, policy awareness, and uncertainty-confidence measures across both first-time buyers and switchers/adders cohorts. It is noted that university education systematically elevates awareness and policy understanding scores across both mega-city and metro contexts.

Thus, the segmentation results show that EV adoption is not characterized by ideological resistance but by barriers to information, infrastructure readiness, and confidence in the product. It is also observed that mega-city budget segments appear more prepared to buy an EV, driven by strong environmental alignment and high infrastructure visibility, combined with moderate-to-high awareness. Additionally, affluent non-university metro segments appear information-constrained and moderately uncertainty-sensitive, indicating a need for targeted communication and assurance mechanisms rather than broader normative persuasion.

It is therefore noted that policy and industry interventions may require differentiated approaches for improving EV adoption in India. For segments with high environmental values but moderate confidence in uncertainty estimates, interventions focused on extended warranties, battery performance transparency, and standardized resale guarantees may reduce initial hesitation. For segments showing lower awareness and policy understanding, simplified communication channels and dealership-level advisory reinforcement may improve informational adequacy. It is also worth noting that visibility and signaling of charging infrastructure remain universally relevant, given consistently high importance scores across segments.

6. Exploring Post-Adoption Experiences Among Existing EV Car Owners in Urban India

6.1. Context and Motivation

Understanding the determinants of EV adoption is crucial to designing policies that mitigate barriers to adoption. However, it is also crucial to understand the challenges faced by those who have already purchased EVs and intend to keep them for the long term. The EV adoption journey is incomplete if adoption is not for the long term. Hence, this section aims to develop a questionnaire to help understand the concerns of existing EV car users in India.

The Indian government is aggressively supporting the manufacturing and sales of EVs through policies such as the National Electric Mobility Mission Plan (2020) and FAME-I & II. However, as in other developing countries, the situation is the same in India, where EV car sales accounted for only 2.5% of total car sales in 2024 (Amir, 2025; India Brand Equity Foundation, 2025). Moreover, even among those who have purchased EV cars, the majority of them in India are regretting their purchase, showing dissatisfaction with their EV car due to difficulty in maintenance and service, lower resale value, and charging anxiety, and want to switch to a fuel-based vehicle (D'Cruze, 2024; The Economic Times, 2024). Such a continued trend of switching could be a major setback for our EV promotion goals.

Hence, it is essential to understand the challenges faced by existing EV car users so that policies can be designed to retain existing consumers and promote long-term EV adoption in India.

Most prior studies, both globally and in India, have examined EV purchase intentions and adoption barriers (Bhat & Verma, 2025; Krishna, 2021; Miele et al., 2020; Okada et al., 2019; Tarei et al., 2021). However, the literature is scant on EV users globally, especially in India. Some prior studies have analyzed it, but most have been conducted in the global north (Cruz-Jesus et al., 2023; Parthasarathy & Lassar, 2023). However, given the growth of the EV market in India, understanding the challenges faced by existing EV users and designing strategies to retain them in the long term are important for an effective transition to EVs. Hence, this section aims to develop a questionnaire to systematically understand those challenges.

6.2. Literature Review and Questionnaire Design for Understanding the Experiences of Existing EV Car Owners

In 2024, only 2.5% of total car sales were EVs (Amir, 2025), and the government of India aims to increase these sales to 30% by 2030 through the EV30@30 initiative. However, why did these people choose an EV over an ICE vehicle? Or bought both? Parthasarathy & Lassar (2023) argued that these are people with innovative attributes who want to try the latent technology first. However, media reports (D'Cruze, 2024; The Economic Times, 2024) show that many are dissatisfied with their purchase and want to switch back. If even among 2.5% of adopters there is dissatisfaction, retaining this number in the long term would be challenging.

To understand the challenges faced by existing EV car users, we drew on both theoretical insights and media reports. Apart from the factors mentioned above regarding EV adoption, it has also been argued that EV adopters purchased an EV (rather than an ICE/hybrid car) for five reasons (Parthasarathy & Lassar, 2023). The first is relative advantage (i.e., being functionally and technologically superior) compared to existing ICE/hybrid cars. The second is compatibility, which assesses how well the EV car meets the adopter's travel needs. The third is complexity, i.e., how difficult it is to learn to drive and use an EV. The fourth is observability, that is, how visible the EV is in the market and how advertising promotes it; and lastly, trialability, which is the extent to which the EV can be tested on a limited basis. Thus, we can argue that after purchase (and use), if they do not find a relative advantage, compatible enough to meet travel needs (e.g., driving range issues), or difficulty in use, they may regret their purchase and may show an intention to switch back to ICE/hybrid cars/previous travel modes (potential discontinuers). However, many might be enjoying their EVs and want to continue using them (continuers), while some might have switched from EVs to ICE/hybrid cars/previous travel modes (discontinuers). Thus, EV car users can be classified into these three groups (continuers, potential discontinuers, and discontinuers). We incorporated questions on these five factors into our questionnaire to explore them across three groups of EV users.

To explore the above factors further, we incorporated questions about the factors current EV users considered before purchase. These include environmental and health-related factors (such as less pollution by EVs), performance-related factors (such as the convenience of charging at home, less noise, instant acceleration, etc.), policy-related factors (such as government incentives), cost-related

factors (such as no fuel costs), and social image-related factors (such as driving an EV looks cool and modern) (Bhat et al., 2024; Sahoo et al., 2022; X. Zhao et al., 2024).

To understand their EV use (frequency and distance traveled) compared with other vehicles (if any) or public transit, we incorporated usage-related questions (Li & Liu, 2014; Parthasarathy & Lassar, 2023). We also sought to understand factors that could frustrate EV car users, such as long charging times, difficulty finding local mechanics for repairs, and performance issues (D'Cruze, 2024; Susskind, 2004; The Economic Times, 2024; Yadav, 2023). We also included questions related to their satisfaction with their EV car in general and in relation to various aspects of EV ownership (such as cost of ownership, repairs and maintenance, vehicle performance, charging at home, charging outside the home, and environmental impact) (D'Cruze, 2024; Hasan, 2021; Parthasarathy & Lassar, 2023; The Economic Times, 2024; D. Zhao et al., 2024). Finally, we incorporated questions to explore whether supportive technologies and services (such as apps for learning about and using EVs, or apps/systems for monitoring car performance and charging) help increase EV utilization and satisfaction (Li & Liu, 2014; Sharma, 2025). Besides, dissatisfaction and concerns of one EV car user may influence the usage and satisfaction of other users. We have also incorporated questions to understand how negative word of mouth affects utilization and satisfaction (Chu, 2023; Ismagilova et al., 2020; Laczniak et al., 2001; Parthasarathy & Lassar, 2023; Richins, 1983; Sahoo et al., 2022). Together, these factors could help us understand why some EV users intend to switch back and why they are not satisfied. This understanding helps us design strategies and policies to mitigate these challenges and boost long-term EV car adoption.

6.3. Description of Data Obtained from Existing EV Owners

This section describes the collected data thematically. Figure 67 shows the socio-demographics of the sampled households. It shows that 52.8% of the sampled households earn 10-25 lakh INR annually, and 65.6% of households have a household size of 3–5 members. It also shows that 91.2% of the respondents are male. It further shows that the highest percentage of the respondents is in the 30–39 years age group, at 36.9%. Additionally, 60.1% of the respondents hold a bachelor's degree. 86.4% of the respondents are married.

Figure 68 shows that 35.0% of the sampled households have solar panel systems.

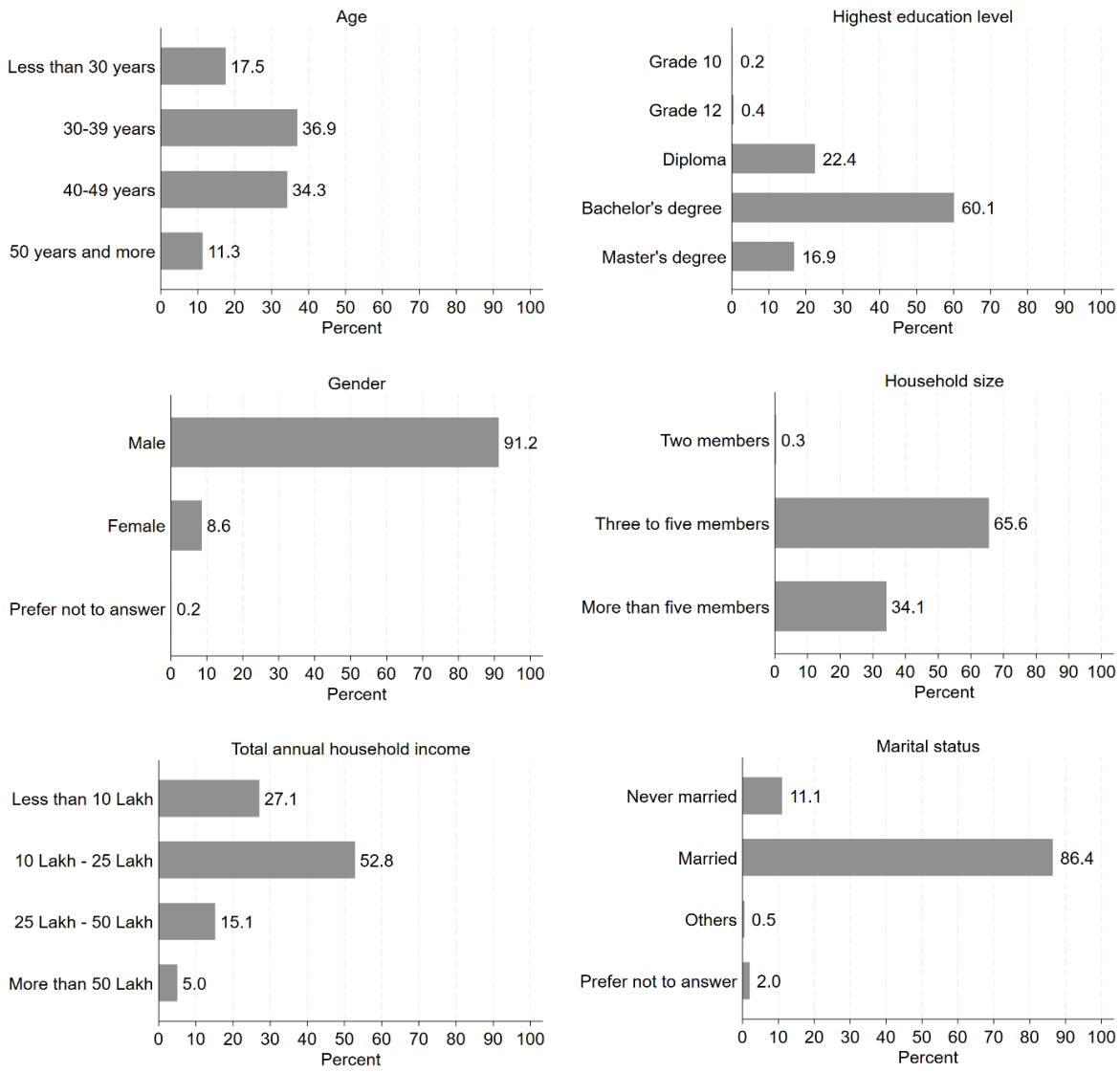


Figure 66: Socio-Demographic Characteristics of the Sampled Households

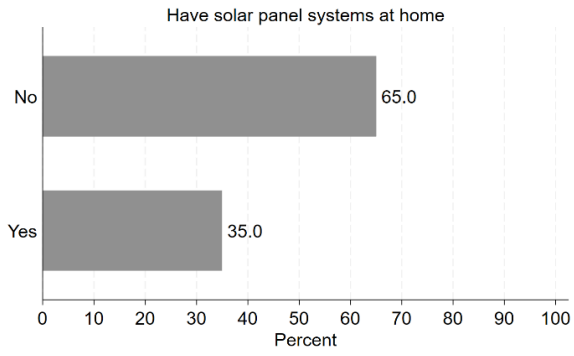


Figure 67: Solar Panel Ownership Among Sampled Households

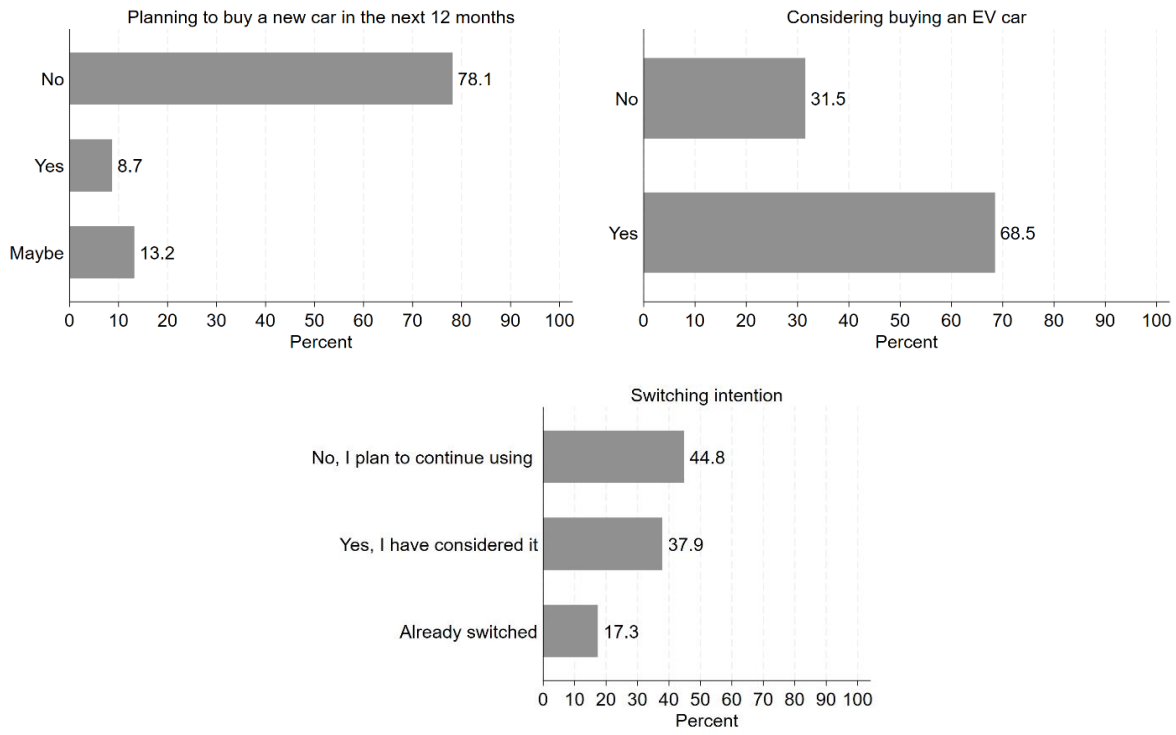


Figure 68: EV Continuation, Switching Intentions, and Future Purchase Plans

Figure 69 shows the respondents' vehicle purchase plans and switching intentions. Here, switching intentions refer to whether an EV car owner wants to continue using his/her EV car (continuers), consider switching back to his/her previous mode of travel (potential discontinuers), or has already switched from his/her EV car (discontinuers). Figure 69 shows that 44.8% of respondents plan to continue using their EVs. It also shows that 8.7% of the sampled respondents plan to buy a new car in the next 12 months, or are considering it (13.2%). It further shows that among those planning or considering buying a new car, 68.5% want to buy an EV car.

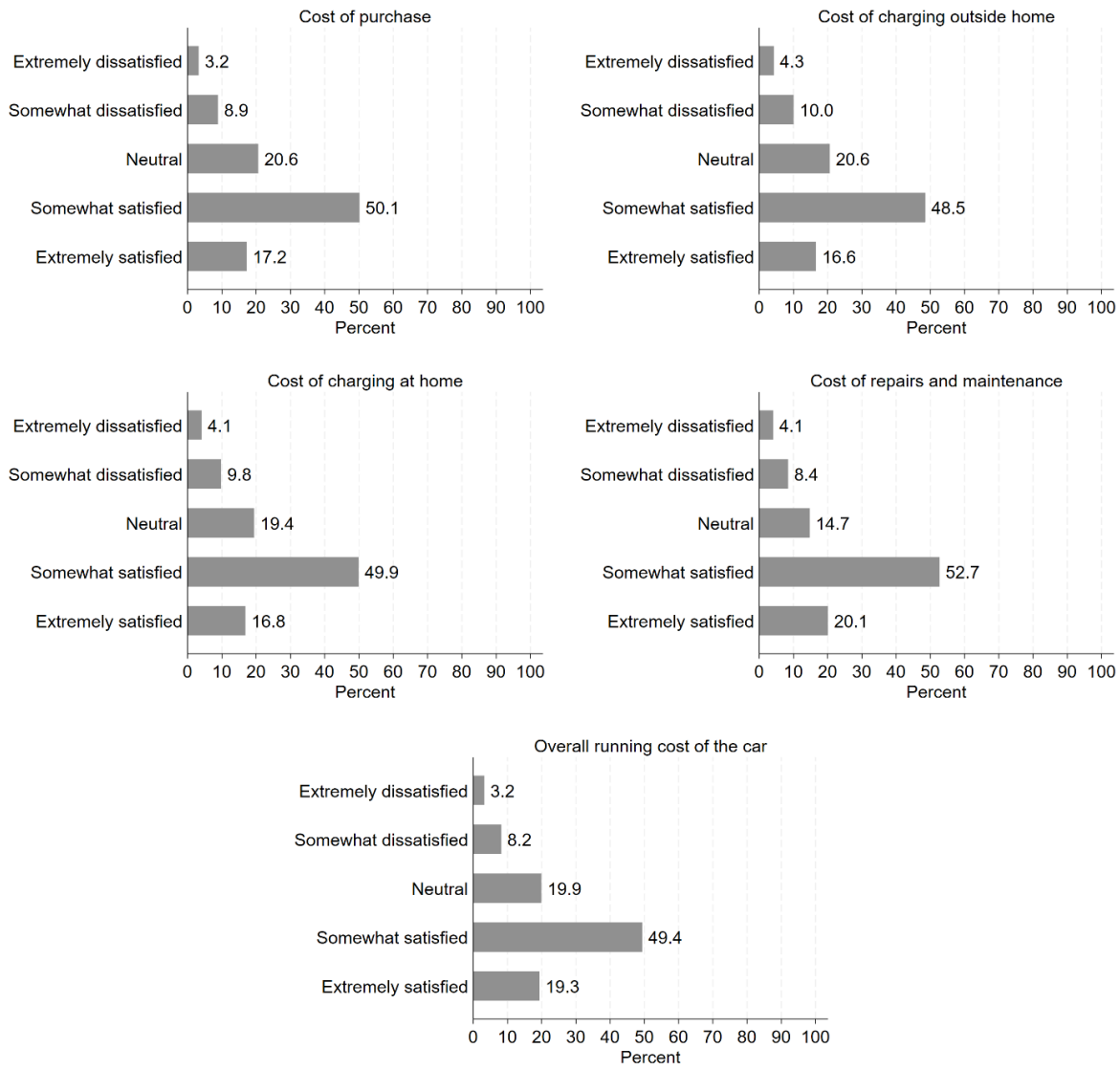


Figure 69: Satisfaction with Cost Aspects of EV Car Ownership

Figure 70 shows the satisfaction levels across various cost aspects of EV car ownership. It shows that 67.3% (50.1% + 17.2%) of respondents are somewhat/extremely satisfied with the purchase cost. It also shows that 65.1% (48.5% + 16.6%) of the respondents are somewhat/extremely satisfied with the cost of charging outside the home. It further shows that 66.7% (49.9% + 16.8%) of the respondents are somewhat/extremely satisfied with the cost of charging at home. Additionally, Figure 70 shows that 72.8% (52.7% + 20.1%) of the respondents are somewhat/extremely satisfied with the cost of repairs and maintenance. Further, it shows that 68.7% (49.4% + 19.3%) of the respondents are somewhat/extremely satisfied with the overall running cost of the car.

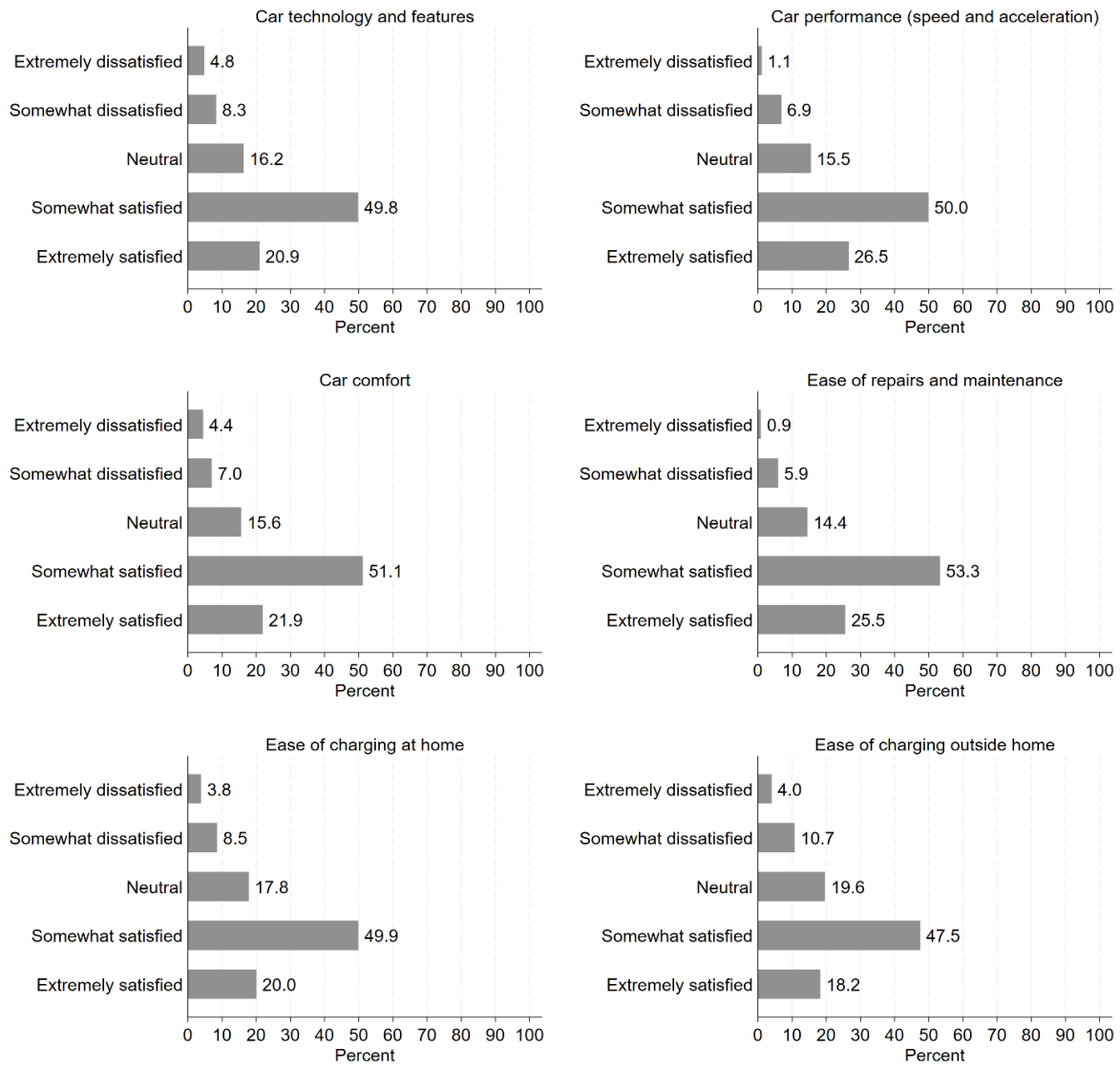


Figure 70: Satisfaction with Operational and Daily Use Aspects of EV Ownership

Figure 71 shows the satisfaction levels across various aspects of daily EV car use. It shows that 70.7% (49.8% + 20.9%) of respondents are somewhat/extremely satisfied with car technology and features, and 76.5% (50.0% + 26.5%) are somewhat/extremely satisfied with car performance. It also shows that 73.0% (51.1% + 21.9%) of respondents are somewhat/extremely satisfied with car comfort. Additionally, Figure 71 shows that 78.8% (53.3% + 25.5%) of respondents are somewhat/extremely satisfied with the ease of repair and maintenance. Further, 69.9% (49.9% + 20.0%) of respondents are somewhat/extremely satisfied with the ease of charging at home, and 65.7% (47.5% + 18.2%) are somewhat/extremely satisfied with the ease of charging outside the home.

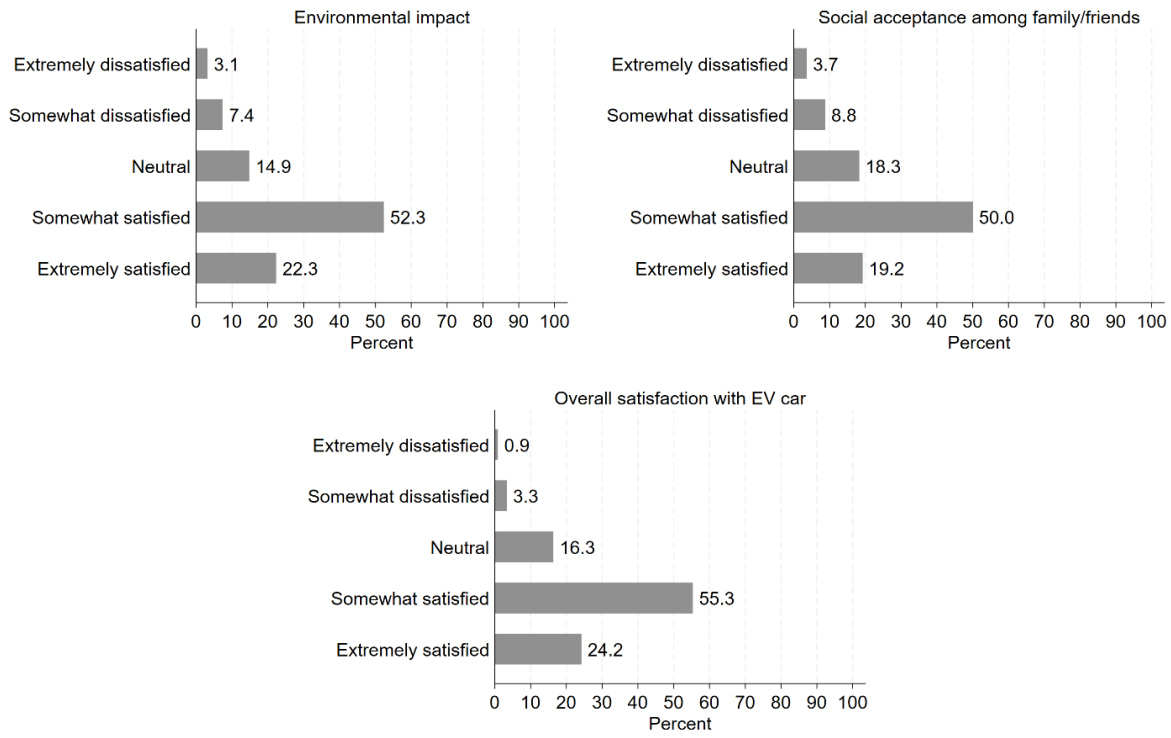


Figure 71: Satisfaction with Environmental, Social, and Overall Aspects of EV Ownership

Figure 72 shows respondents' satisfaction levels with their EVs across environmental, social, and overall dimensions. It shows that 74.6% (52.3% + 22.3%) of respondents are somewhat or extremely satisfied with the environmental impact of their EV car. It also shows that 69.2% (50% + 19.2%) of respondents are somewhat or extremely satisfied with the social acceptance of their EV car among family and friends. Finally, it shows that 79.5% (55.3% + 24.2%) of the respondents are somewhat or extremely satisfied with their EV.

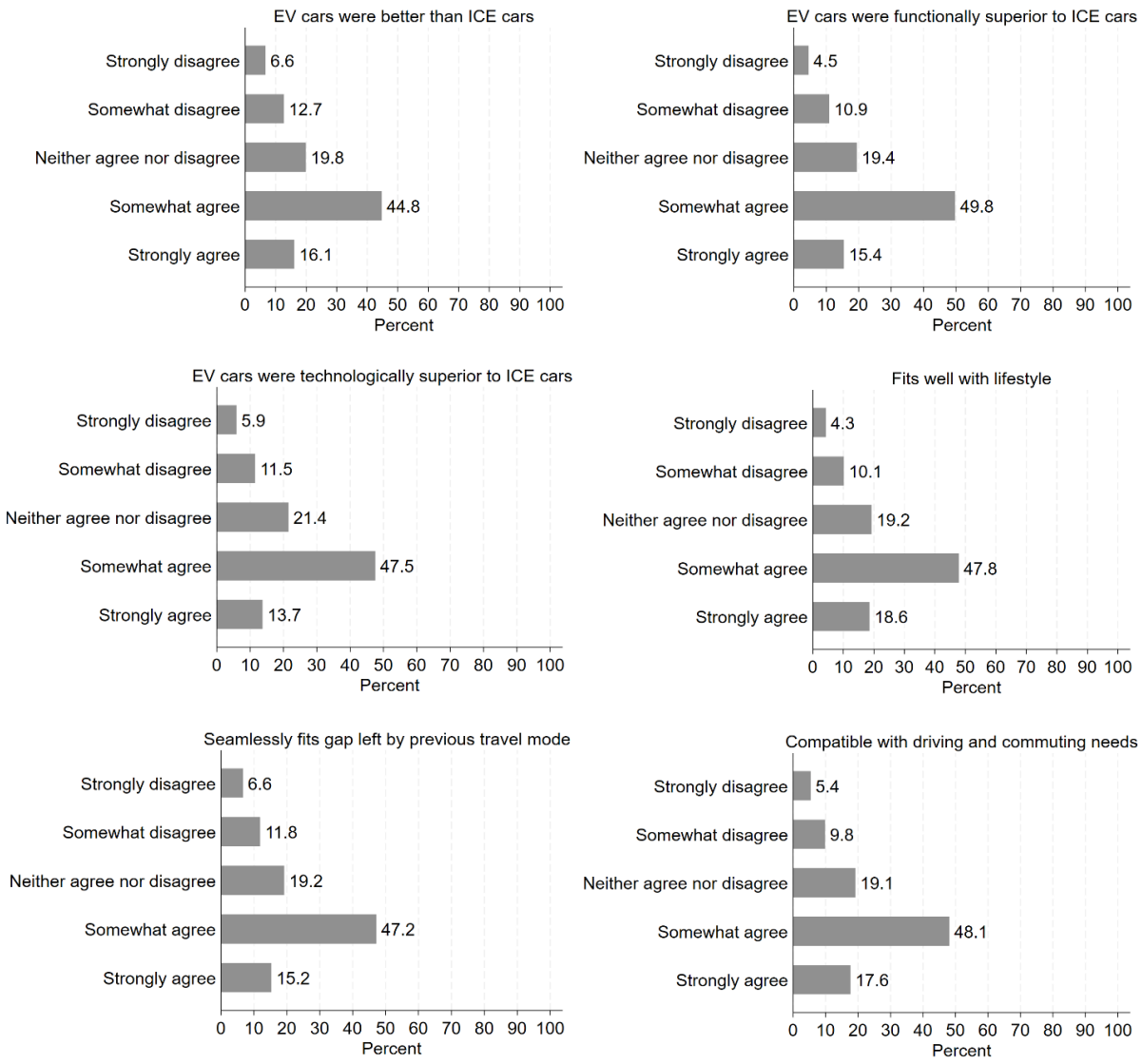


Figure 72: Perceived Relative Advantage and Compatibility of EVs During Adoption

Figure 73 shows respondents' perceptions of their EV car at the time of purchase, in terms of its relative advantage and compatibility. It shows that 60.9% (44.8% + 16.1%) of respondents somewhat/strongly agree that they perceive EV cars as better than ICE cars. It also shows that 65.2% (49.8% + 15.4%) of respondents somewhat/strongly agree that they perceive EV cars as functionally superior, and 61.2% (47.5% + 13.7%) somewhat/strongly agree that they perceive EV cars as technologically superior to ICE cars. 66.4% (47.8% + 18.6%) of respondents somewhat/strongly agree that EV cars would fit well with their lifestyle. It also shows that 62.4% (47.2% + 15.2%) of the respondents somewhat/strongly agree that they thought EV cars would seamlessly fit into the gap left by their previous travel mode (such as an ICE car or public transport), and 65.7% (48.1% + 17.6%) of the respondents somewhat/strongly agree that EV cars would be compatible with their driving/commuting needs.

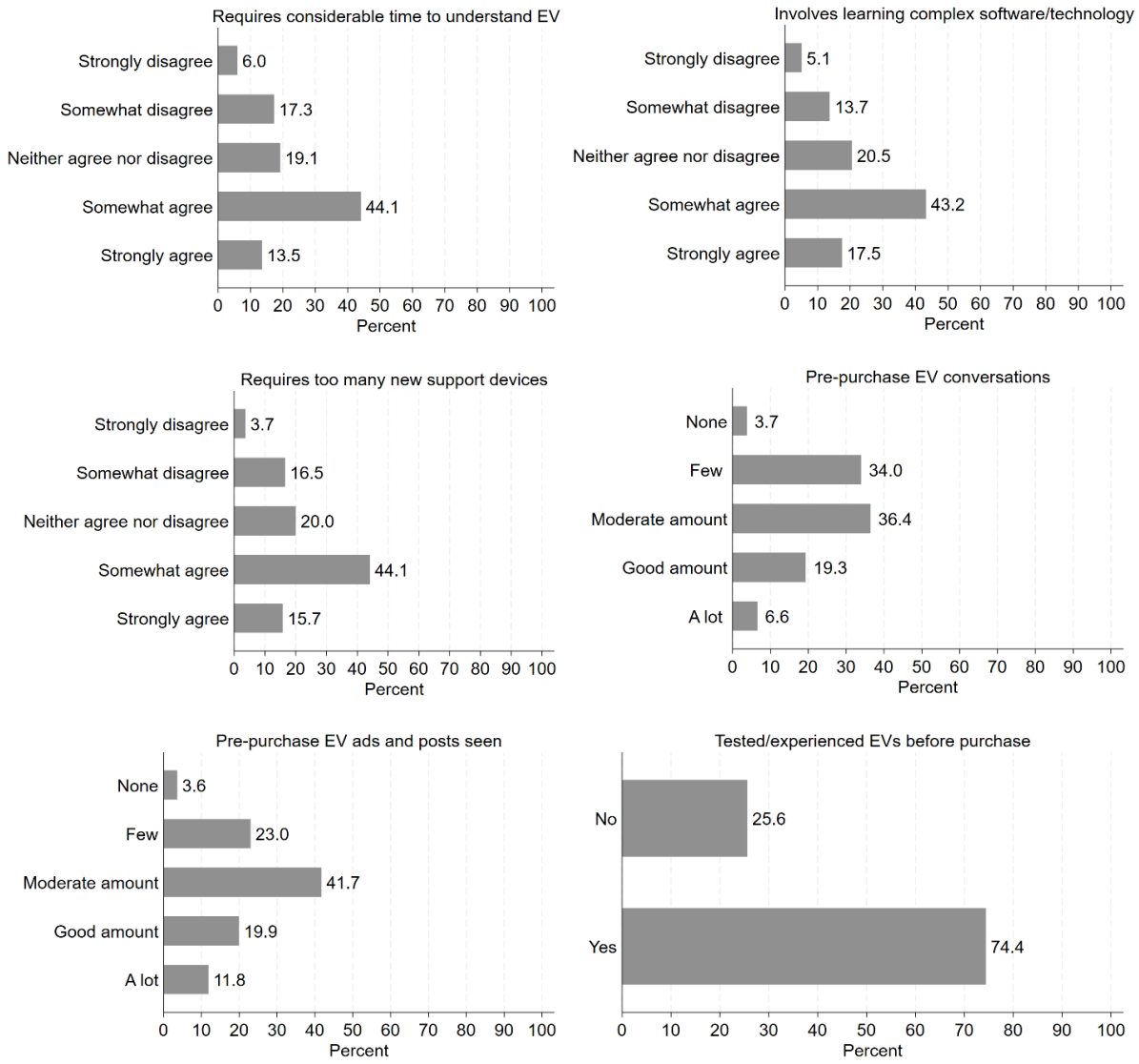


Figure 73: Perceived Complexity and Communication Channels During EV Adoption

Figure 74 shows respondents' perceptions of their EV at the time of purchase, including the complexity of their EV and the roles of media, conversations, and test drives in their purchase decision. It shows that 57.6% (44.1% + 13.5%) of the respondents somewhat/strongly agree that they thought the EV car would require considerable time to understand the technology, 60.7% (43.2% + 17.5%) somewhat/strongly agree that they thought it would involve learning complex software and technology, and 59.8% (44.1% + 15.7%) somewhat/strongly agree that they thought it would require too many new support devices (e.g., chargers) to function properly. 25.9% (19.3% + 6.6%) of respondents had a good number/a lot of personal conversations with other individuals about EV cars, and 31.7% (19.9% + 11.8%) of respondents saw a good number/a lot of media advertisements and informational posts about EV cars in mass media or on the internet before their own EV purchase. Additionally, 74.4% of respondents had tested or experienced EV cars before purchase.

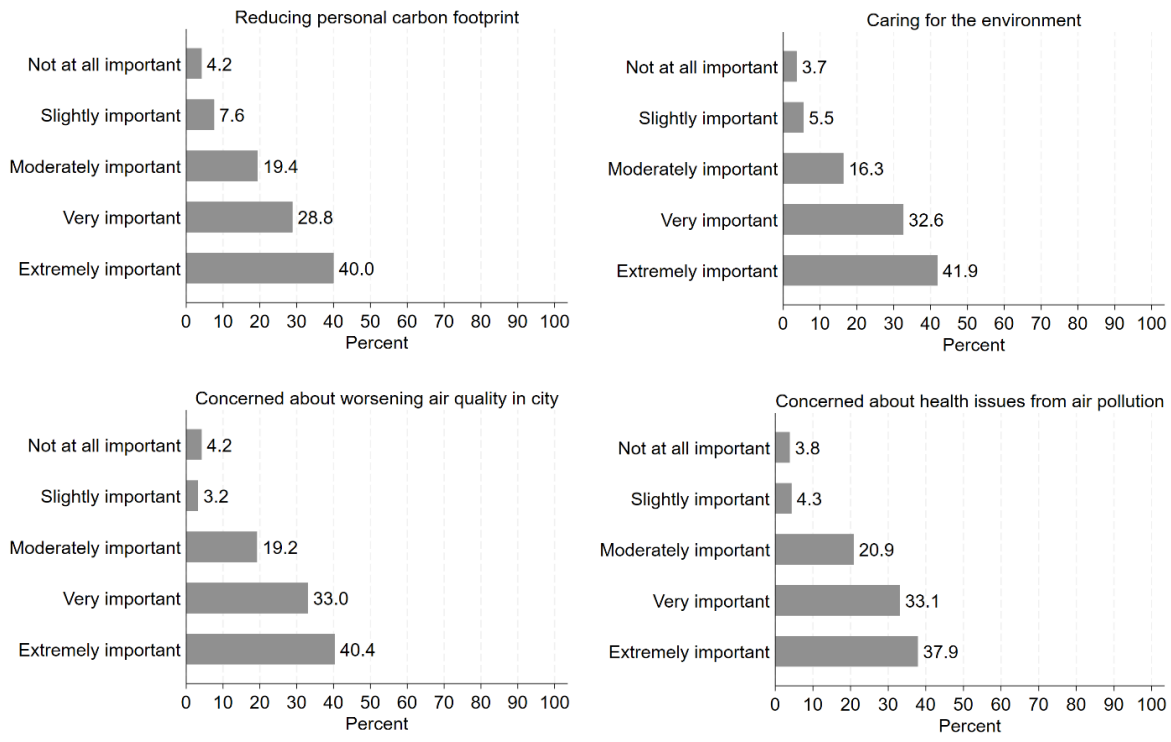


Figure 74: Environmental and Health-Related Motivations During EV Adoption

Figure 75 shows respondents' environmental and health-related reasons for purchasing their first EV. It shows that 68.8% (40.0% + 28.8%) of the respondents rated reducing their personal carbon footprint as extremely or very important, 74.5% (41.9% + 32.6%) rated caring for the environment as extremely or very important, 73.4% (40.4% + 33.0%) rated being concerned about worsening air quality in the city as extremely or very important, and 71.0% (37.9% + 33.1%) rated being concerned about health issues from air pollution as extremely or very important.

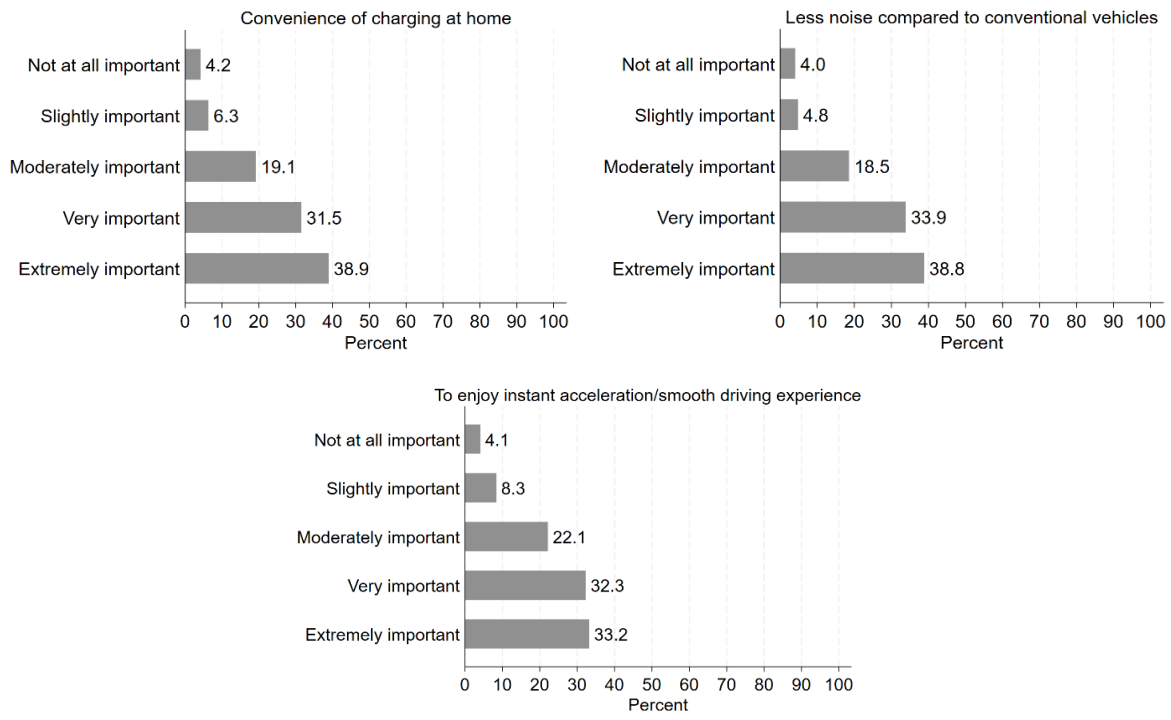


Figure 75: Convenience and Performance-Related Motivations During EV Adoption

Figure 76 shows respondents' convenience and performance-related reasons for purchasing their first EV. It shows that 70.4% (38.9% + 31.5%) of the respondents rated the convenience of charging at home as extremely or very important, 72.7% (38.8% + 33.9%) rated less noise compared to conventional vehicles as extremely or very important, and 65.5% (33.2% + 32.3%) rated enjoying instant acceleration and a smooth driving experience as extremely or very important.

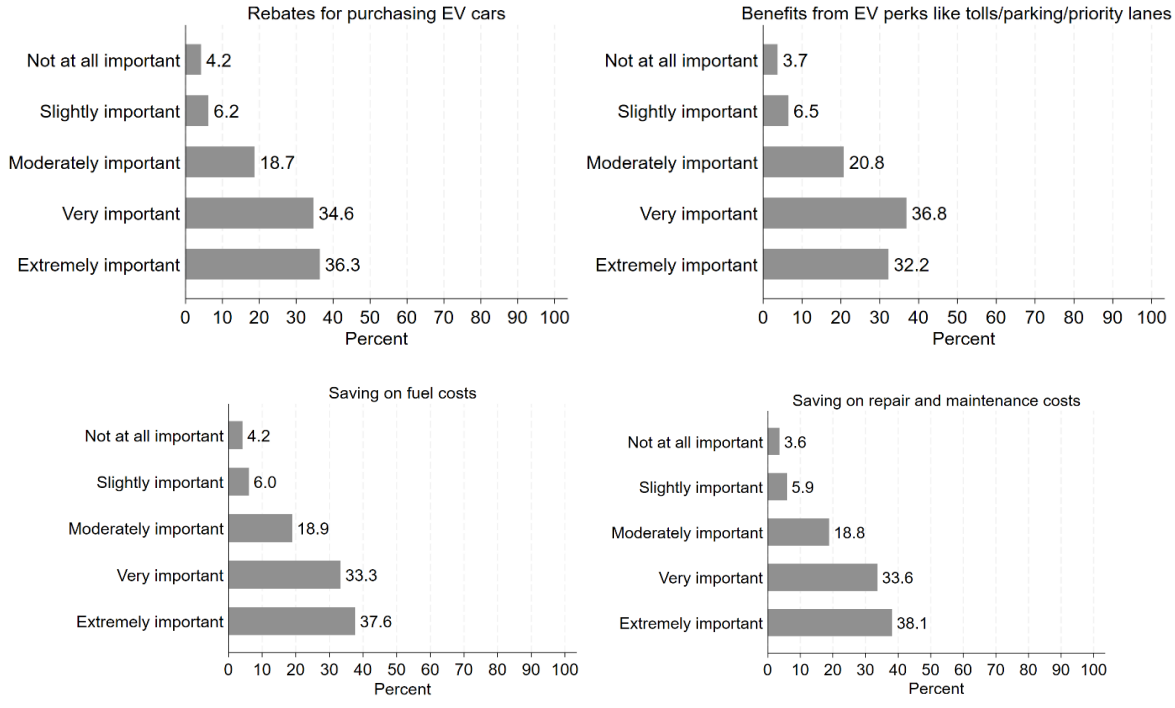


Figure 76: Policy and Cost-Related Motivations During EV Adoption

Figure 77 shows respondents' policy and cost-related reasons for purchasing their first EV. It shows that 70.9% (36.3% + 34.6%) of the respondents rated rebates for purchasing EV cars as extremely or very important, 69.0% (32.2% + 36.8%) rated benefits from EV perks like tolls, parking, and priority lanes as extremely or very important, 70.9% (37.6% + 33.3%) rated saving on fuel costs as extremely or very important, and 71.7% (38.1% + 33.6%) rated saving on repair and maintenance costs as extremely or very important.

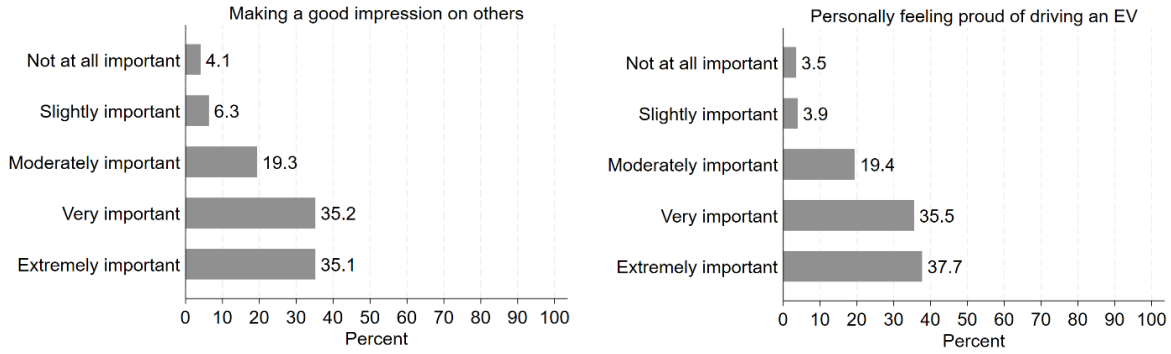


Figure 77: Social and Personal Motivations During EV Adoption

Figure 78 shows respondents' social and personal reasons for purchasing their first EV. It shows that 70.3% (35.1% + 35.2%) of the respondents rated making a good impression on others as extremely or very important, and 73.2% (37.7% + 35.5%) rated personally feeling proud of driving an EV as extremely or very important.

Figure 79 shows that respondents use their EVs to meet most of their travel needs. It shows that 66.4% (20.1% + 46.3%) of the respondents strongly or somewhat agree that they use the EV more often than other travel modes, and 64.7% (18.8% + 45.9%) strongly or somewhat agree that they frequently use the EV for long-distance trips.

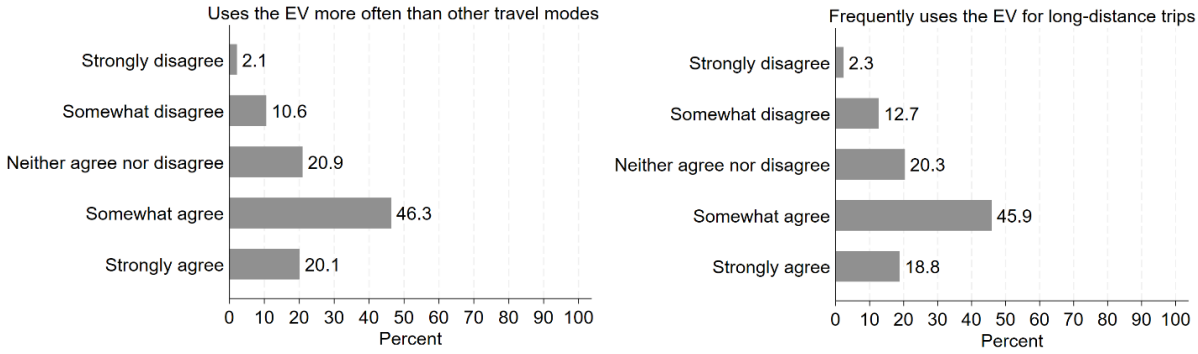


Figure 78: Degree of EV Reliance for Daily and Long-Distance Travel

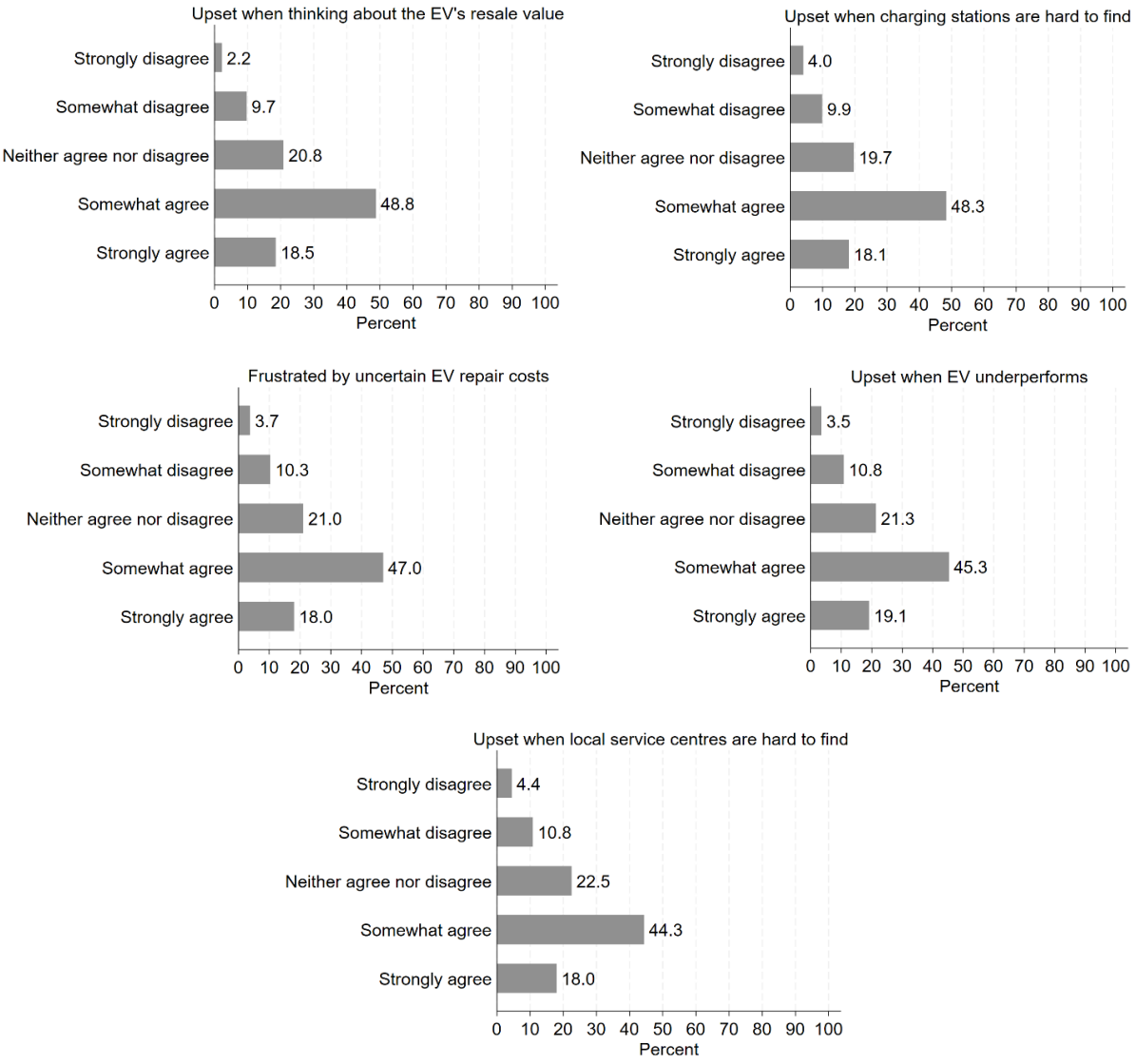


Figure 79: Frustration-Related Experiences Related to EV Use

Figure 80 shows respondents' various aspects of frustration with their EV cars. It shows that 67.3% (18.5% + 48.8%) of the respondents strongly or somewhat agree that they often get upset when thinking about the EV's resale value, and 66.4% (18.1% + 48.3%) strongly or somewhat agree that they are often upset when charging stations are difficult to find. Furthermore, 65.0% (18.0% + 47.0%) strongly or somewhat agree that they are frustrated when EV repair costs are hard to estimate, while 64.4% (19.1% + 45.3%) strongly or somewhat agree that they get upset when the EV does not perform as expected, and 62.3% (18.0% + 44.3%) strongly or somewhat agree that they are often upset when local repair and maintenance centers are difficult to find.

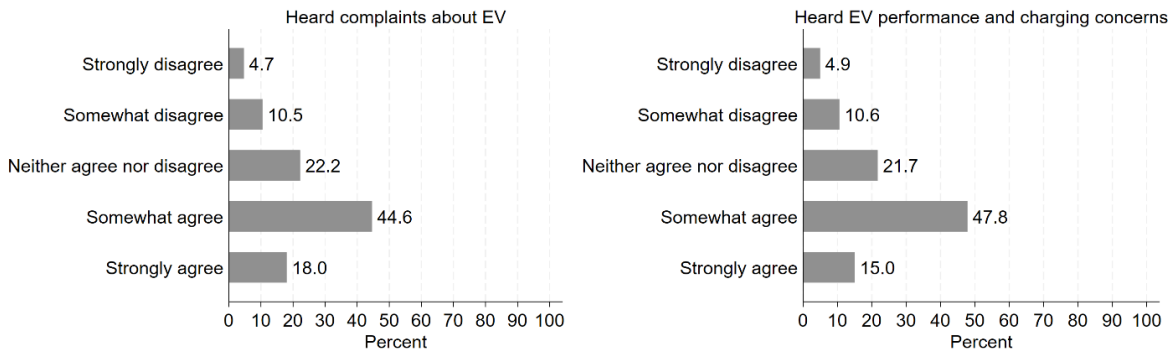


Figure 80: Exposure to Negative Word-of-Mouth about EV Cars

Figure 81 shows respondents' exposure to negative word of mouth about EV cars. It shows that 62.6% (18.0% + 44.6%) of respondents strongly or somewhat agreed that they had heard people complain about frustrations with EV cars. Additionally, 62.8% (15.0% + 47.8%) of the respondents strongly or somewhat agreed that they have heard concerns specifically about EV performance, charging, and maintenance.

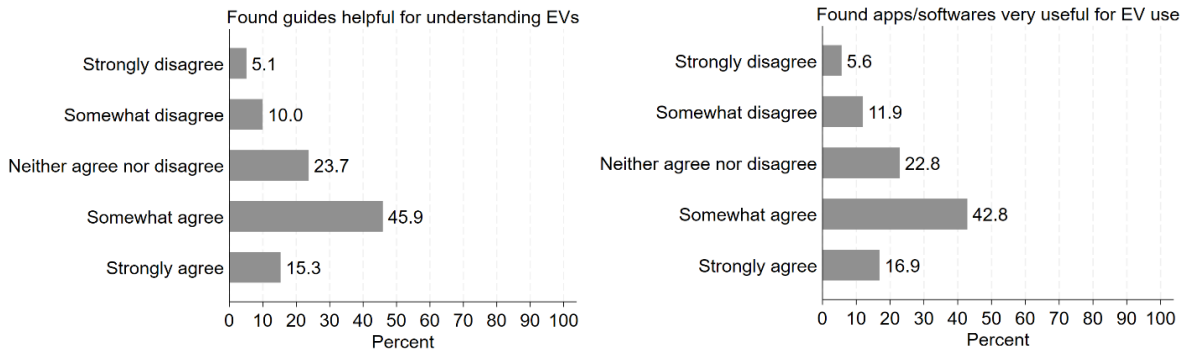


Figure 81: Helpfulness of Digital Resources for EV Use

Figure 82 shows respondents' perceptions of the helpfulness of digital resources for their EV car use. It shows that 61.2% (15.3% + 45.9%) of respondents strongly or somewhat agreed that guides or online resources helped them understand EVs. Furthermore, 59.7% (16.9% + 42.8%) of the respondents strongly or somewhat agreed that they found apps and software very useful for their EV use.

Figure 83 shows respondents' innovativeness and adoption of new vehicle technology. It shows that 66.7% (18.6% + 48.1%) of respondents strongly or somewhat agreed that they are usually the first among friends and family to learn about the latest automotive technology. Furthermore, 65.4% (16.8% + 48.6%) strongly or somewhat agreed that they own or have owned more vehicles with innovative features than their friends and family, while 61.3% (13.2% + 48.1%) strongly or somewhat agreed that they are among the first in their circle to adopt new vehicle technology.

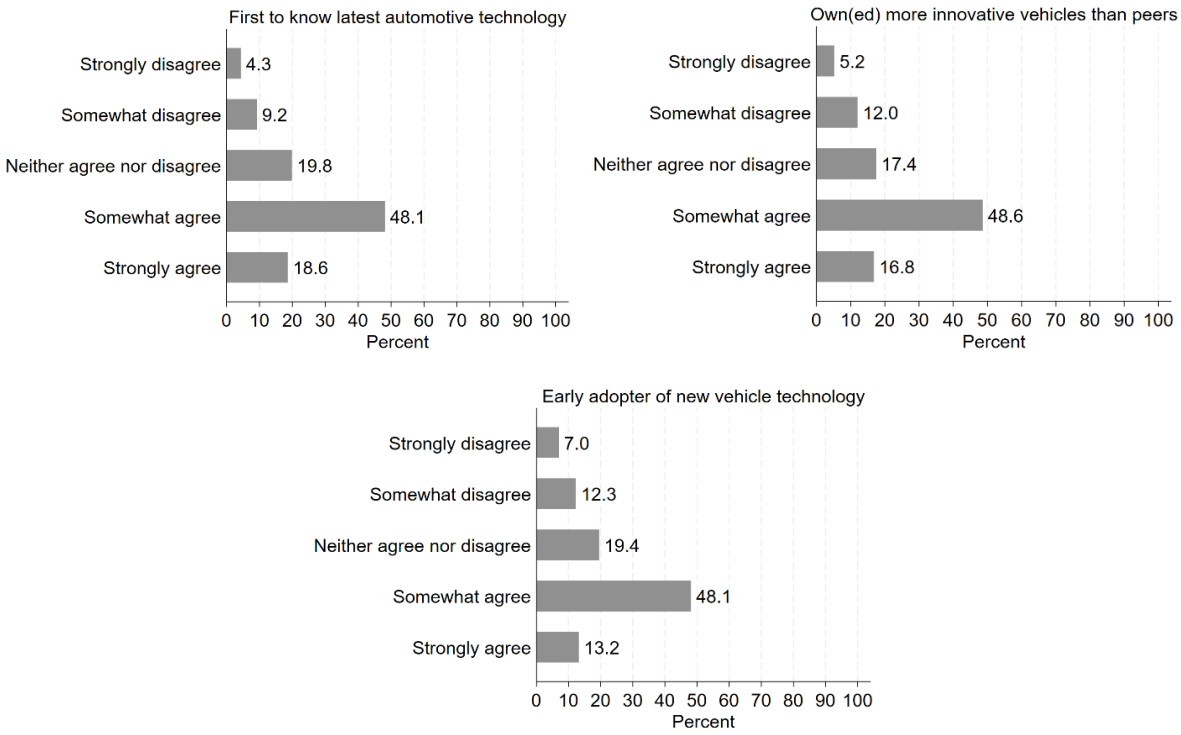


Figure 82: Respondents' Technological Innovativeness in Vehicle Adoption

6.4. Cross-tabulation of Data Obtained from Existing EV Owners

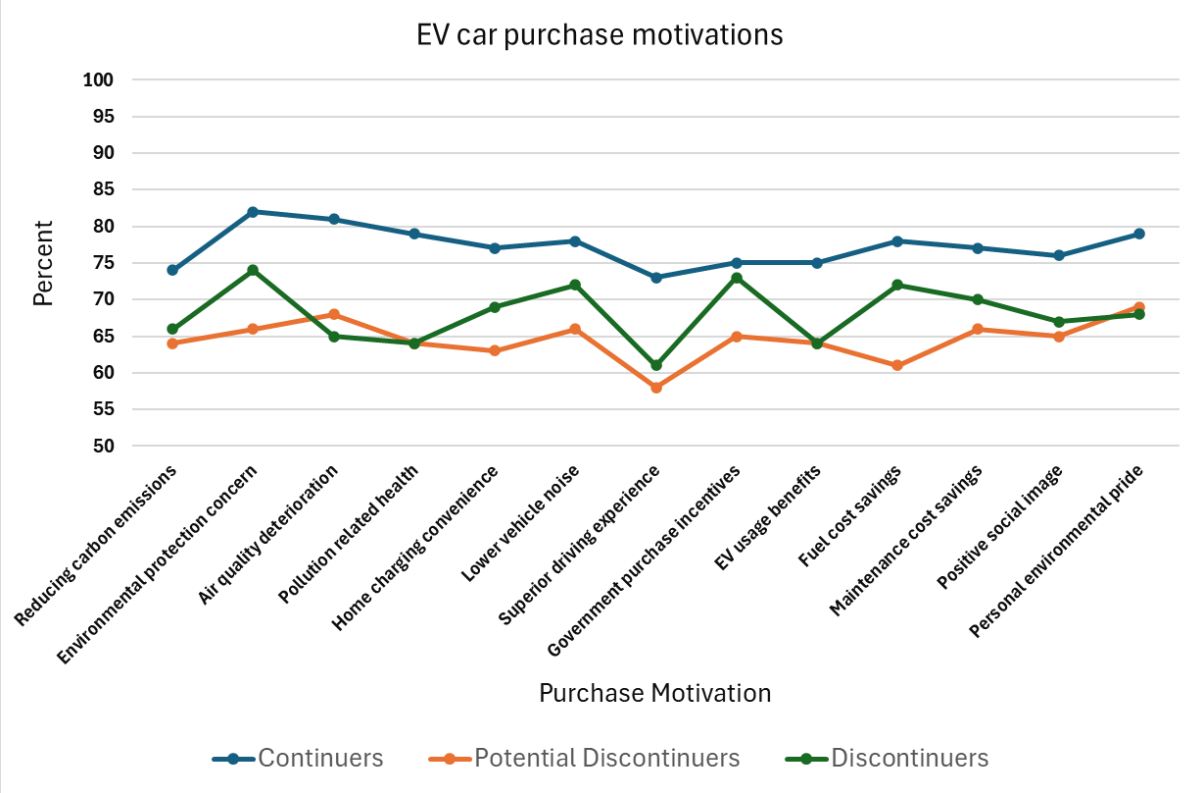


Figure 83: EV car purchase motivations

This section presents a cross-tabulation of the data across selected themes. Figure 84 shows that across all purchase motivations, continuers report higher agreement levels than both potential discontinuers and discontinuers. The clearest separations appear in environmental concern (especially environmental protection and air quality), fuel cost savings, and superior driving experience. Government purchase incentives are relatively equally important across continuers and discontinuers, with potential discontinuers reporting somewhat lower agreement.

Figure 85 shows the importance of rebates for EV car purchases across different household income levels. Figure 85 shows that 87.4% (32.1% + 55.3%) of low-income households (less than 10 lakh) rate EV purchase rebates as very (32.1%) or extremely important (55.3%). In comparison, a lower share of persons from higher-income households rate EV purchase rebates as very/extremely important.

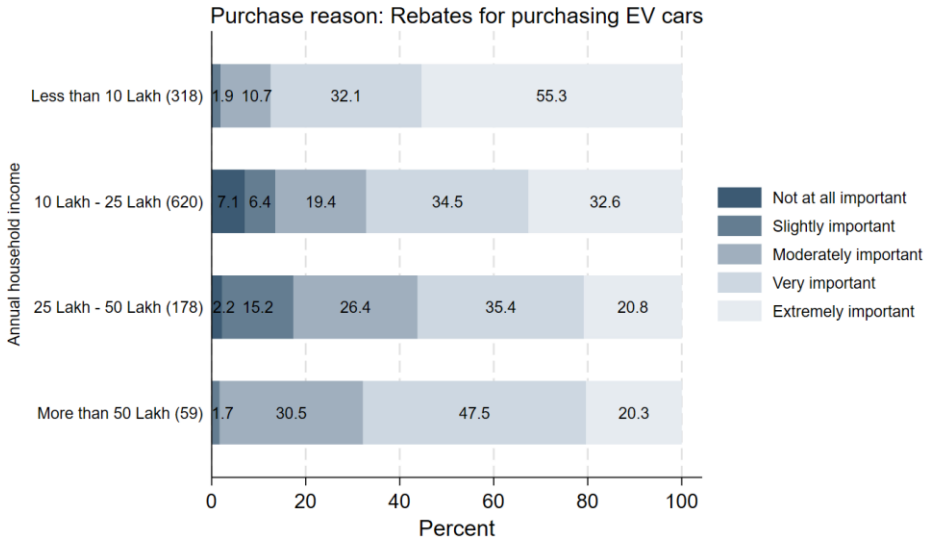


Figure 84: Importance of rebates for purchasing EV cars

Figure 86 shows the importance of use benefits (e.g., toll exemptions, free parking, priority lanes) for EV purchases across household income levels. It shows that 85.8% (43.7% + 42.1%) of low-income households (less than 10 lakh) rated the benefits of EVs as very important (43.7%) or extremely important (42.1%). In comparison, a lower share of persons from higher-income households rate the importance of benefits as very/extremely important.

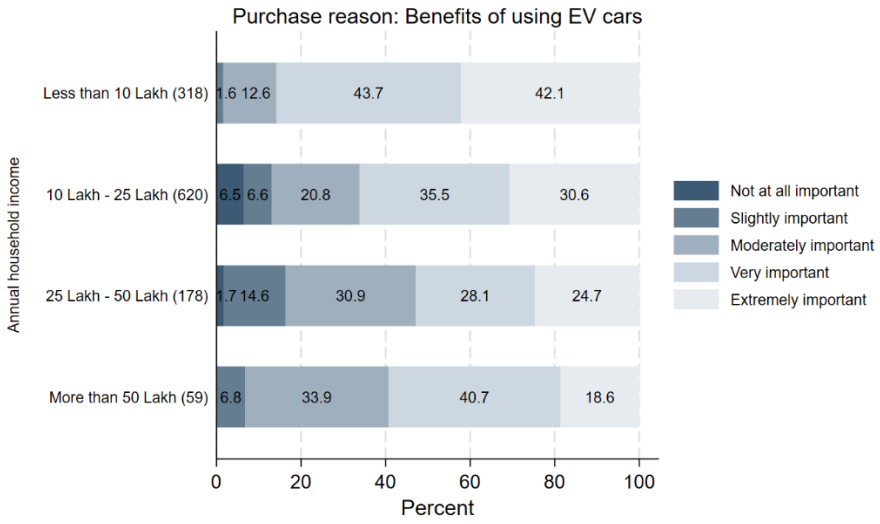


Figure 85: Importance of use benefits (e.g., toll exemptions) for purchasing EV cars

Figure 87 shows the frequency of EV use compared to other modes of travel across different household income levels. It shows that 81.5% (56.3% + 25.2%) of low-income households (less than 10 lakh) somewhat (56.3%) or strongly (25.2%) agree that they use their EV car more frequently than other modes of travel. In comparison, a relatively lower share of persons in higher-income households somewhat/strongly agree that they use their EV more frequently than other travel means.

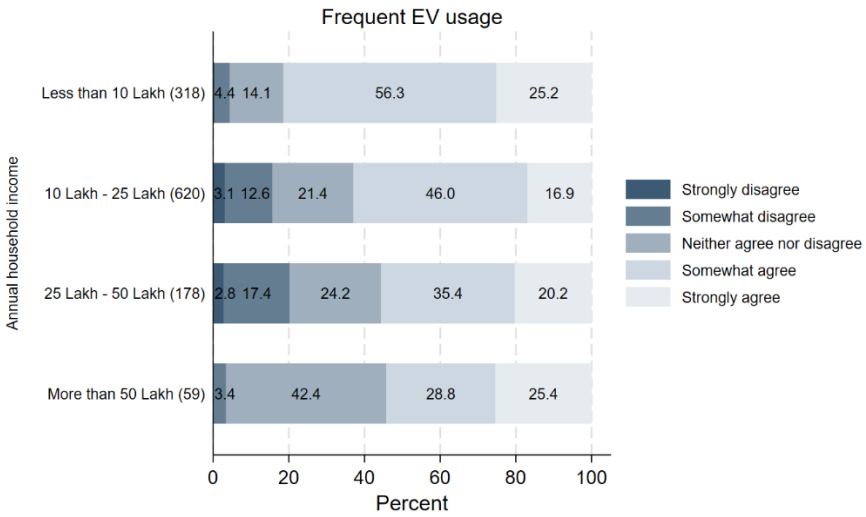


Figure 86: Frequency of use of EV cars compared to other travel means

Figure 88 shows the frequency of EV use for long-distance trips across different household income levels. It shows that 79.3% (53.8% + 25.5%) of low-income households (less than 10 lakh) somewhat (53.8%) or strongly (25.5%) agree that they frequently use their EV car for long-distance trips. In comparison, a lower share of persons from higher-income households somewhat/strongly agree that they frequently use their EV for long-distance trips.

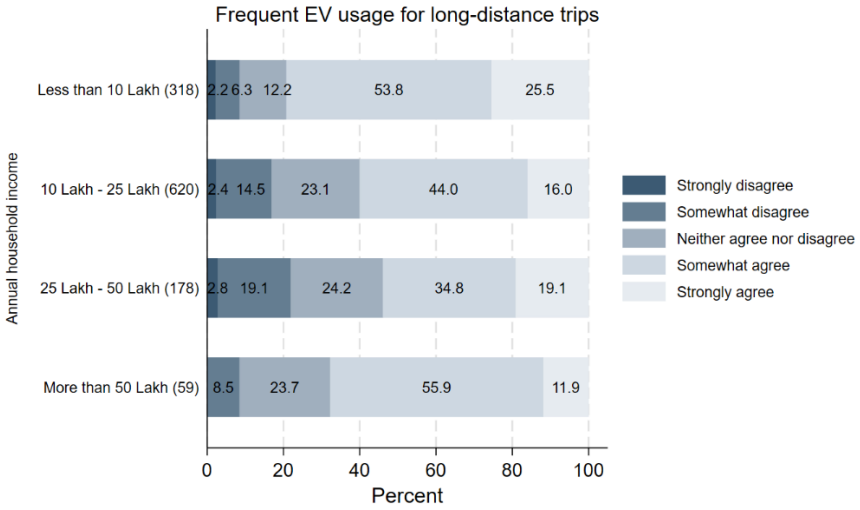


Figure 87: Frequent use of EV cars for long-distance trips

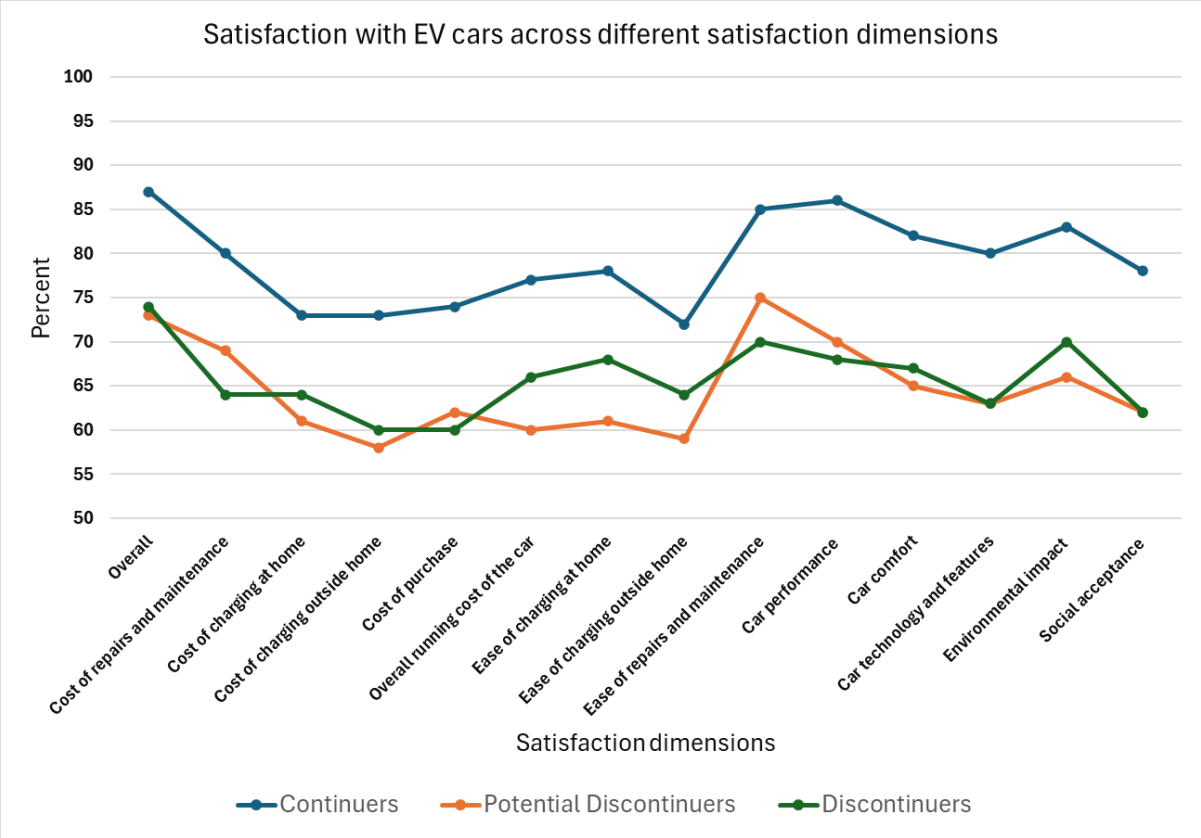


Figure 88: Satisfaction with EV cars across different satisfaction dimensions

Figure 89 shows that across all satisfaction dimensions, continuers consistently report higher satisfaction than the other two groups. Significant differences across the three groups are observed in car performance, charging convenience (both at home and outside), and overall running costs. Satisfaction with ease of outside charging appears relatively low for all three groups.

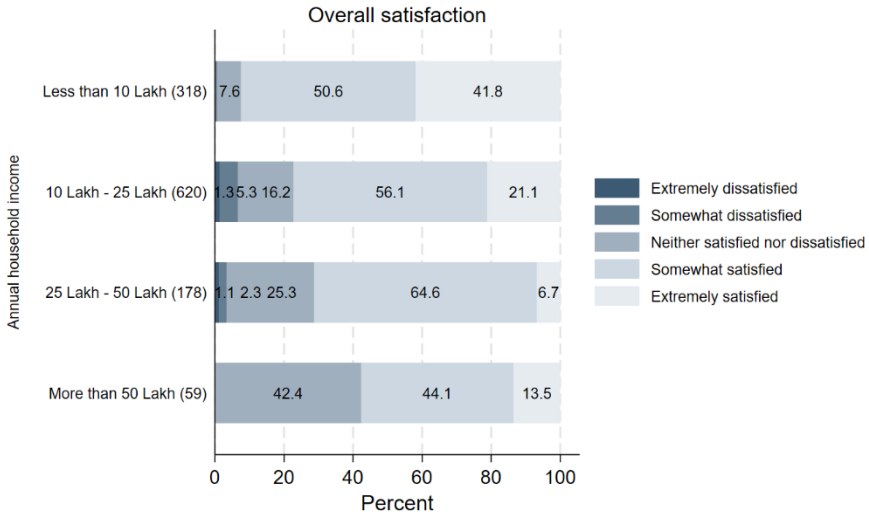


Figure 89: Overall satisfaction with EV cars

Figure 90 shows overall satisfaction with EVs across different household income levels. It shows that 92.4% (50.6% + 41.8%) of low-income households (less than 10 lakh) are somewhat (50.6%) or strongly

(41.8%) satisfied with their EV car. In comparison, a lower share of persons from higher-income households report being overall somewhat/strongly satisfied with their EV car.

Figure 91 shows EV car users' switching intention toward their previous travel modes across different household income groups. It shows that 60.7% of low-income households (less than 10 lakh) plan to continue using their EVs, while 27.4% have considered switching, and 11.9% have already switched. In comparison, a lower share of persons in higher-income households report planning to continue using their EV, while a higher share report having considered switching or already switching.

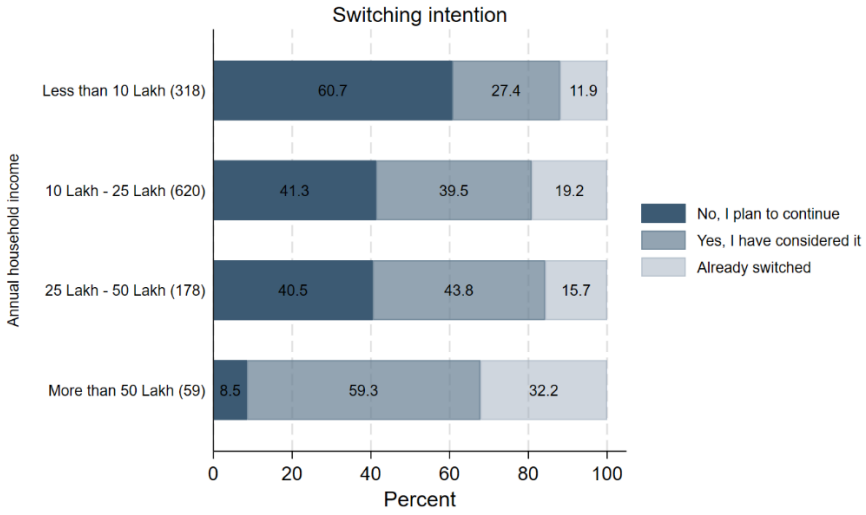


Figure 90: Switching intention towards previous means of travel

Figure 92 shows satisfaction with the ease of charging outside the home across different switching intention groups. It shows that among respondents who plan to continue using their EV car, 72.0% (51.3% + 20.7%) are somewhat (51.3%) or extremely (20.7%) satisfied with the ease of charging outside the home. Among respondents who have considered switching, 59.0% (46.2% + 12.8%) are somewhat (46.2%) or extremely (12.8%) satisfied. Among respondents who have already switched, 63.7% (40.2% + 23.5%) are somewhat (40.2%) or extremely (23.5%) satisfied.

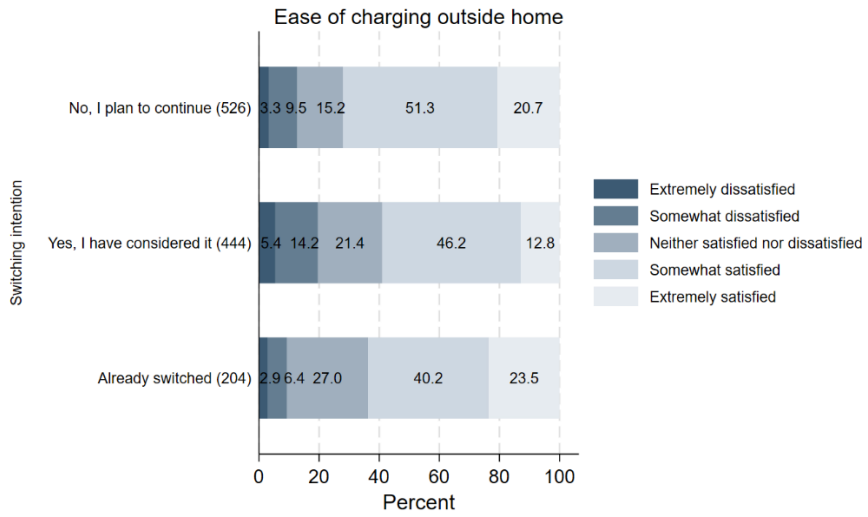


Figure 91: Ease of outside-home charging across switching intention groups

Figure 93 shows satisfaction with the ease of charging EVs outside the home by gender. It shows that among male respondents, 66.4% (48.1% + 18.3%) of respondents are somewhat (48.1%) or extremely (18.3%) satisfied with the ease of charging outside the home. In comparison, a relatively lower share of female respondents, 57.4% (39.6% + 17.8%), report being somewhat (39.6%) or extremely (17.8%) satisfied with the ease of charging outside the home.

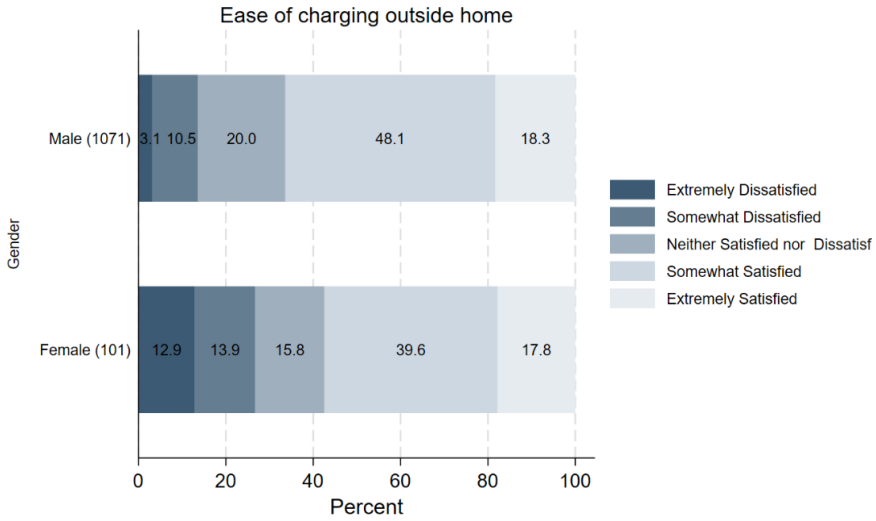


Figure 92: Ease of outside-home charging by gender

Figure 94 shows frustration with locating EV charging stations across different switching intention groups. Figure 94 shows that among respondents who plan to continue using their EV car, 73.8% (52.1% + 21.7%) somewhat (52.1%) or strongly (21.7%) agree that they often get upset when they have difficulty finding charging stations. In comparison, a lower share of respondents in other switching-intention groups (those considering switching or who have already switched) somewhat/strongly agree that they often get upset when they have difficulty finding charging stations.

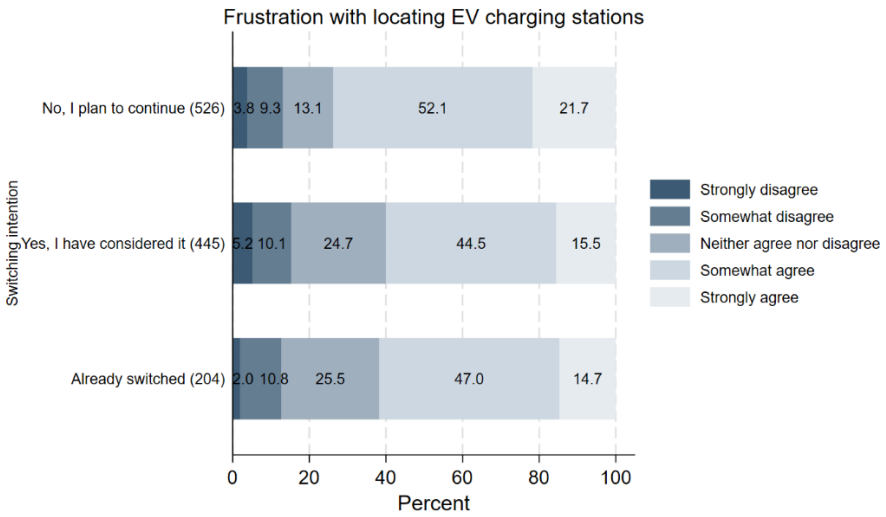


Figure 93: EV charger location frustration across switching intention groups

Figure 95 shows frustration with EV performance across different switching intention groups. It shows that among respondents who plan to continue using their EV, 70.3% (50.0% + 20.3%) somewhat (50.0%) or strongly (20.3%) agree that they often get upset when their EV does not perform as expected. In comparison, a lower share of respondents in the other switching intention groups (those who have considered switching or have already switched) somewhat or strongly agree that they often get upset when their EV does not perform as expected.

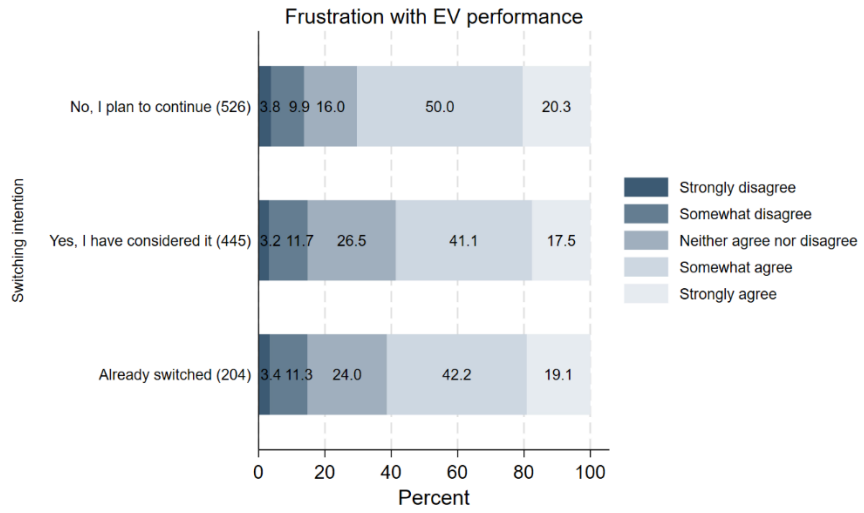


Figure 94: EV performance frustration across different switching intention groups

Figure 96 shows frustration with locating local EV repair and maintenance centers across different switching intention groups. It shows that among respondents who plan to continue using their EV car, 67.9% (48.9% + 19.0%) somewhat (48.9%) or strongly (19.0%) agree that they often get upset when they face difficulties finding local repair and maintenance centers. In comparison, a relatively lower share of respondents in the other switching intention groups (those who have considered switching or

have already switched) somewhat or strongly agree that they often get upset when they face difficulties finding local repair and maintenance centers.

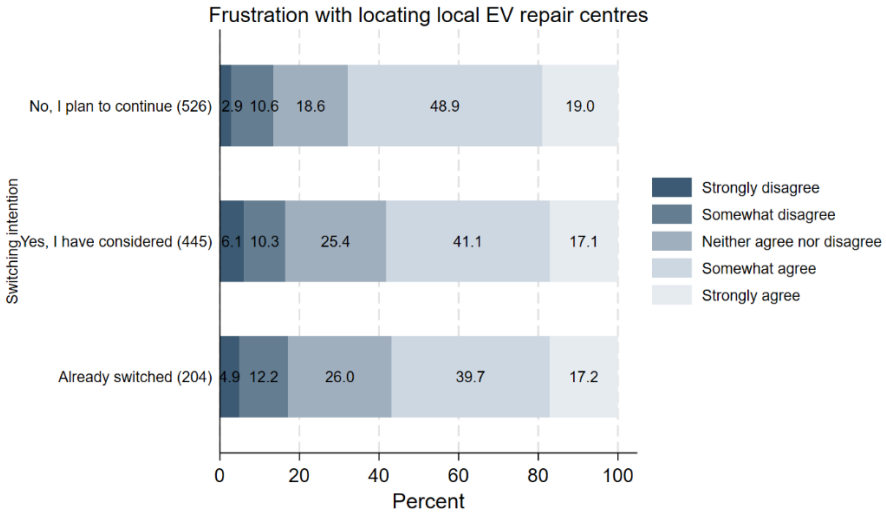


Figure 95: EV Repair access difficulty across switching intention groups

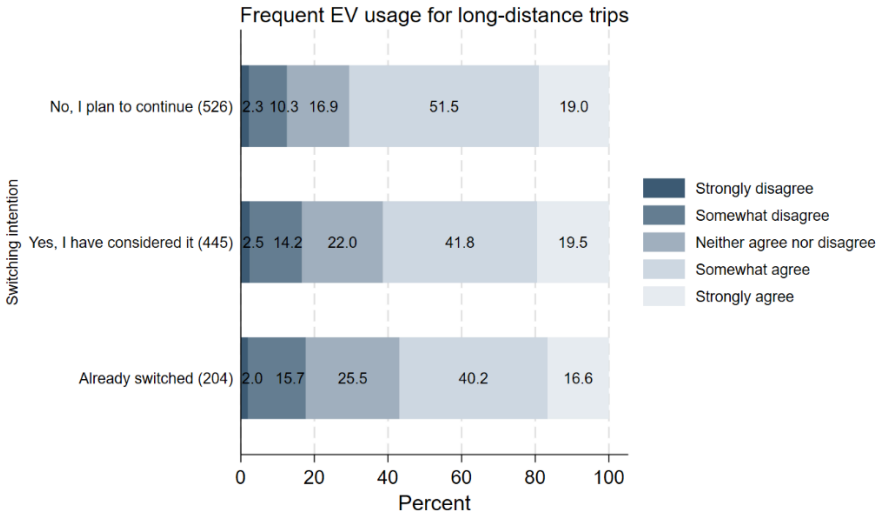


Figure 96: Long-distance EV use across switching intention groups

Figure 97 shows the frequency of EV use for long-distance trips across different switching-intention groups. It shows that among respondents who plan to continue using their EV, 70.5% (51.5% + 19.0%) of respondents somewhat (51.5%) or strongly (19.0%) agree that they frequently use their EV for long-distance trips. In comparison, a relatively lower share of respondents in the other switching-intention groups (those who have considered switching or have already switched) somewhat or strongly agree that they frequently use their EV for long-distance trips.

Figure 98 shows the usefulness of EV apps and software for EV use across different switching-intention groups. It shows that among respondents who plan to continue using their EV car, 64.3% (50.4% + 13.9%) of respondents somewhat (50.4%) or strongly (13.9%) agree that they found apps and software (e.g., battery management systems, real-time charging updates, maintenance, and performance updates) that are very useful for EV use. In comparison, a relatively lower share of respondents in the other switching intention groups (those who have considered switching or have already switched) somewhat or strongly agree that they found apps and software very useful for EV use.

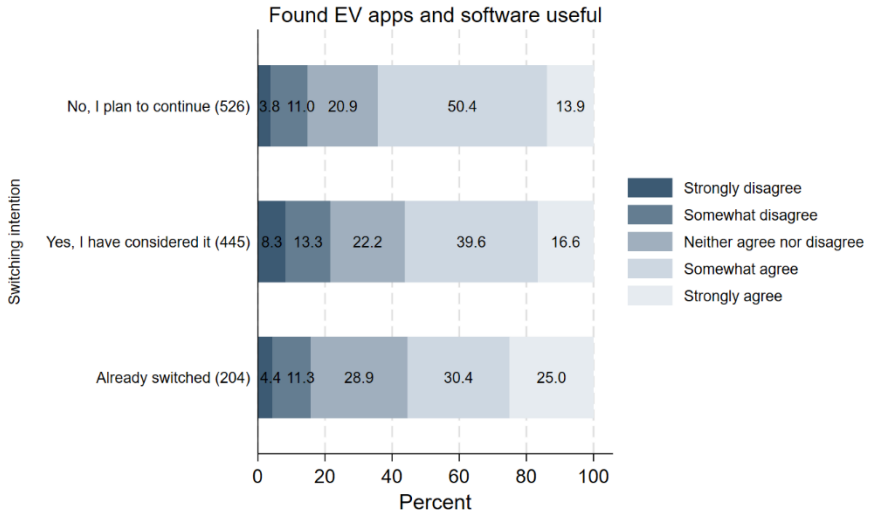


Figure 97: Usefulness of EV apps and software across switching intention groups

6.5. Key Insights about EV Car Owners in India

India's EV car owners are not a single, homogeneous group. The findings above suggest that everyday experiences with EVs can differ across population segments. It suggests a stratified adoption story in which socio-demographic characteristics such as income and gender shape motivation, usage, satisfaction, and even the decision to stay or exit the EV ecosystem.

We found that rebates are important for getting people into EVs, but not for keeping them there. Continuers and discontinuers both placed high importance on purchase incentives, while potential discontinuers show weaker rebate motivation. This indicates that rebates facilitate adoption but do not determine long-term retention. It also means that at the time of purchase, motivations varied for different EV user segments (Continuers, potential discontinuers, and discontinuers). This difference becomes much clearer in a superior driving experience (enjoying instant acceleration and a smooth driving experience) as purchase motivation, which clearly separates continuers from those at risk of leaving (potential discontinuers) and those who have already left (discontinuers). Thus, EVs are bought for financial reasons but kept for experiential ones. A deeper dive into the financial dimensions of EV cars reveals that EV purchase rebates and use benefits (e.g., toll exemptions and free parking) are significantly more important for low-income households (less than 10 lakhs annually) than for higher-income households. Further explorations into the experiential dimensions of EV cars suggest that continuers are consistently more satisfied across almost every dimension of EV car use than both potential discontinuers and discontinuers. Continuers report significantly higher satisfaction with car performance, comfort, technology, and repairs & maintenance compared to other dimensions of

satisfaction. It means experiential and functional satisfaction matter most for staying. In contrast, charging seems to be a major pressure point. Satisfaction with the ease and cost of charging, especially outside the home, is low across all groups, but lowest among potential discontinuers. This suggests that charging friction is not just annoying; it actively pushes users toward reconsideration before they fully exit. Potential discontinuers are less satisfied than even discontinuers on many dimensions (charging ease, costs). This implies they are still trying to make EVs work but are experiencing unresolved frustration. Thus, people stay with EVs when they are satisfied not just financially, but functionally and experientially. This also suggests that the cost of using EV cars and the ease of charging matter a lot in day-to-day use. Hence, once purchased, what matters is the cost and ease of daily mobility with an EV car.

We also found that, among existing EV owners, reliance on EVs as the primary travel mode (frequent use) declines with income, and low-income EV users report the highest reliance on EVs for long trips. Data also shows that overall EV satisfaction declines as income rises, reflecting differences in how EVs are used and what users expect from them. This pattern suggests that EV use, satisfaction, and income are tightly linked through dependence and expectations. Low-income EV owners rely most on their vehicles because EVs often serve as their primary or only car, forcing them to use them frequently, including for long trips, despite infrastructure limitations. This high reliance encourages adaptation; users learn to manage range, charging, and trip planning, which helps sustain satisfaction. As income rises, EVs are more likely to become secondary or selective vehicles, reducing their frequent use and reliance for long trips. This argument becomes even clearer from the finding that, among existing EV owners, commitment to continued EV use declines sharply with income. Higher-income EV owners are significantly more likely to consider or enact a switch back to ICE or hybrid vehicles. This indicates that EV retention challenges are concentrated among wealthier users rather than lower-income adopters.

Understanding what drives EV car owners to consider switching or to switch finally is important for promoting long-term adoption. We found that charging friction drives EV switching. Continuers show higher satisfaction with the ease of outside charging than potential discontinuers and discontinuers. However, this satisfaction is skewed towards males. This suggests that public charging may feel more accessible, safe, or manageable for men than for women. Furthermore, operational frustrations are widespread: more than 56% of respondents across all three adopter groups (continuers, potential discontinuers, and discontinuers) agree that they often get upset about finding public charging stations, locating local repair and maintenance centers, and coping with unexpected performance issues.

However, the relatively higher frustration among continuers appears counterintuitive, as they also report higher satisfaction across all dimensions. One possible explanation could lie in learning and adaptation. Continuers report high frustration but still report high satisfaction, suggesting normalization rather than ecosystem success. Greater exposure through frequent use may increase stress, but users tolerate it until a functional threshold is crossed, at which point they begin to consider switching. Thus, EV users are not necessarily leaving because they are less satisfied; they leave when the effort required to remain satisfied becomes too high. We also found that users who continue with EVs are far more likely to use them for long trips, and low-income owners, in particular, rely more frequently on their EVs for both short- and long-distance travel. This indicates that greater reliance may build adaptive capacity, but it also increases exposure to friction, making long-term retention dependent on whether users can sustainably manage this effort.

The role of post-purchase guidance further supports this interpretation. Continuers are more likely to report access to helpful information on battery management, charging, and maintenance, which likely reduces the effort required to manage everyday frictions. In contrast, information gaps among potential discontinuers and discontinuers may leave unresolved usage challenges, accelerating disengagement and eventual switching. However, while digital tools, apps, and tutorials can ease individual-level adaptation, they cannot substitute for systemic infrastructure improvements. Long-term EV retention in India will ultimately depend on reducing ecosystem-level friction across charging, repair, and performance networks, rather than merely helping users cope with it.

6.6. Segmentation of Existing EV Car Owners in India



Figure 98: Consumer segmentation of existing EV car owners

This section presents customer segmentation across selected themes from the collected data for existing EV car owners (across all 3 groups: continuers, potential discontinuers, and discontinuers). Figure 99 presents the segmentation heatmap for households that already own/owned an EV car. The values represent mean Likert scores (1–5 scale) for each construct across consumer segments, with higher values indicating greater satisfaction/importance/EV car/app use.

It shows that overall satisfaction remains high across segments, with all means above 3.75. For example, Young Budget Non-University Metro Owners report 4.50, Mature Budget Non-University Mega-City Owners report 4.47, and young budget non-university mega-city owners report 4.35. Running cost satisfaction is similarly strong, mostly above 4.00 across budget segments, while affluent groups (both in mega-cities and metro-cities) report comparatively lower levels of running cost satisfaction (around 3.55–3.74).

Environmental care motivation as a reason for car purchase ranges from 3.60 (Young Affluent University-Educated Mega-city Owners) to 4.58 (Young Budget University-Educated Metro Owners). For most segments, values remain above 4.00, particularly among budget mega/metro-city groups. Segment-wise, the highest values are observed among the budget segments, while the affluent mega-city segments report comparatively lower levels. Performance motivation ranges from 3.57 (Young/Mature Affluent University-Educated Mega-city Owners) to 4.47 (Young Budget Non-University Mega-city Owners). For most segments, performance motivation ranges from 3.80 to 4.40, with several budget mega- and metro-city groups exceeding 4.20. Segment-wise, young/mature budget

mega/metro-city groups report the strongest performance motivation, whereas affluent mega/metro-city segments remain at the lower end of the range. Policy rebate motivation ranges from 3.52 (Young Affluent University-Educated Mega-city Owners) to 4.67 (Mature Budget University-Educated Mega-city Owners). For most segments, values are above 4.00 among budget groups, while affluent segments report values largely between 3.50 and 4.00. Segment-wise, mature budget mega-city owners report the highest levels, whereas affluent mega-city owners report the lowest. Cost-saving motivation ranges from 3.60 (Young Affluent Mega-city Owners) to 4.80 (Mature Budget Non-University Mega-city Owners). Social image motivation ranges from 3.65 (Young Affluent University-Educated Mega-city Owners) to 4.33 (Mature Budget University-Educated Metro Owners). For most segments, values range from 3.75 to 4.30, with several budget mega- and metro-city groups exceeding 4.20.

Regarding post-purchase EV car use variables, frequent EV use ranges from 3.46 (Mature Affluent University-Educated Mega-city Owners) to 4.35 (Young Budget Non-University Mega-city Owners). For most segments, values range from 3.70 to 4.30, with most budget mega-city groups reporting values above 4.00. Long-distance EV use ranges from 3.32 (Mature Affluent Non-University Metro Owners) to 4.35 (Young Budget Non-University Mega-city Owners). For most segments, values range from 3.50 to 4.20, with budget mega-city groups again reporting the highest levels (above 4.15). Affluent metro-city groups report the lowest values.

Regarding post-purchase experience variables, performance ease ranges from 1.47 (Mature Budget University-Educated Mega-city Owners) to 2.62 (Young Affluent Non-University Mega-city Owners). Maintenance ease ranges from 1.67 (Mature Budget University-Educated Mega-City Owners) to 2.81 (Young, Affluent, Non-University, Metro Owners). Ease of charging ranges from 1.76 (Young Budget Non-University Mega-city Owners) to 2.62 (Young Affluent Non-University Mega-city Owners). Resale ease ranges from 1.82 (Young Budget Non-University Mega-city owners) to 2.49 (Young Affluent Non-University Mega-city owners). For most segments, these post-purchase experience variables range from 1.80 to 2.50, with budget mega-city groups generally reporting the lowest values and affluent mega/metro-city groups reporting higher values.

Positive word-of-mouth (hearing good about EV cars from others) ranges from 1.76 (Young Budget Non-University Mega-city Owners) to 2.63 (Mature Affluent University-Educated Mega-city Owners). For most segments, values range from 1.90 to 2.50, with budget mega-city groups reporting the lowest values. EV app use ranges from 3.05 (Mature, Affluent, Non-University, Metro Owners) to 4.06 (Young, Budget, Non-University, Mega-city Owners). For most segments, values range from 3.40 to 3.90, with budget mega-city groups reporting the highest levels of app engagement.

6.6.1. Insights and Targeted Implications from Consumer Segmentation Analysis of Existing EV Owners

In general, EV car owner segmentation indicates that budget segments, especially mega-city budget owners, are the most motivated and usage-intensive EV car users. They exhibit higher overall satisfaction and purchase motivations for EVs purchased for environmental, performance, policy rebate, and cost-saving reasons. Their higher frequency of EV use, longer-distance trips, and higher app engagement indicate a deeper integration of EVs into their mobility patterns. This trend is similar for metro budget owners. Affluent mega- and metro-city segments exhibit relatively lower purchase

motivation and satisfaction than budget segments. Their lower cost-saving and policy motivations indicate a weaker dependence on financial incentives. In contrast, their relatively lower frequency of use and app engagement may indicate more diversified mobility alternatives or a weaker dependence on the EV car as a primary vehicle. The lower values for the post-purchase experience variables (performance ease, maintenance ease, charging ease, and resale ease) across all consumer segments indicate operational and EV ecosystem difficulties regardless of the socio-demographic segment. Budget mega-city groups have the lowest ease scores despite high satisfaction and high usage. This indicates a possible mismatch between motivational enthusiasm and ownership experience. The affluent groups have lower satisfaction levels than the budget groups, but also relatively lower EV car usage and app engagement. Taken together, the findings of the segmentation analysis indicate a systematic pattern in which budget mega-city groups are the most motivationally enthusiastic and usage-intensive EV owners, despite having the lowest ease scores. This indicates that budget mega-city groups are likely to be motivated by rational considerations (such as environmental concerns, performance, cost, policy, and social factors) and to have higher satisfaction levels and higher usage intensity, but are also likely to face difficulties in operational use. It may indicate their adjustment to the vehicle and the EV ecosystem, but the difficulties may undermine long-term retention unless the ecosystem and operational inefficiencies are systematically removed. Affluent owners report lower operational difficulties; this may also reflect their lower EV use, suggesting the vehicle is not as integral to their mobility as it is for budget mega-city owners. Overall, the results suggest that policy should move beyond purchase incentives and place greater emphasis on post-purchase ecosystem improvements to sustain long-term adoption across segments, particularly among budget EV owners.

7. Exploring Pre-Adoption Attitudes Towards Electric Two-wheelers in Urban India

7.1. Context and Motivation

India is a major market and manufacturer of two-wheelers, which account for more than 70% of all registered motorized vehicles in the country (Bhat & Verma, 2024; Statista, 2025; Times of India, 2026). In 2025, around 20 million two-wheelers were registered (Murali, 2025), of which 1.27 million were electric, representing approximately 6.3% of total two-wheeler sales (Kumar, 2025; I. Verma, 2025). The Government of India aims to increase the share of electric two-wheelers to 80% of total sales by 2030 (The Hindu, 2021). Given the relatively small share of electric two-wheelers in total motorcycle sales in India, understanding the factors that encourage or discourage existing non-electric motorcycle users allows us to identify the key drivers and barriers influencing the adoption of electric two-wheelers. Hence, this section aims to develop a questionnaire to help understand the concerns of existing non-electric motorcycle users in India.

The survey instrument was developed by drawing on established academic literature and current concerns about electric two-wheelers highlighted in recent media discussions. Accordingly, we asked questions on basic socio-demographic information, their current vehicle ownership status, and their ICE two-wheeler use (Sovacool et al., 2018); their knowledge and awareness about electric two-wheelers in terms of their performance, use cost, and relative advantages over traditional gasoline

vehicles (M. Verma et al., 2020; Wang et al., 2018). To understand the benefits and associated risks they see with EV two-wheelers, we asked questions about the perceived usefulness of EV two-wheelers in terms of environmental benefits, cost, travel efficiency, etc. (Wang et al., 2018). We further asked about the perceived risk associated with electric two-wheelers, encompassing financial risk (higher prices and potential monetary loss), performance, and time risk (range anxiety, charging delays, and reliability concerns), and physical safety risk (road safety, weather-related risks, and family safety) (Deolalikar, 2025; He et al., 2018; Schmalfuß et al., 2017; Times of India, 2025; Wang et al., 2018). We also included questions on policy incentives to understand the role of government support in shaping awareness, perceived benefits, and purchase intentions for electric two-wheelers (Jaiswal et al., 2021; Wang et al., 2018). We also included questions related to word-of-mouth influence to understand how perceived problems and usage-related concerns shared by family, friends, peers, and social media shape attitudes and intentions toward electric two-wheelers (Sahoo et al., 2022). Finally, we included questions that capture the purchase intention of existing ICE/gasoline two-wheelers for EV two-wheelers (Bhat & Verma, 2025; Wang et al., 2018).

7.2. Description of Data Obtained from Potential Electric Two-Wheelers Consumers

This section describes the collected data thematically. Figure 100 shows the socio-demographic characteristics of the sampled potential consumers of electric two-wheelers. Figure 100 shows that the highest percentage of respondents belongs to the 30–39 years age group, at 52.4%. It also shows that 71.2% of the sampled households report a total annual household income of less than 10 lakh INR. It further shows that 72.1% of respondents belong to households with 3–5 members. Figure 100 also shows that 85.4% of the respondents are male. Additionally, it shows that 46.5% of respondents hold a Bachelor's degree, while 25.9% report holding a diploma but no Bachelor's degree. Further, Figure 100 shows that 78.9% of the respondents are married.

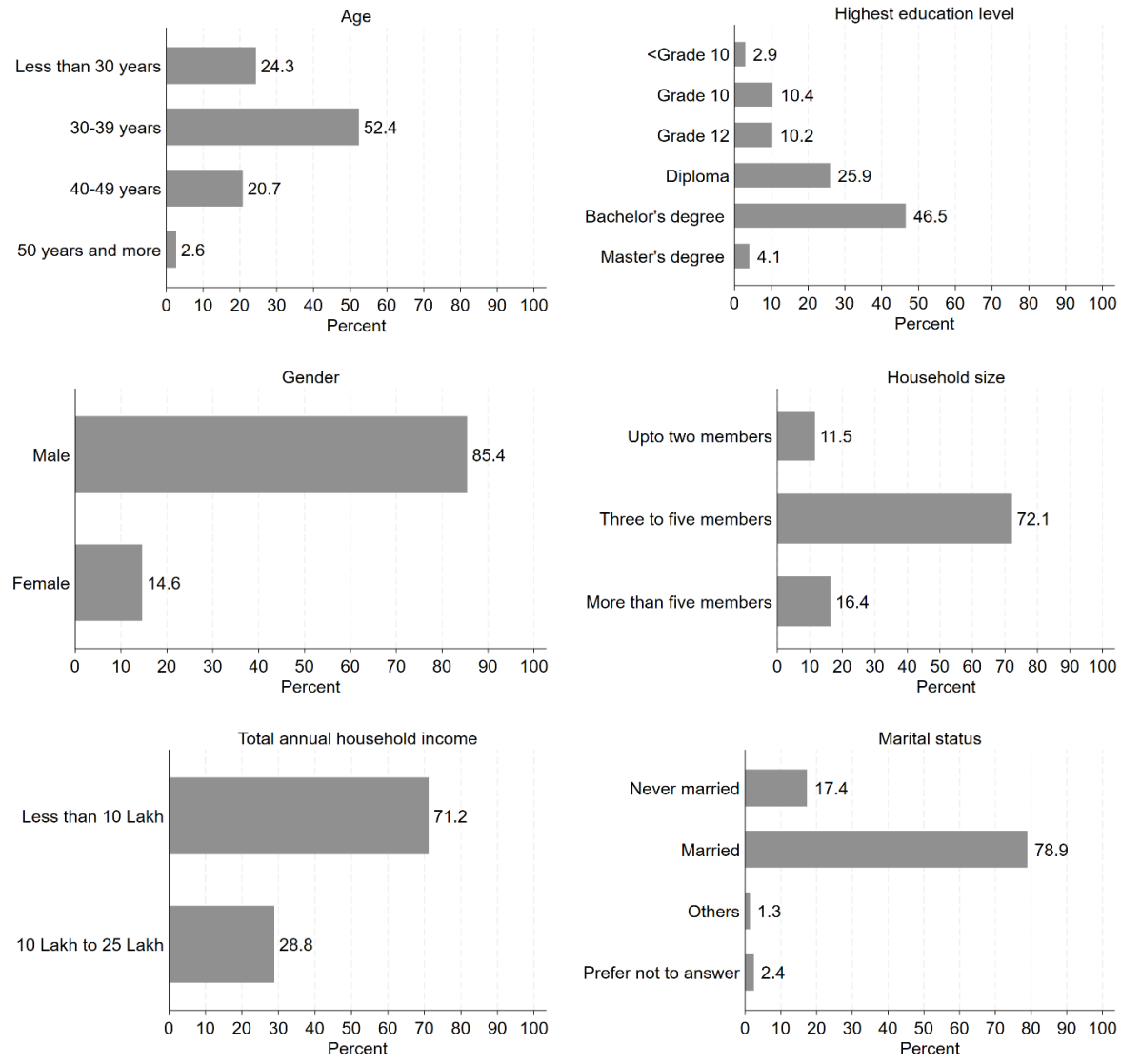


Figure 99: Socio-demographic characteristics of the sampled potential electric two-wheelers consumers

Figure 101 shows respondents' two-wheeler purchase plans in the next 12 months and their consideration of electric two-wheelers. It shows that 56.3% of respondents do not plan to buy a new

two-wheeler in the next 12 months. It also shows that 21.2% of respondents may consider buying a new two-wheeler, while 22.5% plan to buy one in the next 12 months. Figure 101 further shows that 33.3% of respondents are not considering buying an electric two-wheeler, while 66.7% are.

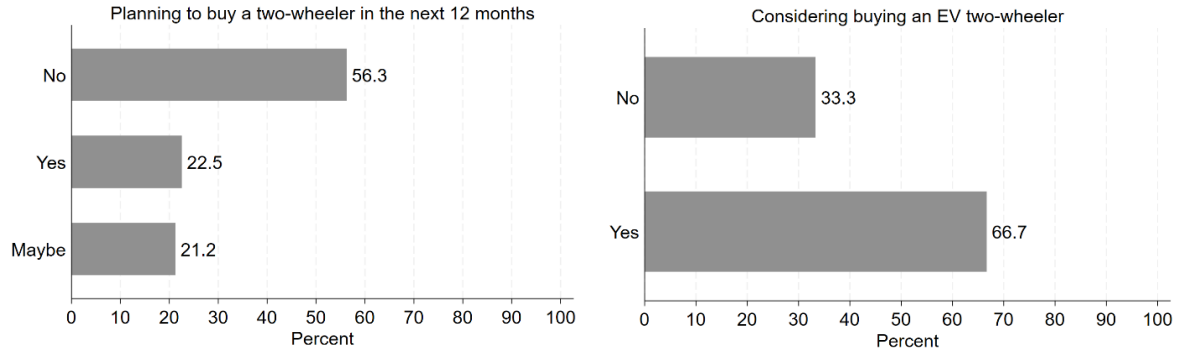


Figure 100: Respondents' two-wheeler purchase plans in the next 12 months and their consideration of electric two-wheelers

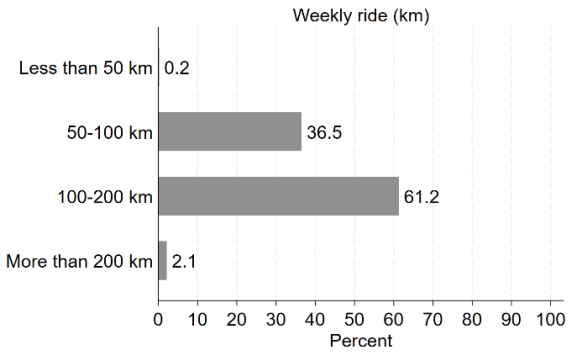


Figure 101: Weekly ride (km) of the sampled potential electric two-wheeler consumers

Figure 102 shows the weekly ride (km) of the sampled potential electric two-wheeler consumers. It shows that 61.2% of the respondents report a weekly ride of 100–200 km. It also shows that 36.5% of the respondents report a weekly ride of 50–100 km. It further shows that 2.1% of the respondents report a weekly ride of more than 200 km. Additionally, it shows that 0.2% of the respondents report a weekly ride of less than 50 km.

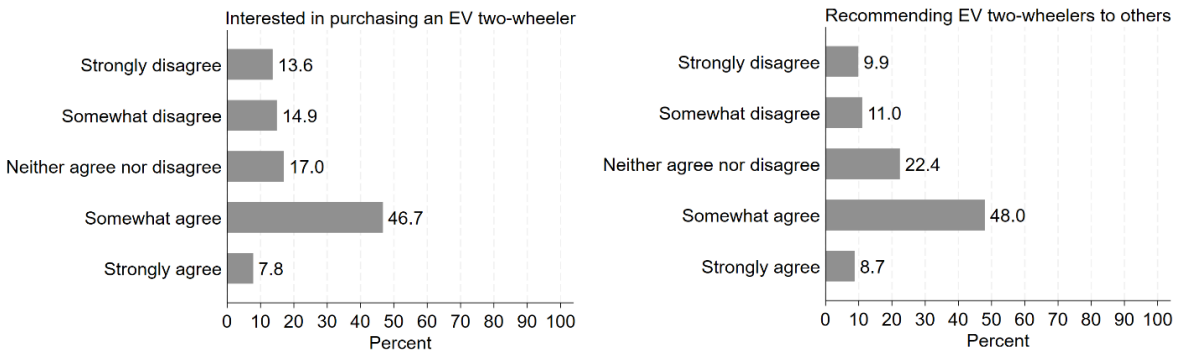


Figure 102: Respondents' interest in purchasing and recommending electric two-wheelers

Figure 103 shows the respondents' interest in purchasing and recommending electric two-wheelers. It shows that 54.5% (46.7% + 7.8%) of respondents somewhat or strongly agree they are interested in purchasing an electric two-wheeler. It also shows that 56.7% (48.0% + 8.7%) of respondents somewhat or strongly agree they would recommend electric two-wheelers to others.

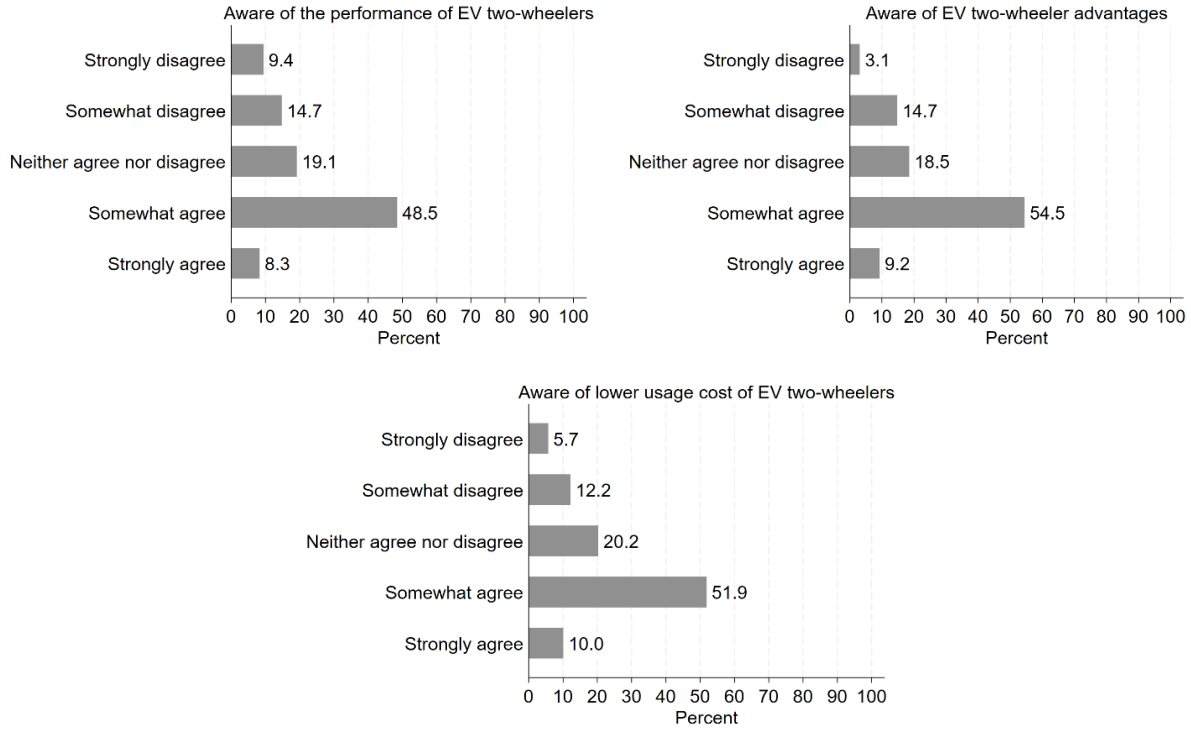


Figure 103: Respondents' awareness regarding the performance, advantages, and usage cost of electric two-wheelers

Figure 104 shows respondents' awareness of the performance, advantages, and operating costs of electric two-wheelers. Figure 104 shows that 56.8% (48.5% + 8.3%) of respondents somewhat or strongly agree they are aware of the performance of electric two-wheelers. It also shows that 63.7% (54.5% + 9.2%) of respondents somewhat or strongly agree they are aware of the advantages of electric two-wheelers over traditional two-wheelers. Additionally, Figure 104 also shows that 61.9% (51.9% + 10.0%) of respondents somewhat or strongly agree that they are aware of the lower operating costs of electric two-wheelers.

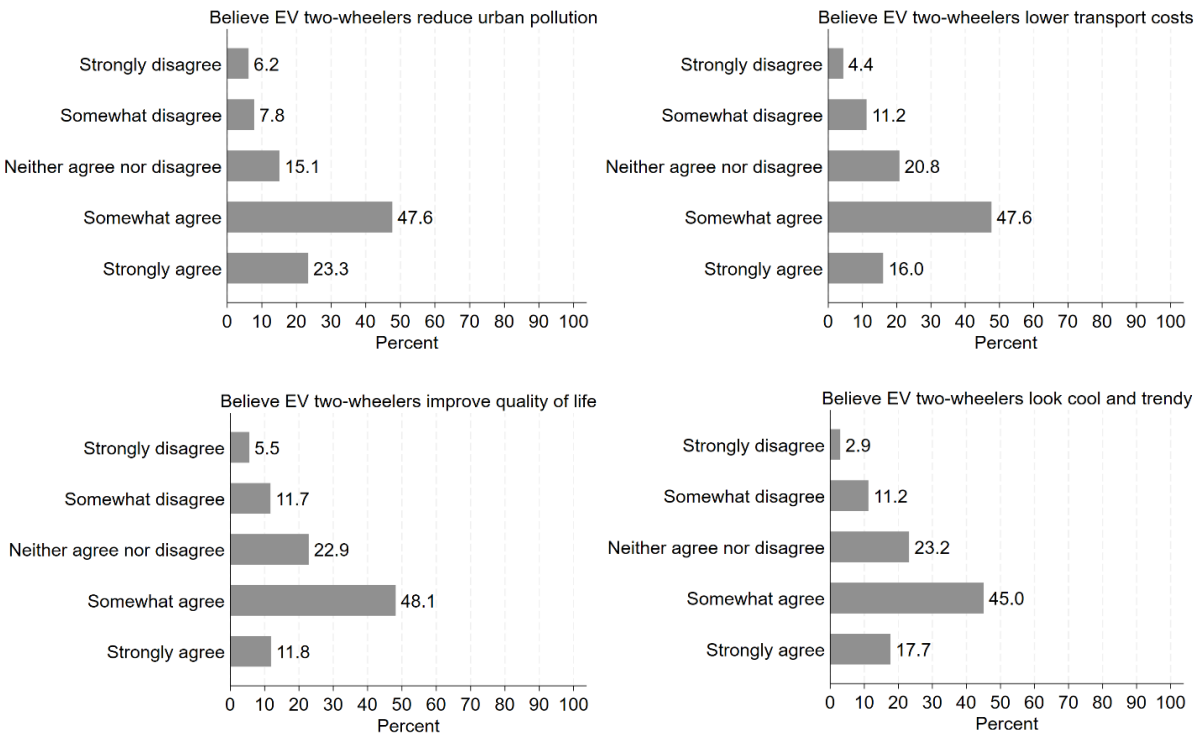


Figure 104: Respondents' perceptions regarding the environmental benefits, costs, and social image of electric two-wheelers

Figure 105 shows respondents' perceptions of the environmental benefits, costs, and social image of electric two-wheelers. Figure 105 shows that 70.9% (47.6% + 23.3%) of respondents somewhat or strongly agree that electric two-wheeler reduces urban air pollution. It also shows that 63.6% (47.6% + 16.0%) of respondents somewhat or strongly agree that an electric two-wheeler is cheaper and reduces transport costs. Additionally, Figure 105 shows that 59.9% (48.1% + 11.8%) of respondents somewhat or strongly agree that electric two-wheeler can improve quality of life. Further, it also shows that 62.7% (45.0% + 17.7%) of respondents somewhat or strongly agree that an electric two-wheeler makes riders look cool and trendy.

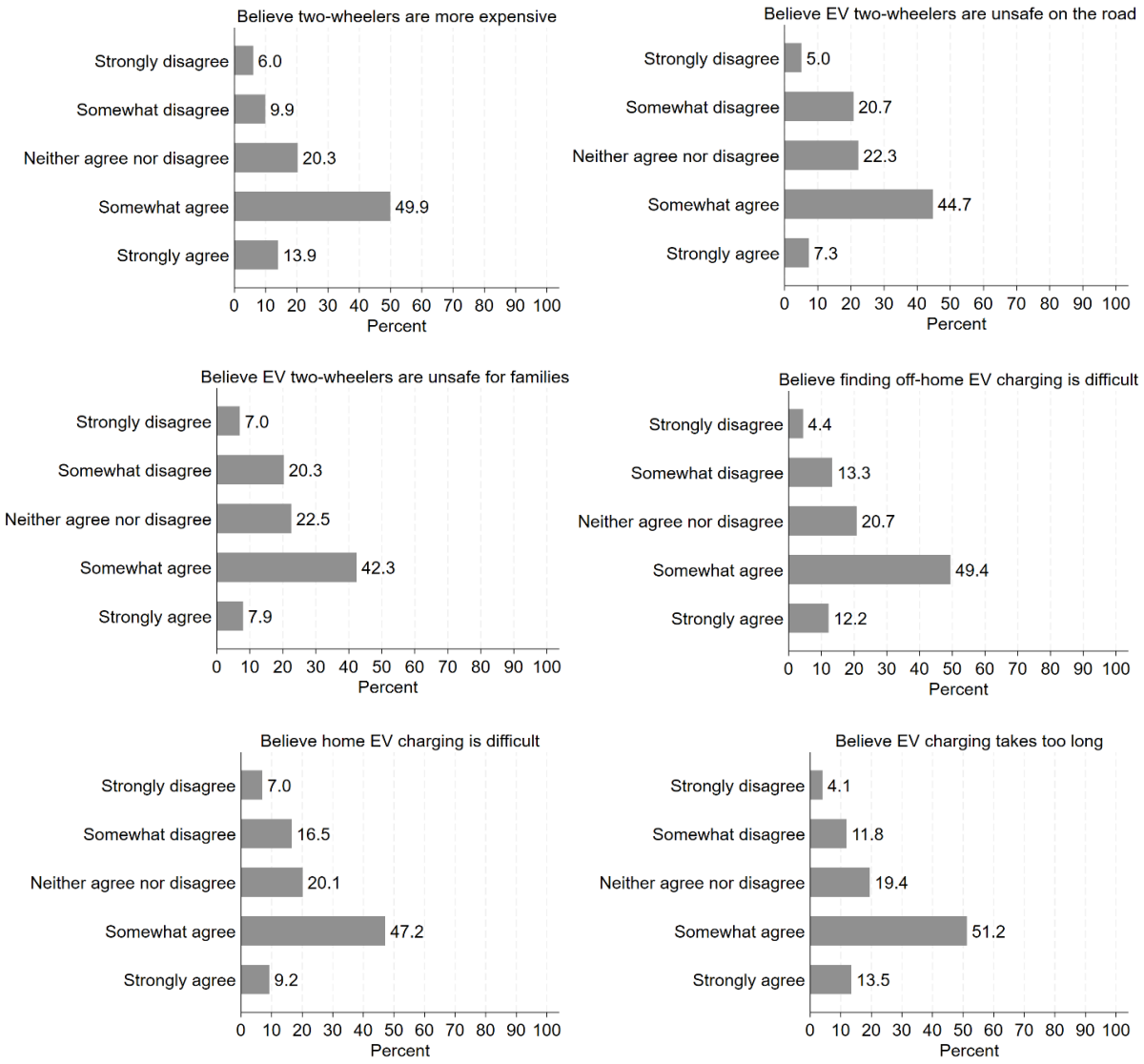


Figure 105: Respondents' perceived risks regarding cost, safety, and charging of electric two-wheeler

Figure 106 shows the respondents' perceived risks regarding cost, safety, and charging of electric two-wheeler. It shows that 63.8% (49.9% + 13.9%) of respondents somewhat or strongly agree that EV two-wheelers are more expensive than regular two-wheelers. It also shows that 52.0% (44.7% + 7.3%) of respondents somewhat or strongly agree that driving an electric two-wheeler on the road is unsafe. Additionally, it shows that 50.2% (42.3% + 7.9%) of respondents somewhat or strongly agree that electric two-wheelers are unsafe for families. Further, Figure 106 shows that 61.6% (49.4% + 12.2%) of respondents somewhat or strongly agree that finding electric two-wheeler charging away from home is difficult. It also shows that 56.4% (47.2% + 9.2%) of respondents somewhat or strongly agree that charging an electric two-wheeler at home is problematic. Additionally, 64.7% (51.2% + 13.5%) of respondents somewhat or strongly agree that charging electric two-wheelers takes too long.

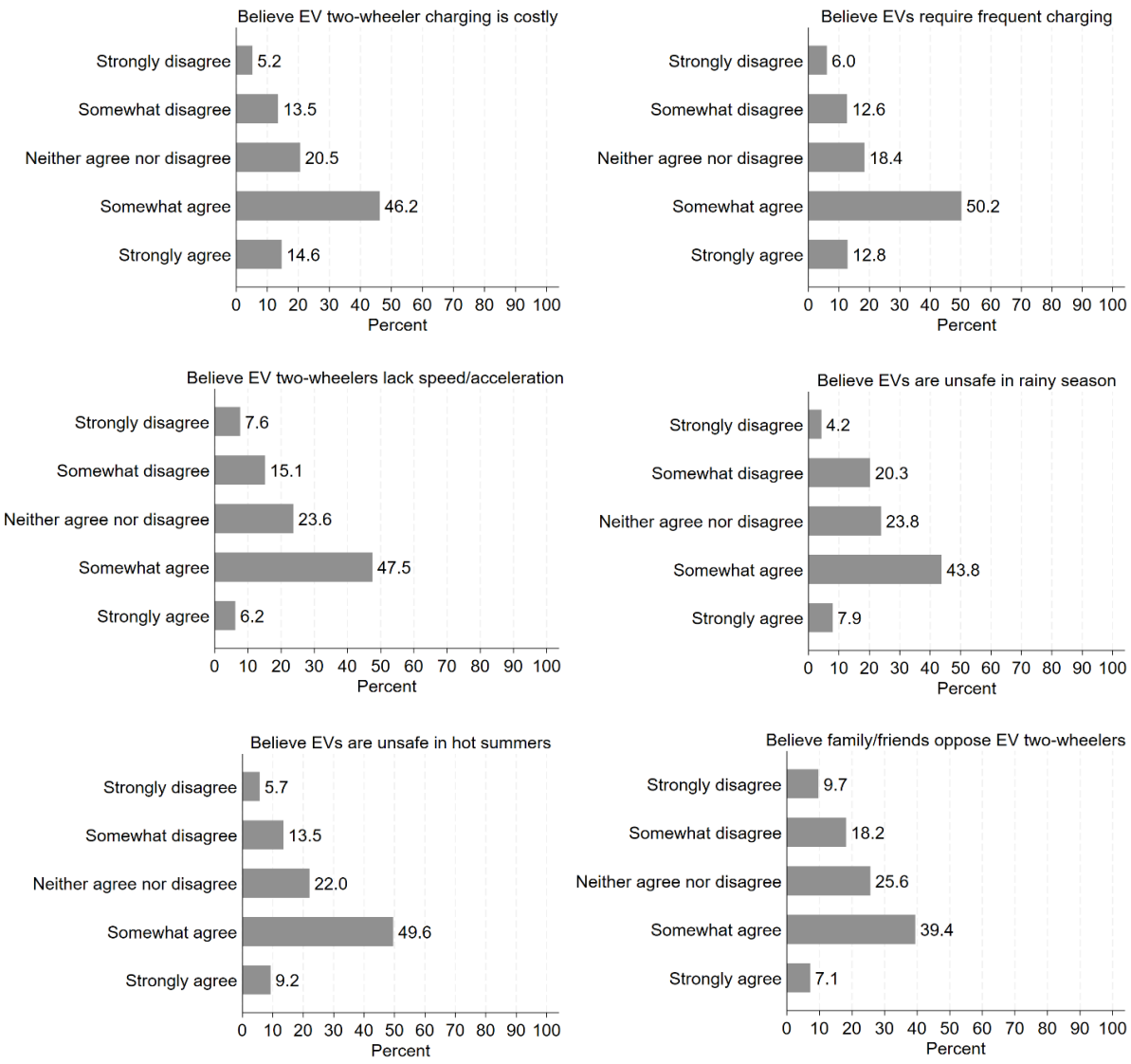


Figure 106: Respondents' perceived risks and social barriers associated with electric two-wheelers

Figure 107 shows the respondents' perceived risks and social barriers associated with electric two-wheeler. It shows that 60.8% (46.2% + 14.6%) of respondents somewhat or strongly agree that charging electric two-wheelers is costly. It also shows that 63.0% (50.2% + 12.8%) of respondents somewhat or strongly agree that electric two-wheeler have a limited range and require frequent recharging. Additionally, Figure 107 shows that 53.7% (47.5% + 6.2%) of respondents somewhat or strongly agree that electric two-wheeler lacks speed and acceleration. Further, it shows that 51.7% (43.8% + 7.9%) of respondents somewhat or strongly agree that EV two-wheelers are unsafe in the rainy season. It also shows that 58.8% (49.6% + 9.2%) of respondents somewhat or strongly agree that an electric two-wheeler is unsafe in hot summers. Finally, it shows that 46.5% (39.4% + 7.1%) of respondents somewhat or strongly agree that their family and friends would not support the purchase of an electric two-wheeler.

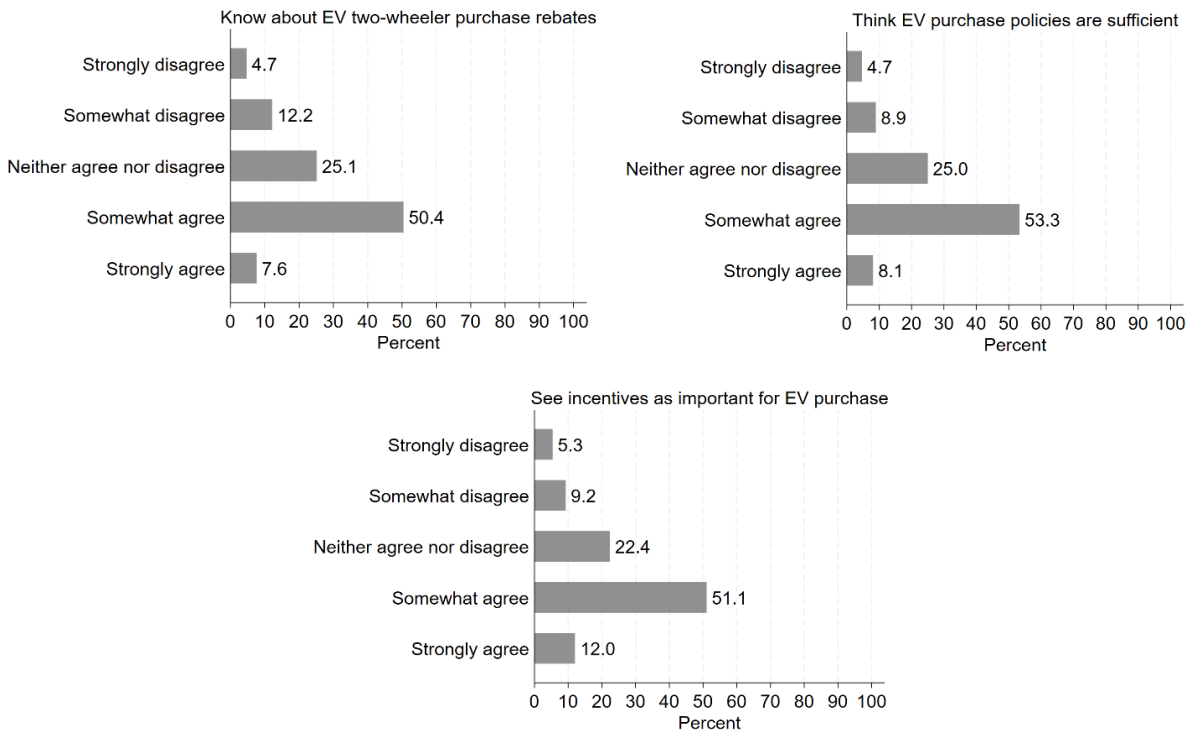


Figure 107: Respondents' awareness and perceptions regarding government policy support and rebates for electric two-wheeler

Figure 108 shows the respondents' awareness and perceptions regarding government policy support and rebates for electric two-wheeler vehicles. It shows that 58.0% (50.4% + 7.6%) of respondents somewhat or strongly agree they know about electric two-wheeler purchase rebates. It also shows that 61.4% (53.3% + 8.1%) of respondents somewhat or strongly agree that policy support for electric two-wheelers is sufficient. Additionally, 63.1% (51.1% + 12.0%) of respondents somewhat or strongly agree that rebates and support are important when purchasing an electric two-wheeler.

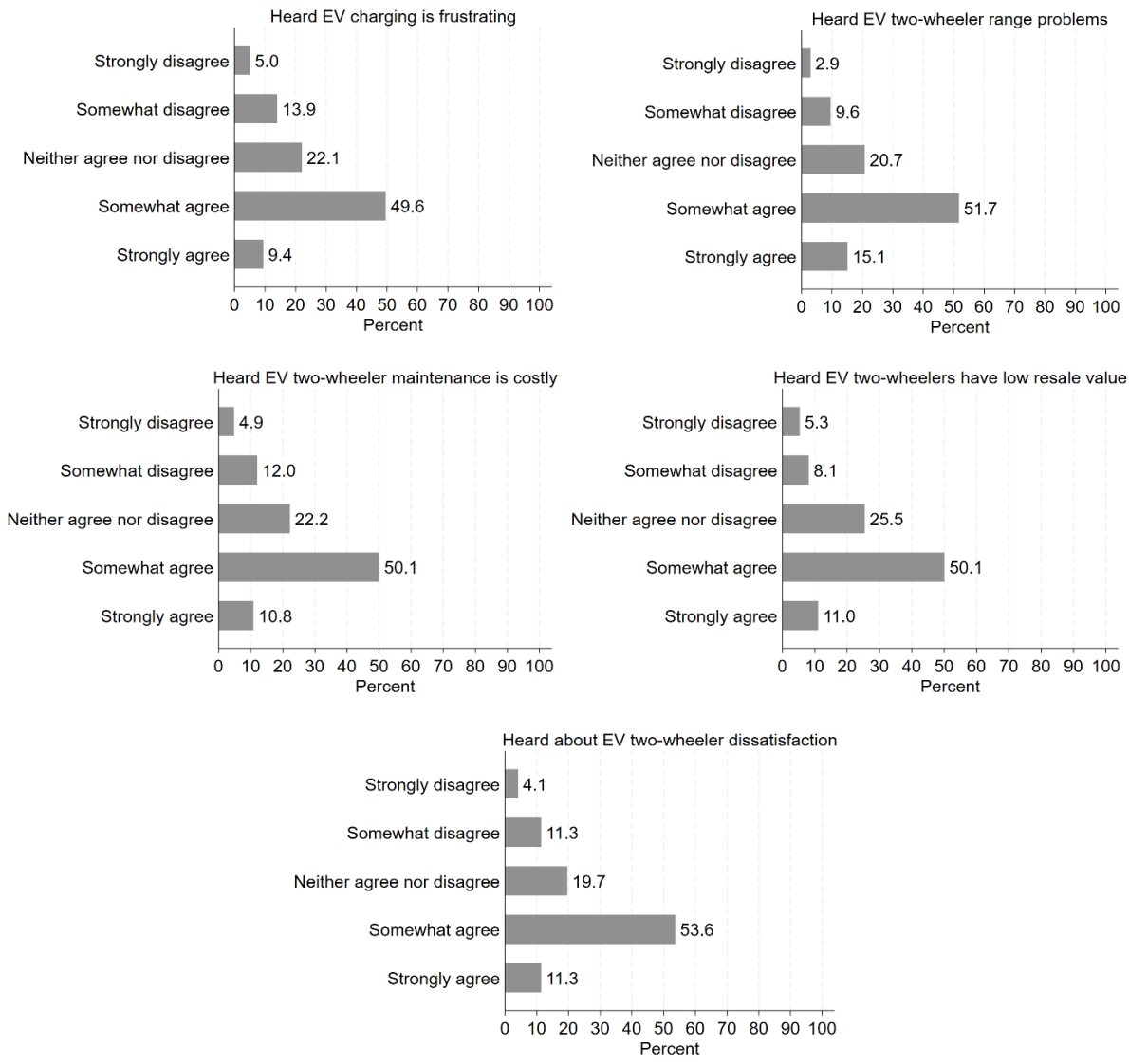


Figure 108: Respondents' awareness of negative word-of-mouth regarding electric two-wheelers

Figure 109 shows respondents' awareness of negative word-of-mouth regarding electric two-wheelers. It shows that 59.0% (49.6% + 9.4%) of respondents somewhat or strongly agree they have heard about frustrations with electric two-wheeler charging. It also shows that 66.8% (51.7% + 15.1%) of respondents somewhat or strongly agree they have heard about frustrations with the low-range electric two-wheeler. Additionally, Figure 109 shows that 60.9% (50.1% + 10.8%) of respondents somewhat or strongly agree they have heard about high electric two-wheeler repair and maintenance costs. Further, 61.1% (50.1% + 11.0%) of respondents somewhat or strongly agree they have heard about the low resale value of electric two-wheeler. Also, 64.9% (53.6% + 11.3%) of respondents somewhat or strongly agree that they have heard of overall dissatisfaction with electric two-wheelers.

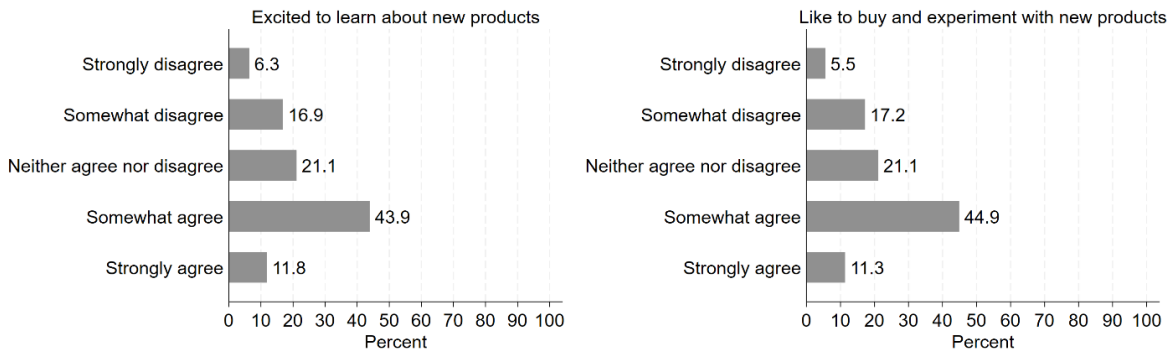


Figure 109: Respondents' enthusiasm and willingness to experiment with new products

Figure 110 shows the respondents' enthusiasm and willingness to experiment with new products. It shows that 55.7% (43.9% + 11.8%) of respondents somewhat or strongly agree they are excited to learn about new products. It also shows that 56.2% (44.9% + 11.3%) of respondents somewhat or strongly agree they like to buy and experiment with new products.

7.3. Cross-Tabulation of Data Across Selected Themes

This section presents a cross-tabulation of the data collected across selected themes for respondents considering switching to/adding an Electric two-wheeler. Figure 111 shows the perceived concern about electric two-wheeler safety in the rain across age groups. It shows that respondents aged 30–39 years report the highest combined agreement at 53.2% (46.1% + 7.1%). In comparison, respondents aged 30 years or younger report the lowest combined agreement at 48.0% (42.0% + 6.0%). It also shows that respondents aged 40–49 years report the highest combined disagreement at 28.9% (6.2% + 22.7%), while those aged 30–39 years report the lowest at 19.5% (3.4% + 16.1%).

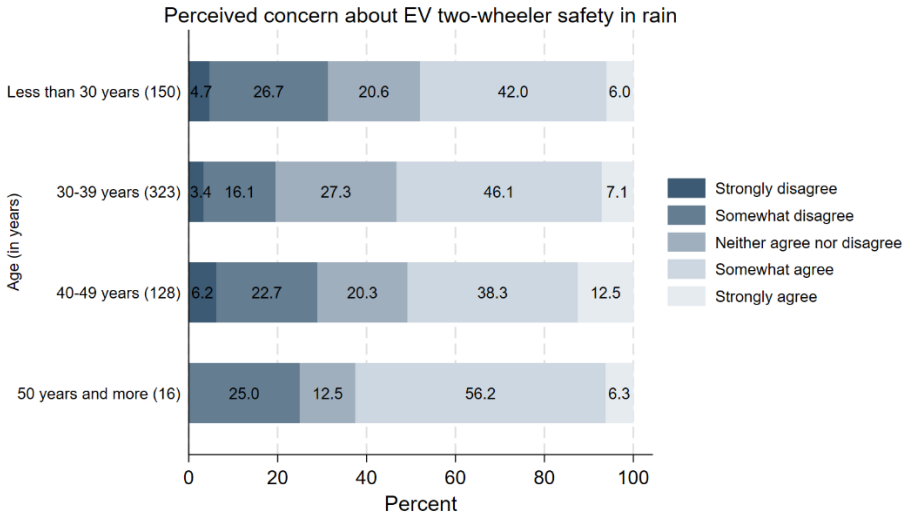


Figure 110: Perceived concern about electric two-wheeler safety in rain by age group

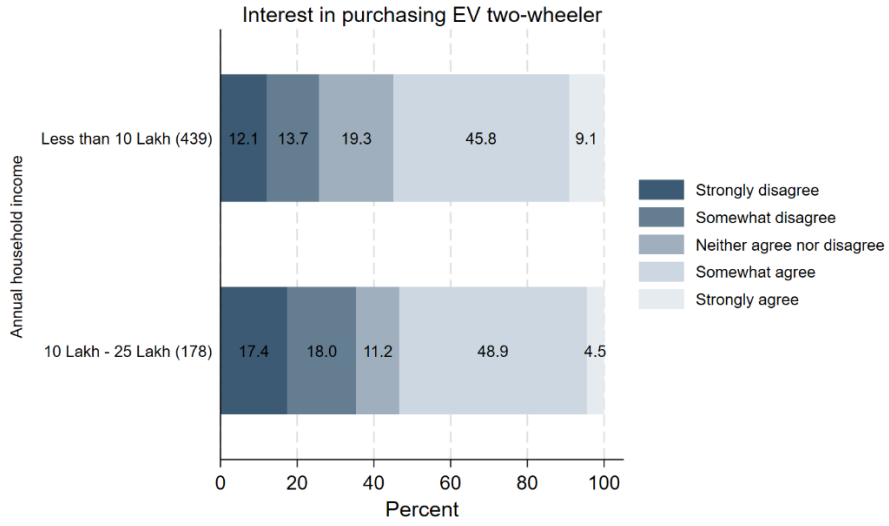


Figure 111: Interest in purchasing an electric two-wheeler by annual household income

Figure 112 shows interest in purchasing an electric two-wheeler across income groups. It shows that respondents earning less than ₹10 lakh report the highest combined agreement at 54.9% (45.8% + 9.1%), while those in the ₹10–25 lakh income group report lower at 53.4% (48.9% + 4.5%). It also shows that respondents in the ₹10–25 lakh income group report the highest combined disagreement at 35.4% (17.4% + 18.0%), while those earning less than ₹10 lakh report lower combined disagreement at 25.8% (12.1% + 13.7%).

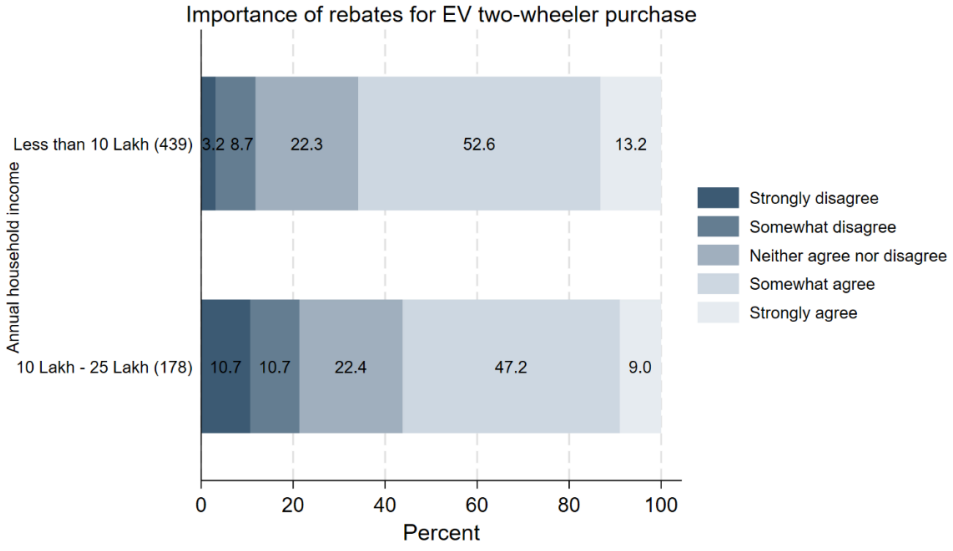


Figure 112: Importance of rebates for electric two-wheeler purchase by annual household income

Figure 113 shows the importance of rebates across income groups. It shows that respondents earning less than ₹10 lakh report the highest combined agreement at 65.8% (52.6% + 13.2%), while those in the ₹10–25 lakh income group report lower 56.2% (47.2% + 9.0%). It also shows that respondents in the ₹10–25 lakh income group report the highest combined disagreement at 21.4% (10.7% + 10.7%), while those earning less than ₹10 lakh report lower combined disagreement at 11.9% (3.2% + 8.7%).

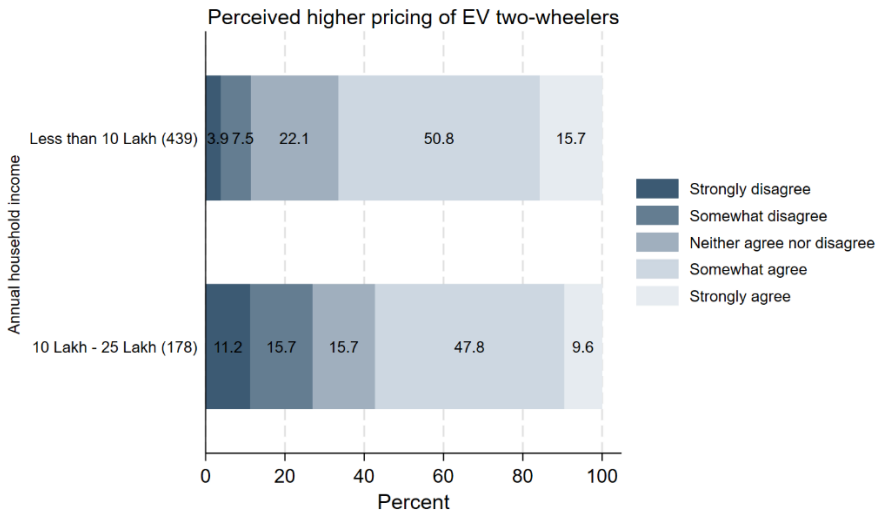


Figure 113: Perceived higher pricing of electric two-wheeler by annual household income

Figure 114 shows the perception of higher pricing across income groups. It shows that respondents earning less than ₹10 lakh report the highest combined agreement at 66.5% (50.8% + 15.7%), while those in the ₹10–25 lakh income group report the lowest at 57.4% (47.8% + 9.6%). It also shows that respondents in the ₹10–25 lakh income group report the highest combined disagreement at 26.9% (11.2% + 15.7%), while those earning less than ₹10 lakh report the lowest combined disagreement at 11.4% (3.9% + 7.5%).

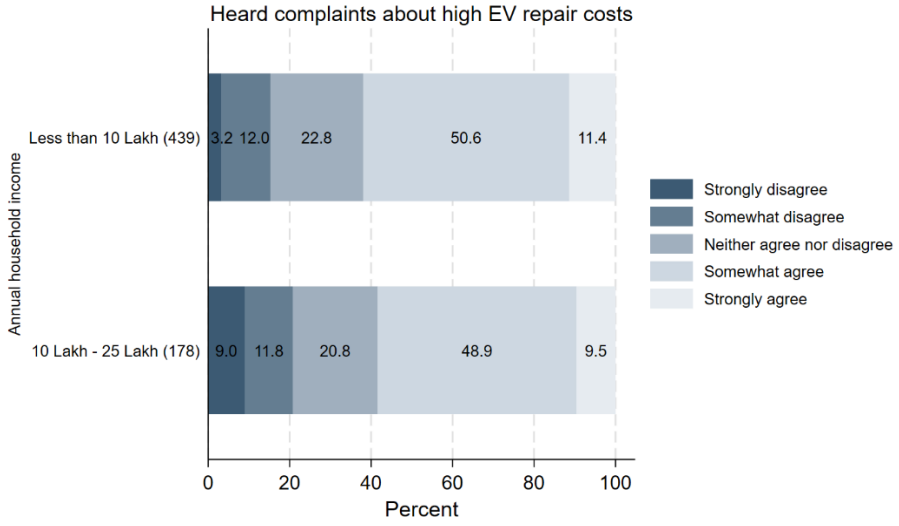


Figure 114: Heard complaints about high EV repair costs by annual household income

Figure 115 shows whether respondents have heard complaints about high EV repair costs across income groups. Figure 115 shows that respondents earning less than ₹10 lakh report the highest combined agreement at 62.0% (50.6% + 11.4%), while those in the ₹10–25 lakh income group report the lowest at 58.4% (48.9% + 9.5%). It also shows that respondents in the ₹10–25 lakh income group report the highest combined disagreement at 20.8% (9.0% + 11.8%), while those earning less than ₹10 lakh report lower combined disagreement at 15.2% (3.2% + 12.0%).

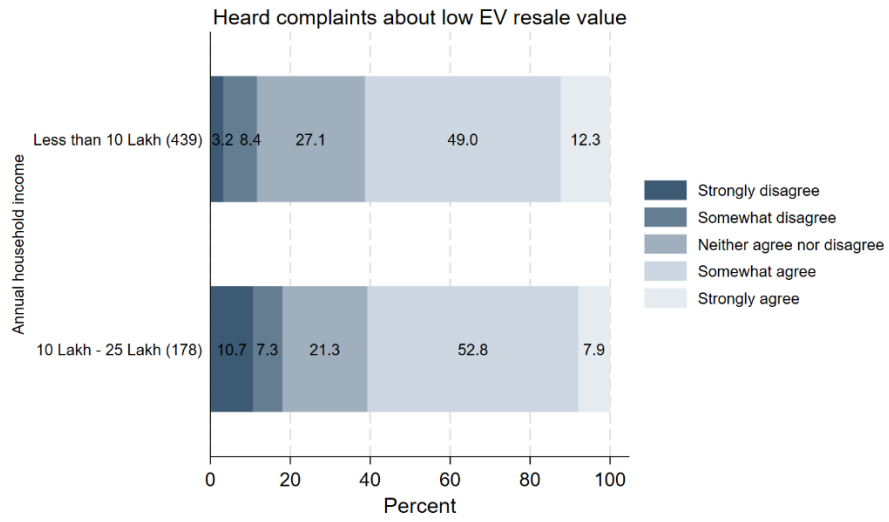


Figure 115: Heard complaints about low EV resale value by annual household income

Figure 116 shows whether respondents have heard complaints about low EV resale value across income groups. Figure 116 shows that respondents earning less than ₹10 lakh report the highest combined agreement at 61.3% (49.0% + 12.3%), while those in the ₹10–25 lakh income group report the lowest at 60.7% (52.8% + 7.9%). It also shows that respondents in the ₹10–25 lakh income group report the highest combined disagreement at 18.0% (10.7% + 7.3%), while those earning less than ₹10 lakh report lower combined disagreement at 11.6% (3.2% + 8.4%).

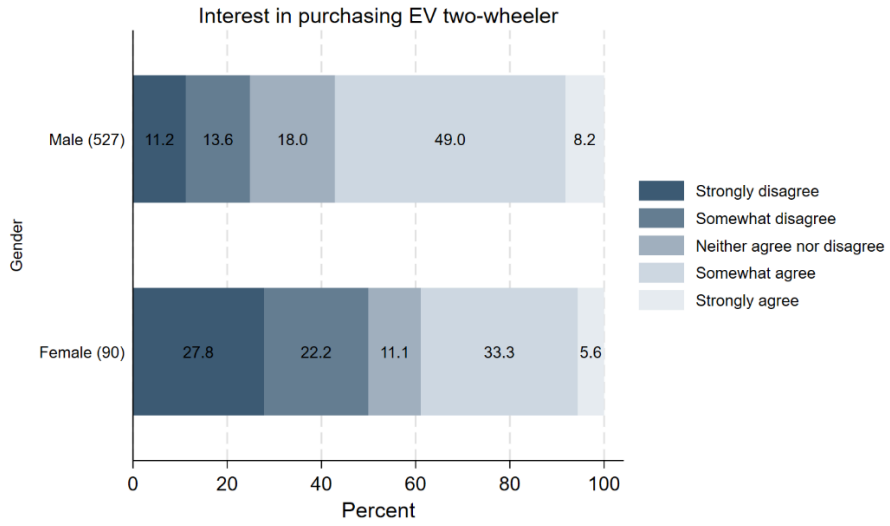


Figure 116: Interest in purchasing an electric two-wheeler by gender

Figure 117 shows interest in purchasing an electric two-wheeler across gender groups. Figure 117 shows that male respondents report the highest combined agreement at 57.2% (49.0% + 8.2%), whereas female respondents report the lowest at 38.9% (33.3% + 5.6%). It also shows that female respondents report the highest combined disagreement, at 50.0% (27.8% + 22.2%), while male respondents report the lowest, at 24.8% (11.2% + 13.6%).

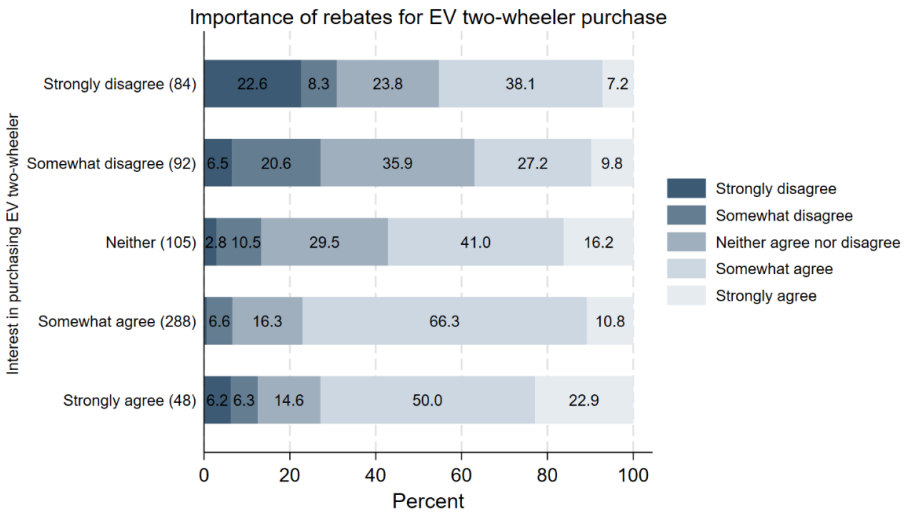


Figure 117: Importance of rebates for electric two-wheeler purchase by level of purchase interest

Figure 118 shows the importance of rebates for electric two-wheeler purchase by level of purchase interest. It shows that respondents who somewhat agree that they are interested in purchasing an electric two-wheeler report the highest combined agreement at 77.1% (66.3% + 10.8%), while respondents who strongly disagree with purchase interest report the lowest combined agreement at 45.3% (38.1% + 7.2%). It also shows that respondents who strongly disagree with purchase interest report the highest combined disagreement at 30.9% (22.6% + 8.3%), while those who strongly agree with purchase interest report the lowest combined disagreement at 12.5% (6.2% + 6.3%).

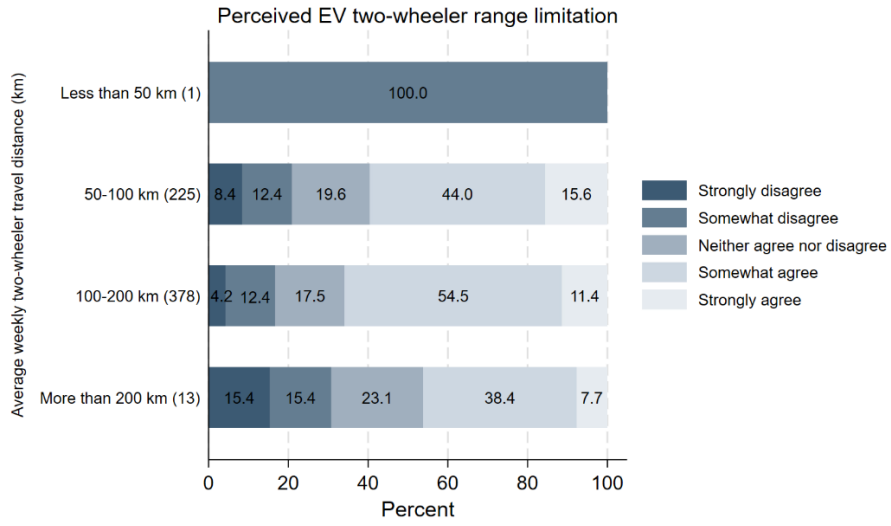


Figure 118: Perceived electric two-wheeler range limitation by average weekly two-wheeler travel distance

Figure 119 shows the perceived range limitation of electric two-wheelers across various levels of average weekly two-wheeler travel distance. It shows that respondents traveling 100–200 km per week report the highest combined agreement, at 65.9% (54.5% + 11.4%), while those traveling more than 200 km per week report the lowest, at 46.1% (38.4% + 7.7%). It also shows that respondents traveling

more than 200 km report the highest combined disagreement, at 30.8% (15.4% + 15.4%), while those traveling 100–200 km report the lowest, at 16.6% (4.2% + 12.4%).

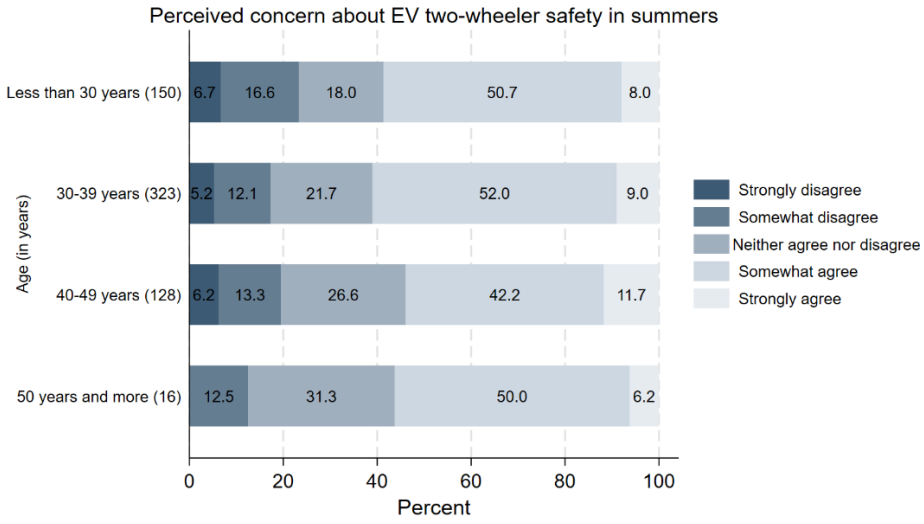


Figure 119: Perceived concern about electric two-wheeler safety in the summer by age group

Figure 120 shows the perceived concern about electric two-wheeler safety in the summer across different age groups. It shows that respondents aged 30–39 years report the highest combined agreement at 61.0% (52.0% + 9.0%). In comparison, respondents aged 40–49 years report the lowest combined agreement at 53.9% (42.2% + 11.7%). It also shows that respondents aged 40–49 years report the highest combined disagreement at 19.5% (6.2% + 13.3%), while those aged 30–39 years report the lowest at 17.3% (5.2% + 12.1%).

7.4. Key Insights about Potential Electric Two-Wheeler Consumers in India

The cross-tabulations show that price sensitivity and subsidy dependence remain structurally central to electric two-wheeler adoption, particularly among lower-income households. Respondents earning less than ₹10 lakh report the highest combined agreement that electric two-wheelers are highly priced (66.5%) and the highest combined agreement on the importance of rebates (65.8%). This pattern indicates that affordability remains a primary constraint for this income group. In comparison, the ₹10–25 lakh group reports lower combined agreement on both perceived higher pricing (57.4%) and the importance of rebates (56.2%), and higher combined disagreement on these dimensions. This suggests that while price remains relevant across income groups, subsidy sensitivity is disproportionately concentrated among lower-income consumers.

The results also show that negative word of mouth about repair costs and resale value is widespread across income groups. Combined agreement that respondents have heard complaints about high repair costs exceeds 58% for both income segments, and combined agreement regarding low resale value exceeds 60% for both segments. The minimal variation between income groups indicates that perceived risk related to ownership costs is not income-segmented but system-wide. This implies that

confidence-building measures related to durability, warranty, and resale assurance would have a broad-based impact rather than a segment-specific impact.

Gender differences in purchase intent are structurally pronounced. Male respondents report a combined agreement rate of 57.2% for purchasing an electric two-wheeler, while female respondents report only 38.9%. Simultaneously, female respondents report the highest combined disagreement at 50.0%, compared to 24.8% among male respondents. This gap suggests that the electric two-wheeler market remains male-dominated in terms of expressed purchase intention. The data indicate that interventions targeting female awareness, safety assurance, and product design may be necessary to close this gap.

The relationship between purchase interest and the importance of the rebate is strongly aligned. Respondents who somewhat agree that they are interested in purchasing report the highest combined agreement on the importance of rebates at 77.1%, while those who strongly agree report 72.9%. In contrast, respondents who strongly disagree with purchase interest report the lowest combined agreement at 45.3% and the highest combined disagreement at 30.9%. This indicates that subsidy design disproportionately influences the already interested segment rather than converting the strongly resistant segment. Therefore, rebate policies may be more effective as acceleration tools rather than persuasion tools.

Range limitation concerns are most pronounced among respondents traveling 100–200 km per week, who report the highest combined agreement at 65.9%. In contrast, respondents traveling more than 200 km report the lowest combined agreement at 46.1% and the highest combined disagreement at 30.8%. This pattern suggests that moderate-to-high usage commuters perceive range limitations more acutely than very high-distance riders. It indicates that battery performance, communication, and real-world range assurance would be particularly relevant for mid- to high-distance commuters rather than very long-distance users.

Age differences in safety perception during rain are moderate but structured. Respondents aged 30–39 years report the highest combined agreement at 53.2%, while those below 30 years report the lowest at 48.0%. Combined disagreement is lowest among respondents aged 30–39, at 19.5%, and highest among those aged 40–49, at 28.9%. This suggests that safety concerns are present across working-age cohorts, with no extreme polarization, but slightly elevated caution among middle-aged riders.

Age differences in safety perceptions during summer further reinforce the age-based pattern observed in rain-related safety perceptions. Respondents aged 30–39 years report the highest combined agreement at 61.0%, indicating comparatively greater concern regarding seasonal safety risks. In contrast, respondents aged 40–49 years report lower combined agreement (53.9%) and the highest combined disagreement (19.5%). This suggests that seasonal safety concerns are present across working-age cohorts but are slightly more pronounced among respondents in their thirties.

Overall, the G4 findings indicate three distinct intervention levers. First, price and subsidy mechanisms remain critical for lower-income and already-interested consumers. Second, ownership risk perceptions related to repair costs and resale value are widespread and require ecosystem-level confidence-building measures. Third, gender-based differences in purchase intent suggest a structural demand gap that may require differentiated communication, product positioning, and safety

assurance strategies. These findings collectively indicate that electric two-wheeler adoption is constrained not by a single factor but by a combination of affordability, perceived lifecycle risk, and segment-specific confidence gaps.

7.5. Segmentation of Potential Electric Two-Wheeler Consumers in India

This section presents customer segmentation based on data collected across selected themes from respondents considering switching to/adding an electric two-wheeler.

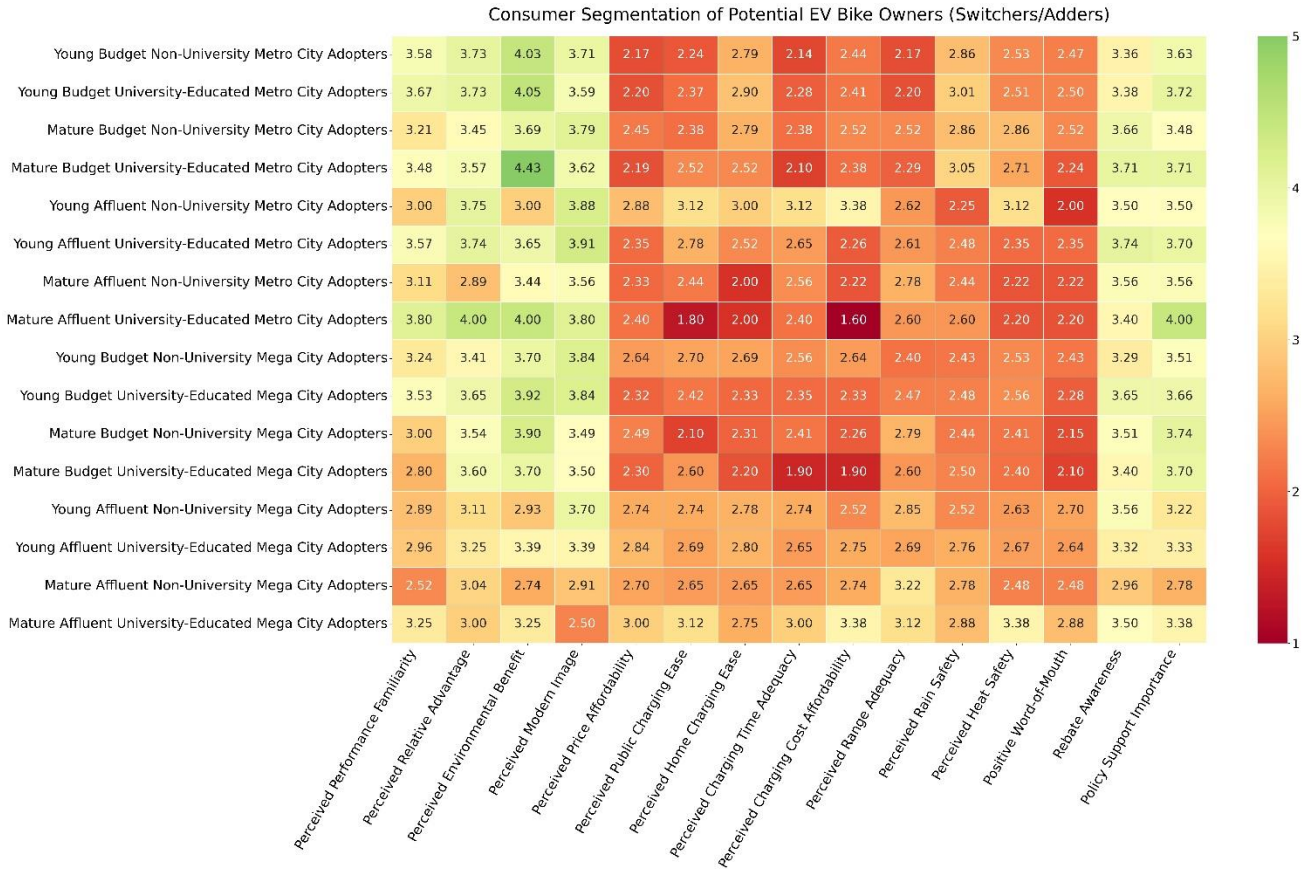


Figure 120: Consumer segmentation of potential electric two-wheeler owners (Switchers/Adders)

Figure 121 shows the mean scores of perception and preference variables across segmented consumer groups for the electric two-wheeler. The values represent mean averages for each consumer segment across the listed attributes.

It shows that perceived environmental benefit records consistently high mean values across segments, with the highest mean observed among Mature Budget University-Educated Metro Adopters at 4.43, while the lowest mean is observed among Mature Affluent Non-University Mega-city Adopters at 2.74. It also shows that perceived relative advantage remains high among university-educated segments, with Mature Affluent University-Educated Metro Adopters reporting the highest mean at 4.00, while Young Affluent Non-University Mega-city Adopters report the lowest at 3.11.

Figure 121 further shows that the perceived modern image is highest among Young Affluent University-Educated Metro Adopters at 3.91, while Mature Affluent University-Educated Mega-city Adopters report the lowest at 2.50. Additionally, perceived performance familiarity is highest among Mature Affluent University-Educated Metro Adopters at 3.80 and lowest among Mature Affluent Non-University Mega-city Adopters at 2.52.

In contrast, affordability-related variables show relatively lower mean values across most segments. Perceived price affordability is lowest among Young Budget Non-University Metro Adopters at 2.17 and highest among Mature Affluent University-educated Mega-city Adopters at 3.00. Perceived charging cost affordability shows the lowest mean of 1.60 among Mature Affluent University-Educated Metro Adopters and the highest of 3.38 among Mature Affluent University-Educated Mega-city Adopters.

Charging-related perceptions show moderate variation. Perceived public charging ease is highest among Young Affluent Non-University Metro Adopters at 3.12 and lowest among Mature Affluent University-Educated Metro Adopters at 1.80. Perceived home charging ease is highest among Young Affluent Non-University Metro Adopters at 3.00 and lowest among Mature Affluent Non-University Metro Adopters at 2.00. Perceived adequacy of charging time is highest among Young Affluent Non-University Metro-city Adopters at 3.12 and lowest among Mature Budget University-Educated Mega-city Adopters at 1.90.

Perceived range adequacy is highest among Mature Affluent Non-University Mega-city Adopters at 3.22 and lowest among Young Budget Non-University Metro Adopters at 2.17. Safety perceptions also show variation, with perceived rain safety highest among Mature Budget University-educated Metro-city Adopters at 3.05 and lowest among Young Affluent Non-University Metro Adopters at 2.25. Perceived heat safety is highest among Mature Affluent University-Educated Mega-city Adopters at 3.38 and lowest among Mature Affluent University-educated Metro Adopters at 2.2.

Positive word-of-mouth perception is highest among Mature Affluent University-Educated Mega-city Adopters at 2.88 and lowest among Young Affluent Non-University Metro Adopters at 2.00. Rebate awareness is highest among Young Affluent University-Educated Metro Adopters at 3.74 and lowest among Mature Affluent Non-University Mega-city Adopters at 2.96. The importance of policy support is highest among Mature Affluent University-Educated Metro Adopters at 4.00 and lowest among Mature Affluent Non-University Mega-city Adopters at 2.78.

Overall, Figure 121 shows that university-educated and metro segments report consistently higher mean values on environmental benefit, relative advantage, and policy support importance. At the same time, affordability and charging time adequacy remain comparatively lower across most segments. Mega-city-affluent segments show comparatively higher means for range and safety perceptions, whereas metro budget segments report a comparatively stronger emphasis on environmental benefits and policy support.

7.5.1. Insights and Targeted Implications from Consumer Segmentation Analysis of Potential Electric Two-Wheeler Consumers

The segmentation analysis for G4 shows that environmental and policy-driven motivations are structurally stronger than affordability perceptions across most segments. Perceived environmental

benefit records the highest mean of 4.43 among Mature Budget University-Educated Metro Adopters, while the lowest mean of 2.74 is observed among Mature Affluent Non-University Mega-city Adopters. Similarly, the importance of policy support reaches a maximum mean of 4.00 among Mature Affluent University-Educated Metro Adopters and falls to a minimum of 2.78 among Mature Affluent Non-University Mega-city Adopters. This indicates that metro and university-educated segments show stronger normative alignment with environmental and policy narratives than affluent mega-city non-university segments.

Affordability variables remain structurally weaker across segments. Perceived price affordability records a lowest mean of 2.17 among Young Budget Non-University Metro Adopters and does not exceed 3 in any segment. Perceived charging cost affordability reaches a minimum of 1.60 among Mature Affluent University-Educated Metro Adopters and a maximum of 3.38 among Mature Affluent University-Educated Mega-city Adopters. These values indicate that even among higher-income or university-educated groups, affordability remains a constrained perception dimension rather than a strong positive driver.

Charging and range perceptions show moderate but segmented variation. Perceived public charging ease falls as low as 1.80 among Mature Affluent University-Educated Metro Adopters and does not exceed 3.12 across segments. Perceived range adequacy reaches a maximum of 3.12 among Mature Affluent University-Educated Mega-city Adopters and a minimum of 2.17 among Young Budget Non-University Metro Adopters. This pattern suggests that range adequacy and charging ease remain mid-level perception variables rather than high-confidence attributes, particularly among budget and non-university groups.

Safety perceptions also remain moderate. Perceived rain safety ranges from a low of 2.25 among Young Affluent Non-University Metro Adopters to a high of 3.05 among Mature budget University-educated Metro-city Adopters. Perceived heat safety reaches a maximum of 3.38 among Mature Affluent University-Educated Mega-city Adopters and a minimum of 2.20 among Mature Affluent University-educated Metro Adopters. These values indicate that safety confidence is neither uniformly high nor uniformly low but varies across income and education segments.

Performance familiarity and relative advantage show comparatively stronger mean values among university-educated segments. Perceived performance familiarity reaches 3.80 among Mature Affluent University-Educated Metro Adopters and declines to 2.52 among Mature Affluent Non-University Mega-city Adopters. Perceived relative advantage reaches 4.00 among Mature Affluent University-Educated Metro Adopters and drops to 3.00 among Mature Affluent University-Educated Mega-city Adopters.

Taken together, the G4 segmentation results indicate three structured consumer clusters for intervention. First, university-educated metro segments demonstrate strong alignment with environmental and policy goals but relatively weak perceptions of affordability, suggesting that targeted financial instruments may accelerate adoption among already motivated groups. Second, affluent mega-city segments exhibit relatively stronger perceptions of range and safety but weaker environmental and policy orientations, suggesting that positioning strategies emphasizing performance and technological sophistication may be more effective. Third, the budget and non-university segments show lower familiarity, lower range adequacy, and lower safety perceptions,

suggesting that awareness-building and experiential demonstration programs would be critical for building confidence.

8. Conclusion and Future Recommendations

The evidence from findings across all four sections reveals that India's electric vehicle transition is fundamentally a crisis of confidence rather than a lack of intent. While awareness of government policies and environmental benefits is high across all consumer segments, agreement scores frequently exceed 70%, actual adoption is stalled by a "translation gap" around long-term ownership risks. The most striking evidence is the structural concern regarding resale value and repair costs, which persists across all segments regardless of income or ownership status. Approximately 67.3% of existing EV owners report frustration regarding resale value, a sentiment mirrored by nearly 75% of potential EV buyers. This suggests that the Indian market is moving away from moral or economic evaluations of EVs toward a risk-based assessment. For first-time buyers, the barrier is the perceived immaturity of the urban system. At the same time, for existing owners, it is the potential for "technological obsolescence" and the complexity of high-cost repairs.

The post-adoption data provide crucial evidence that, while subsidies drive initial sales, they do not guarantee ecosystem retention. A significant finding is that "continuers" and "discontinuers" both initially placed high importance on purchase incentives, yet their paths diverged based on functional satisfaction. Continuers are characterized by a superior driving experience and high app engagement, suggesting they have successfully adapted to the EV's operational requirements. However, potential discontinuers, or those still using EVs but considering an exit, report the lowest satisfaction with the ease of public charging. This indicates that charging friction is not merely a nuisance but an active driver of market exit. Furthermore, the evidence shows that low-income EV owners (earning <10 lakh INR) are the most reliant on their vehicles for long-distance travel, frequently outperforming higher-income segments in usage intensity. This high reliance builds adaptive capacity but also increases exposure to system failures, making this "budget-intensive" segment the most vulnerable to infrastructure gaps.

In the two-wheeler segment, the data identifies a distinct "Mid-Range Rider" anxiety. Those traveling 100–200 km per week, or the core of the urban workforce, perceive range limitations more acutely (65.9% agreement) than even high-distance riders. This is compounded by a pronounced gender gap, where male interest in EV two-wheelers (57.2%) significantly outpaces female interest (38.9%), driven largely by safety concerns and a lack of targeted product positioning. The overarching takeaway is that range anxiety has evolved into "information anxiety." Consumers are less afraid of the battery's physical limits and more concerned about the inability to find a reliable, fast-charging station or a qualified local mechanic when an inevitable issue arises.

Based on these findings, the policy and market roadmap must shift from "Incentivizing the Purchase" to "Securing the Lifecycle." First, the government and industry must collaborate to establish a standardized secondary EV market. Without guaranteed buyback schemes or transparent battery health certification, the 60-70% resale-value concern will continue to deter risk-averse households. Second, the repair ecosystem must be decentralized. The current reliance on OEM-exclusive service

centers creates a perception of repair complexity and cost uncertainty; skilling local mechanics and mandating standardized diagnostic tools is essential to normalize EV maintenance.

Third, infrastructure visibility must take precedence over the mere number of chargers. Digital integration that provides real-time, universal visibility of public charging stations effectively treats information as infrastructure, the only way to resolve the deep-seated range anxiety among potential two-wheeler consumers. Fourth, marketing strategies must be bifurcated for consumer segments in metro cities earning below 10 lakh per annum. The narrative for these consumers should emphasize "Cost and System Reliability," while for affluent segments, the focus should shift to "Technology and Aspirational Image". Finally, to close gender- and age-based gaps, safety assurance during monsoon and summer extremes must be demystified through transparent test data and extended warranties. By addressing these ecosystem-level frictions rather than just lowering upfront costs, India can transition from a policy-supported early market to a self-sustaining, consumer-led electric mobility future.

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Chapter 8

EV Dealership Capabilities and Consumer Ground Realities

Chapter Summary

Content:

1. Examines electric vehicle (EV) adoption in India from the perspective of automobile dealerships, shifting the analytical focus away from consumers and policymakers.
2. Draws on 32 semi-structured interviews with EV dealership managers and salespersons across Delhi, Ahmedabad, and Varanasi to understand sales processes, customer interactions, and marketing challenges.

Findings:

1. Dealers identify multiple, interlinked barriers to EV adoption, including infrastructural, technological, financial, psychological, and policy-related constraints that shape customer hesitation.
2. These barriers generate a dealership-level motivation dilemma, driven by lower margins, longer sales cycles, inadequate incentives, limited training, and pressure to meet manufacturer targets.

Takeaways:

1. Strengthening EV adoption requires addressing demand-side barriers alongside dealership-specific constraints through improved charging reliability, stable incentives, and affordable EV offerings.
2. Dealer-focused interventions, such as targeted training, aligned incentives, and differentiated strategies across customer segments, are critical to improving customer experience and boosting EV sales.

1. Introduction

India is actively advancing the electrification of its road transport, implementing policies such as the Faster Adoption and Manufacturing of Electric Vehicles (FAME) scheme to accelerate the transition of transportation away from fossil fuels. The Government of India (GoI) has set an ambitious goal of achieving 30% EV sales out of total new vehicle sales by 2030, recognizing that rapid electrification is key to decarbonizing a sector that contributes significantly to the country's CO2 emissions. However, despite this active support, EV adoption rates for four-wheelers remain modest; for instance, battery-electric vehicles accounted for merely 2.5% of total car sales in India in 2024.

To effectively accelerate EV adoption, it is important to understand the practical challenges and consumer dynamics encountered at the point of sale. Automobile dealerships are crucial intermediate points, bridging the gap between EV manufacturers and potential customers, as they exert a direct influence on consumer experience and purchase decisions. While existing literature often focuses on consumer surveys or expert interviews, the perspectives and ground realities experienced by dealership professionals, such as owners, managers, and salespersons, have largely gone unexplored. These professionals possess unique, first-hand knowledge of market dynamics and consumer behavior that is essential for informing effective policy and strategy.

1.1. Scope

This chapter draws on qualitative insights from dealerships across three diverse Indian metropolitan cities (Delhi, Ahmedabad, and Varanasi) to address this gap. The first section of this chapter outlines the fundamental barriers to faster EV adoption in India, such as infrastructural issues (like an unreliable power supply and a lack of home charging facilities), technological anxieties (like battery range concerns), financial hurdles (higher upfront costs), and unsupportive government policies. Critically, this section details how these market challenges translate into a "motivation-dilemma" for dealership professionals, driven by factors like reduced sales profits, lower back-end income from servicing and repairs, and the greater time and effort required to sell an EV compared to a conventional vehicle.

The second section of this chapter builds on these ground realities by exploring the segmented nature of the emerging EV market through the eyes of the dealership professionals. Based on their experience of customer profiling, six distinct consumer sub-groups are identified, including 'subsidy dependents,' 'symbolic go-getters,' and 'rural conservatives'. This segmentation highlights the diversity in customer needs and demands, emphasizing that decisive factors, such as purchase price, battery range, or the desire for symbolic status, vary widely across these segments.

Finally, by unveiling first-hand dealer experiences and observed consumer realities, this chapter aims to provide the critical information needed to develop customized strategies for manufacturers and policymakers, ensuring that interventions effectively address the inherent heterogeneity of the emerging EV market in India and comparable global geographies.

2. Dealers on the Frontline: A New Perspective on EV Adoption Barriers in India

The perception of automobile dealerships regarding the adoption barriers to Electric Vehicles (EVs) and the corresponding marketing challenges has largely gone unnoticed in contemporary academic literature. The existing literature on EV adoption barriers largely draws on either expert interviews or consumer surveys. A small body of research on car dealerships examines dealers' demotivation to sell EVs, as EVs are often regarded as less attractive options; however, the underlying causes of this demotivation are often unexplored. The present research seeks to address this gap by extending the debate on EV adoption barriers, drawing on the perception of individuals at automobile dealerships – the points where the actual sales process of the vehicle takes place. We consider India a case where the EV market is still in its infancy, and the adoption barriers are extremely prevalent. The principal findings draw on 32 semi-structured interviews with individuals from EV automobile dealerships across three metropolitan cities: Delhi, Ahmedabad, and Varanasi. The research first demonstrates how individuals holding multiple positions in automobile dealerships, as intermediaries between manufacturers and customers, make sense of the barriers to faster EV uptake in India. Subsequently, we assess how such barriers translate into marketing challenges and, ultimately, into instances of motivation dilemmas for dealerships while pursuing EV sales. The findings suggest that dealership individuals, at large, have several reasons for their motivation dilemma, including profit cuts while selling EVs, reduction in back-end profits, investment of greater time and rigor to sell EVs without fair incentives, difficulties in convincing rural and middle-class customers, lack of technical and financial support from manufacturers and government, and others. The results also indicate that such factors are the immediate consequences of infrastructural, technological, financial, psychological/behavioral, and policy barriers. These findings have substantial policy implications because the motivation-dilemma that automobile dealerships in India are presently experiencing may have direct impact on customer experiences, EV sales, aftersales support, and, ultimately, India's long-term goal of transitioning its mobility landscape towards greener alternatives.

2.1. Background

To reduce the transportation sector's carbon footprint, India, like many other countries, has implemented policies to accelerate the adoption of Electric Vehicles (EVs) for road-based passenger and goods transportation. In 2015, the Government of India (GoI) launched the Faster Adoption and Manufacturing of Electric Vehicles (FAME) scheme, which was further extended and subsequently revised in 2019 (Ministry of Power, 2023). Over time, the GoI launched various other EV promotion schemes such as Performance Linked Incentive (PLI) Schemes for the automobile and auto component industry as well as for advanced chemistry cell battery storage (launched in 2021), the Scheme to Promote Manufacturing of Electric Passenger Cars in India (SPMEPCI, launched in 2024), and the PM Electric Drive Revolution in Innovative Vehicle Enhancement Scheme (PM E-DRIVE, launched in 2024). State governments have also launched their own EV-supportive initiatives, supplementing GoI schemes. These schemes involve both demand- and supply-side incentives such as consumer purchase point subsidies, financial stimuli to boost the EV manufacturing ecosystem, investments in public charging infrastructure development, and funding for research and development across the EV value

chain. Given that the road transport sector presently contributes about 14% of India's energy-induced CO2 emissions (Sinha & Sharma, 2021), rapid and widespread electrification is considered key to decarbonizing the country's road transport sector. The GoI has, in fact, set an ambitious target of achieving 30% EV sales (out of total new vehicle sales) by the year 2030 (Ministry of Power, 2023). Unfortunately, despite active support from various levels of government, EV adoption rates in the passenger vehicle segment have failed to meet initial targets, particularly for four-wheelers (EVreporter, 2025). For example, battery-electric vehicles accounted for merely 2.5% of total car sales in India in 2024 (BDO India, 2025). Effective policy design and implementation to accelerate EV adoption in the four-wheeler passenger vehicle segment is, therefore, imperative.

In light of this situation, our research seeks to revisit the barriers to EV adoption (for personal cars, i.e., automobiles only, in the context of this chapter) in India and corresponding marketing challenges from an alternative positionality, i.e., from the perspective of automobile dealers. A large body of research has explored the barriers and challenges to EV adoption in India (Bansal et al., 2021; Tarei et al., 2021; Yadav & Yadav, 2024). Past studies in the automobile domain, however, have primarily investigated consumer-level adoption challenges by surveying consumers directly with a variety of instruments and analytical approaches (Coffman et al., 2016; Sheldon & Dua, 2024). What is largely missing from this contemporary EV adoption narrative is an emphasis on the business outlets where sales occur. In other words, very little is known, in the Indian context or even globally, about the perspective of automobile dealers – owners, managers, and salespersons – on the challenges to EV sales and consumer adoption barriers. This represents a significant research gap, because dealership personnel not only act as critical intermediaries between EV manufacturers and potential customers but also directly interface with consumers daily and control how EVs are marketed and sold (De Rubens et al., 2018). The level of understanding among dealership personnel of consumer preferences, attitudes, and behaviors is unmatched. We know that direct consumer surveys can have inherent biases (Hu et al., 2022) and that manufacturers' or policymakers' perceptions about consumer attitude can be disconnected from ground realities (Ralph & Delbosc, 2017); we, therefore, expect our engagement with dealership individuals to offer novel insights into factors that promote or hinder EV purchase decisions.

Our study seeks to contribute to the existing literature on barriers to EV (fully battery-electric personal cars/automobiles, not hybrids) adoption in a developing nation, where the EV market is still at its infancy, by incorporating the experiences and perceptions of retail dealership individuals – professionals with first-hand experience on vehicle sales and customer behavior.

We first investigate EV adoption barriers that potential automobile customers face. Second, we assess how customer attitudes, perceptions, and behaviors related to EVs introduce new marketing challenges for traditional dealerships. Third, we analyze how dealers' experiences with EV customers and their own EV sales challenges result in specific coping mechanisms, including operational, marketing, and sales adjustments to meet manufacturers' targets that are often influenced by government regulations. Finally, we discuss how dealers' EV sales experiences affect their motivations to promote EV adoption among potential customers. Lack of motivation can negatively affect customer satisfaction, thereby reducing EV sales prospects further. Our study not only helps derive new insights into the barriers to EV adoption but is expected to inform dealers' EV strategy with the larger objective of boosting EV sales in India and comparable geographies globally.

We use a qualitative approach, drawing on 32 semi-structured interviews with managers and salespersons at EV automobile dealerships across Delhi, Ahmedabad, and Varanasi in India. Our research adds to the literature examining the barriers and challenges to EV uptake in the Indian automobile market, which until now, has largely been studied from either consumers' (Bansal et al., 2021; Munshi et al., 2022; Yadav & Yadav, 2024) or experts' perspectives (Dua et al., 2021; Tarei et al., 2021). In addition to capturing the dealer perspective on consumer mindsets, our study offers recommendations on the role dealers can play in improving customer experience and boosting EV sales.

This section is organized as follows: first, situate the study within the existing literature on EV adoption barriers and establish the necessity of the approach; second, describe the data sources and methodology adopted for the study. It then presents and discusses the findings, develops the key arguments emerging from the analysis, and concludes with policy recommendations.

2.2. Literature Review

2.2.1. Barriers to EV Adoption

Empirically-grounded scholarly literature on barriers to EV adoption is largely populated by EV user/non-user surveys or expert interview-based approaches. The barriers can be classified into socio-economic, infrastructural, financial, technological, and psychological/behavioral factors. Several studies, for instance, have found a positive association between education and EV adoption (Hidrue et al., 2011; Carley et al., 2013). Literature in the field of transport justice, in fact, highlights how social and economic status determines EV purchase decisions (Mullen and Marsden, 2016; Sheldon and Dua, 2024; Gupta and Anand, 2025). Elaborating on their meta-analysis of factors enabling/restricting EV adoption, Coffman et al. (2016) highlighted that the likelihood of a person purchasing an EV declines with lower levels of education and family income. While arguing that higher levels of education exacerbate environmental awareness, Gupta et al. (2024) provide a case study of India's e-mobility transition, reflecting on the roles of awareness and knowledge in consumers' intention to purchase electric cars. Moreover, the study by Curran and Tyfield (2020) emphasized that EV adoption is a privilege for urban families who can afford to purchase a second vehicle, thereby highlighting wealth inequality as a major barrier to the mass adoption of EVs.

Among infrastructural barriers, under-performing charging infrastructure, both in terms of quality and quantity, and unavailability of reliable electric supply are the most widely recognized ones (Tarei et al., 2021; Yadav and Yadav, 2024; Sbrocchi et al., 2025). Several studies reported that the lack of charging infrastructure and home charging facilities is detrimental to fast EV adoption (Li et al., 2017; Dua et al., 2021). Findings such as one by Krishna (2021) illustrate that families with more than one EV face the problem of charging priorities ('which car to charge first') because it is difficult to afford and install multiple vehicle charging points at home. Moreover, to compensate for higher electricity bills, households may need to consider installing solar panels that, in turn, contribute to the already higher upfront cost of EVs.

Literature exploring financial and technological barriers highlight issues such as higher upfront cost of EVs compared to conventional ICE vehicles (Mullen and Marsden, 2016; She et al., 2017; Dua et al., 2021; Guo and Kontou, 2021), concerns regarding battery range (Berkeley et al., 2018; Tarei et al.,

2021), resale value anxiety (Ali and Naushad, 2022; Pamidimukkala et al., 2023), and concerns related to long charging time (Li et al., 2017; Adhikari et al., 2020). Furthermore, research has also emphasized on several psychological-behavioral barriers including lack of public awareness and human discomfort with new technologies, as detrimental to faster EV adoption by consumers (Tarei et al., 2021; Munshi et al., 2022).

Despite the extensive research on barriers to EV adoption in India and other countries, a significant gap persists in the literature. As discussed earlier, while existing scholarly work principally draws on the experiences and perceptions of EV consumers or transportation experts, less is known about the perspectives and visions of automobile dealerships regarding EV marketing challenges and barriers to their adoption. A step needs to be taken in this direction, especially in a country like India, where EV adoption is still far from satisfactory. In other words, it is important to shed light on the perception of dealership individuals, people with first-hand experiences on vehicle sales and in-depth understanding of market dynamics and consumer behavior, not only to bring an alternative perspective to the debate but also to validate the findings of prior studies that are based on expert interviews or consumer surveys.

2.2.2. Why are Automobile Dealerships Important?

Automobile dealerships are privately-owned car franchises that are not directly operated or owned by the manufacturers. Such a model of franchised dealership appeared to become a way for manufacturers to balance their production capacity against unsteady demands in an emerging market (Marx, 1985). They play a crucial role in bridging the gap between the manufacturers and customers, as dealerships are the outlets where the actual sales process of the vehicles takes place. Even though automobile dealers essentially have very little or no control over vehicle attributes and features, their role is situated at the forefront of the sales process and after-sales services, where they can directly exert consequential influence on customers' choice and experiences (Golara et al., 2021).

Considering the automobile market, given the diverse range of ventures that a dealership may undertake, including customer consultation, vehicle sale, test drive, financing, parts and repair, servicing, and others, the success or failure of a newly emerging product like EV may largely depend on the performance and goodwill of dealership individuals. Furthermore, automobile dealerships add value for automakers as a reference to highly localized information on customer dynamics, while facilitating hundreds of complicated and unique transactions (Cahill et al., 2014). Though literature provides very little guidance about dealership's perspective on EV marketing challenges and adoption barriers, a very small but significant body of research has demonstrated that the capacity as well as goodwill of EV dealerships can significantly impact the EV sales and accompanying customer experiences (Tromaras et al., 2017; CDK Global, 2024). Since dealership personnel – in managerial and sales positions – exert direct control over customers' experience, they can largely influence car buyers' purchase decisions. De Rubens et al. (2018), for instance, found that in an infantile market condition, many potential customers lack substantial knowledge about EVs, and thereby the experience and information they receive at dealership outlets may have a decisive impact on their EV purchasing decisions. Their research, drawing on several shopping experiences encompassing several dealerships in the Scandinavian context, has not only captured the prevailing reluctance of dealership individuals to sell EVs but also unlayered a few instances where they misled customers with incorrect information

about vehicle features, excluded EVs from sales-related discussions, and heavily steered customers toward conventional vehicles.

Therefore, a lack of understanding of dealership personnel's perspectives may lead to a lack of understanding of the hindrances customers might experience when purchasing or using EVs. Thus, the experience and perception of individuals at automobile dealerships concerning the EV customer dynamics, challenges to EV marketing and barriers to EV uptake is likely to inform policymakers with a synoptic and more subtle view of the intersectionality of social, economic, technological, infrastructural, and other factors that play a crucial role in the success or failure of the overall green-energy narrative grounded in EVs.

2.3. Data and Methods

2.3.1. Selection of Case Cities

This research locates itself empirically in Delhi, Ahmedabad, and Varanasi, three cities in India representing different sizes of demographic clusters and, therefore, different types of EV markets. Delhi, a bustling mega-urban agglomeration with nearly 16.34 million (Census of India, 2011) population, stands as one of the largest and sharply growing EV markets in India. Ahmedabad, with a population of 6.36 million (Census of India, 2011), represents a medium-sized metropolitan city, where the EV market is moderately developed but rapidly growing. Finally, Varanasi, a small metropolitan city with a population of 1.43 million (Census of India, 2011), represents an emerging EV market. The chief objective here is not to facilitate any comparative assessment between the select cities, but to gather as much diverse information as possible concerning the study subject.

2.3.2. Data Collection and Analysis

Consistent with previous studies on emerging transport technologies and associated policymaking (Bhattacherjee, 2012; Peace et al., 2023; Sbrocchi et al., 2025), our study employs a qualitative research design surrounding in-person interviews conducted at automobile dealerships in three case cities (Figure 1). The empirical study design is grounded in a four-step research methodology involving conceptualization, pilot testing, data collection, and analysis-interpretation (Kogler et al., 2025). During the conceptualization phase, drawing on an exhaustive literature review, the structured questions were developed and the targeted respondent groups identified. For the most part, the structured questions in the interview schedule were open-ended, and handwritten interview notes were to be taken. Moreover, before data collection, the study's research plan was presented to the Institutional Review Board (IRB), and post-pilot interviews began only after our study cleared the IRB review process.

For each selected city, a comprehensive list of EV dealerships was compiled from a cross-section of retail outlets and car dealerships. While preparing the list of franchised dealerships, we have endeavored to bring a wide assortment of dealership experiences into a shared conversation concerning the nature of EV marketing challenges and adoption barriers. Contributing to this objective, we have sought to cover as many franchises as possible (e.g., TATA Motors, MG Motors, BYD, Hyundai, Mahindra, and others) while preparing the list of potential respondents in each city. In addition, the

pilot phase has drawn on a few interviews with individuals from different franchised dealerships in Ahmedabad. The ensuing assessment (for example, comparing responses of different interviewees regarding a prevailing issue with existing literature in the field) helped ensure appropriate data quality (Kogler et al., 2025). Subsequently, the structured interview questions were slightly modified based on the insights gathered from pilot interviews.

In the final interview schedule, structured questions were designed to visualize the following: retail experience of automobile dealerships with both actual and potential EV buyers (Cahill et al., 2014), their general visions on customer composition (TRB, 2013), the marketing challenges that they are facing concerning EV sales owing to both the infancy of the EV market as well as existing barriers (Tromaras et al., 2017; CDK Global, 2024) and finally the motivation/demotivation effect of these challenges and barriers that may directly impact their sales capability and willingness (De Rubens et al., 2018). The interview schedule questions were divided into five major thematic categories: background information; sales and profit information; customer information; dealer's perception and action; and challenges and prospects. Depending on the discussion's context and to continue the conversation, follow-up questions not included in the interview schedule (DiCicco-Bloom & Crabtree, 2006) were also asked to allow respondents to share their professional experience in relation to the business model of the specific franchise they work for.

The final empirical data collection for this study involved 32 semi-structured interviews with individuals holding multiple positions at EV dealerships in Delhi (11), Ahmedabad (12), and Varanasi (9). Interviewees represented two principal groups: individuals holding managerial positions (general manager/sales manager and others) at the dealerships and people in sales (salesman/team leader). The number of interviews obtained from each city closely aligns with two factors: data saturation and response rate. One-to-one interviews have been employed as the empirical research tool, as they help capture diverse experiences, opinions, expressions, and thoughts from different participants (Tromaras et al., 2017).

In all instances, potential respondents were approached directly at the dealerships for the interviews. They were provided with a brief outline of the research and asked to sign a consent form confirming their informed consent to participate in the study. Interviewees were informed that their individual identities would be anonymized in published reports, while their dealership affiliation and/or location may be mentioned (Peace et al., 2023). Individuals participating in the study, with their informed consent, were finally asked to provide only that information they were legally permitted to share. It was also brought to their attention that they had been approached for the interviews in their professional capacity. Subsequently, each interview lasted 40 to 60 minutes, and handwritten interview notes were taken to record the responses, as in almost all cases the interviewees did not permit us to use any recording device.

In the last phase, the hand-written interview transcripts were analyzed thematically by the researchers. This method has been proven effective in exploratory research for identifying recurring themes and patterns across interviews, particularly when researchers rely on handwritten interview notes (Peace et al., 2023; Sbrocchi et al., 2025). Based on manual coding of interview notes, an exhaustive catalog of initial themes was identified as concepts started to take shape (Braun & Clarke, 2006). Interview notes were subsequently reassessed in line with our study objective, and the identified themes were systematically applied to different clusters. Each thematic cluster

corresponded to a particular EV adoption barrier and/or marketing challenge (e.g., technological barrier, policy barrier). Five distinct clusters emerged out of the thematic analysis, which were scrutinized against the existing scholarship on EV adoption barriers and the overarching research questions of our study. Themes and categories were extended as additional patterns emerged during the analysis; therefore, empirical materials were also organized into broad categories (such as customer divides, geographical variation, motivation dilemma, and others) in addition to the barriers. Such a manual approach to inductive coding, through thematic analysis and review of interview notes, was employed to facilitate a detailed analysis of a semi-structured dataset while simultaneously drawing on the researchers' own experience and knowledge of the study subject (Peace et al., 2023).

2.4. Results and Discussion

2.4.1. Barriers to EV Adoption – Perspective of Automobile Dealerships

In this section, we aim to discuss the perspectives of dealership personnel on the barriers hindering the faster adoption of electric vehicles by Indian car buyers. After careful analysis of interview transcripts, five major types of barriers were identified: infrastructural, technological, financial, psychological/behavioral, and policy.

a. Infrastructural Barriers – Public Charging Infrastructure is not a Monolithic Concern

An infrastructural barrier refers to a circumstance in which the un/under availability of supportive infrastructural facilities hinders people's access to and/or experience with electric cars (Krishna, 2021; Tarei et al., 2021). While, to a vast majority, previous research suggests that un- or under-availability of public charging stations is the most important infrastructural impediment to faster EV uptake in any given geographical context (Yadav & Yadav, 2024; Sbrocchi et al., 2025), our findings demonstrate that lack of public charging infrastructure is not a monolithic problem across cities. In many interview discussions in Varanasi, for instance, the lack of public charging stations was not consistently identified as the most perceived infrastructural barrier by individuals at the dealership. This is principally due to shorter intra-city commutes and the corresponding preference for home charging among both actual and potential electric car users in a small metropolitan city. Dealership professionals reported that in smaller cities, where people do not commute long distances, the lack of public charging infrastructure is not a commonly perceived barrier. Instead, informants in Varanasi detailed how an unreliable power supply causes interruptions in home charging systems, thereby inducing high perceived risks of using EVs among potential users. As is illustrated by the following response:

'....many of our customers compare EVs with other electronic products like mobile phone or mixer grinder....they speak about their experiences of not being able to charge mobile phone or use other electric equipment because of power cut, in the past...not surprisingly, they perceive potential power cuts as barriers...then questions surrounding difficulties in charging the vehicle at the time of an emergency tend to arise....power cut is a real problem in Varanasi, so is in many other parts of our country...'

Interviews in all three cities expressed similar concerns about infrastructural barriers in rural areas. A dealership manager from Varanasi has further illustrated:

'....you know, in villages, the power supply is still not reliable...power cut happens every now and then...now if there is a storm or heavy rain, then the power cut may prevail for more than a day....how will you charge your vehicle then....these situations are real and not very conducive for the adoption of EVs....'

Lack of public charging infrastructure, however, has been a major concern for dealerships in Ahmedabad. Although the city of Ahmedabad has installed a few charging stations, interviewees have found the number unsatisfactory. Moreover, in a mega-urban agglomeration like Delhi, the nature and magnitude of such an impediment were perceived differently. Delhi has constructed a significant number of public charging stations over the last few years. The number of public charging stations, therefore, is not a major barrier, at least within the city. But the principal hindrance comes from a lack of home charging facilities available at old housing societies, as the following responses would indicate:

'....I had a customer who wanted to purchase an EV....his experience with the test drive was also really good...but finally he couldn't purchase the vehicle because he lives in the fourth floor of an old apartment block [which is very common in Delhi], *where he couldn't get the permission to install home charging infrastructure...this thing very often happens in Delhi....'*

'....in most of the old apartments you don't get the permission to install charging facilities...but people still largely rely on home charging and not on public charging infrastructure....we lose many EV customers this way....'

Furthermore, in correspondence with concerns about the lack of public charging infrastructure and impediments to home charging, dealership personnel repeatedly emphasized that the prevailing charging infrastructure may not be functional, even if it appears on the map. This increases perceived risk among potential EV users, especially those who want to purchase EVs for long-distance travel and take highway corridors outside metropolitan cities. This disappointment was further manifested by the following expression, reflecting that such infrastructural and informational discrepancy not only reduces the trust of customers in dealerships but also increases the range anxiety:

'....different companies have their apps which show the location of charging stations...but we, very often, receive complaints that even if the charging station is visible on the map, on the ground it is not functional...customers get frustrated in such situations...'

b. Technological Barriers – Battery is the Root Cause

Interviews with dealership heads and salespersons revealed that lower battery range, associated range anxiety, and waterlogging anxiety are the major technological barriers hindering faster EV uptake in the Indian automobile market. The effect of scorching summer temperature on battery range, accompanied by insufficient public and home charging facilities, translates into instances where the customers not only question the authenticity of information that they receive at the dealership but also become more range anxious:

'....the company [manufacturer] *promises a particular maximum range for a particular vehicle...we reduce it a bit when we inform the customers...now when the customers run the vehicle they get further less....'*

The above proposition of a respondent from Delhi perfectly aligns with marketing literature where it has long been argued that when manufacturing firms seek to introduce entirely new and discontinuous

products (like EVs), including both goods and services, a gap may very often emerge between the value proposition that is promised to the consumers and the capability of that product to actually accomplish the imperatives of that promise (Moore, 1991; Cahill et al., 2014).

'....I was on a test drive with a customer a few days back....he turned on the AC, and then he made the AC stronger....the battery charge started falling sharply....I also didn't expect that the battery would lose charge so fast if the AC is stronger....my confidence was broken immediately....'

The above response from a salesperson in Ahmedabad suggests that the battery's performance is subject to many other external factors, such as air temperature. This, in turn, makes it more difficult for automobile dealerships to earn customers' trust by providing accurate information about battery range.

As conversations with dealership professionals progressed, it became evident that the principal cause of the higher upfront cost of EVs compared to their ICE counterparts is the battery cost. Several interviewees argued that it would be necessary to separate the battery cost from the rest of the vehicle to achieve price parity between EVs and ICE vehicles. However, a lack of technological support and marketing policies in this regard has been perceived as an important barrier. Such arguments led us to question whether new EV battery supply models, such as Battery as a Service (BaaS), can contribute to greater acceptance of electric vehicles in an emerging market.

There was almost universal agreement that waterlogging anxiety among customers in Indian cities, where waterlogging is a common occurrence during the rainy season, is a major barrier to EV uptake. Hence, we could find a link between the water-sensitivity of electric vehicles and people's anxiety that electric equipment may be damaged if it comes into contact with water. As an interviewee from Ahmedabad has noted:

'....if a customer lives in areas like Narol, Narora, or any other locality in Ahmedabad where waterlogging is a common occurrence during the rainy season, he will never purchase an EV....people still think that EVs are not in good terms with water, like any other electric products...'

Such barriers, however, have more psychological constructs attached to them than technological failure.

c. Financial Barriers – Lack of Product Assortment Makes It Difficult to Target Niche Consumers

The sub-theme 'financial barriers' emerged out of the narratives of interviewees surrounding the higher purchase price of EVs compared to ICE vehicles, albeit with a geographical dimension attached to it. It was found that consumers in small- and medium-sized cities like Varanasi and Ahmedabad are more open to cost-efficient, base models that are 'low type EVs' (Chen et al., 2018). A lack of electric car models tailored to local road conditions, available parking, and people's commuting behavior in smaller cities represents immediate barriers to mass EV adoption across diverse urban geographies.

Discussions with dealership individuals highlighted that middle-class Indian car buyers, the most important niche of vehicle consumers, stay away from adopting EVs because such vehicles are much more expensive than their ICE counterparts. The price difference between EVs and ICE vehicles of the same model is sometimes 3 to 5 lakhs. This makes rationalizing EV purchases more difficult, as EVs are supposed to have higher upfront costs than ICE vehicles. The following response of a team leader of

an EV sales team from Delhi indicates how customers do a cost-benefit analysis while considering the vehicle price and fuel cost at the time of purchase:

'....many customers say that the EV costs them 3 lakh rupees more than the ICE of the same category...so they will better take an ICE and invest that 3 lakh rupees to fuel the car with petrol or CNG over the years....'

As one might expect, such financial constraints are further compounded by the unavailability of EVs in base models from most manufacturing brands, and therefore in their franchised dealerships. With the striking exception of TATA Motors and MG Motors, participants in other dealerships expressed concerns about the availability of EVs in premium car categories only and corresponding difficulties in EV penetration among middle-class car buyers:

'....we don't have any EVs in base models...now, how are you supposed to sell a premium car to a middle-class customer who has budget constraints...most of our customers are middle-class who tend to bypass EVs because the model that they can afford is not available in EVs....'

Therefore, interviewed professionals at automobile dealerships largely anticipated that it is partly the manufacturers' responsibility to add EVs in base models, whereas, in part, it is the government's responsibility to help reduce the upfront cost of EVs through subsidy provisions.

d. Psychological Barriers – Impediments have More Psychological Constructs than Actual Facts

The psychological/behavioral barriers, as interviewees would argue, are associated with internal biases or perceptual prejudices among Indian car buyers, which principally include skepticism about new technologies like EVs, negative publicity, and the spread of misinformation, along with a lack of awareness of EV technology and related government policies. Skepticism about EVs being a new technology was said to exist because of internal biases, as a sales manager from Delhi would emphasize:

'....many car buyers still think EVs are not reliable.... they think such vehicles can malfunction at any time and thus they will be stuck with the vehicle in the middle of nowhere....'

The skepticism about 'being stuck with an EV' corresponds to misinformation about battery range and accompanying range anxiety, which are themselves cited as the most important techno-perceptual barrier to EV adoption, largely driven by negative media coverage (Sbrocchi et al., 2025). While it is true that a lower battery range is a significant and real technological barrier to EV uptake, negative perceptions and misinformation can magnify these barriers and create a hindrance for automobile dealerships to sell such vehicles. An interviewee from Varanasi emphasized:

'I have experienced this now and then that perceptions on battery range [range anxiety]*, water-sensitivity of the vehicle* [waterlogging anxiety], *and a lot of other things are much stronger than facts....sometimes perceptions of customers are so strong that you cannot change them with facts....'*

Furthermore, similar to the findings of many scholarly studies (Tarei et al., 2021; Munshi et al., 2022), interviews with automobile dealerships also suggested that the lack of public awareness about the existence of EVs and associated government policies, especially among the rural population, has had a longstanding negative influence on EV uptake. Very few Indian car buyers are aware of the benefits

of EVs, and very little information about government policies on EV uptake reaches potential car buyers. The discouragement in purchasing EVs is thus often driven by a lack of awareness of the advantages of EVs over ICE vehicles and of government policies that facilitate EV adoption.

e. Policy Barriers – At the Core of the Impediments

Considering the intersection between government policies and faster EV uptake, prior research has identified a strong impact of government policies, including monetary subsidies and other direct and indirect incentives like toll tax exemption for EVs, free parking, road tax incentives, and others, on the purchase intention of vehicle consumers (Sierzchula et al., 2014; Langbroek et al., 2016). Such financial aid helps make EVs more affordable, both in upfront and maintenance costs. Conversely, in our study, the majority of participants believed that the current subsidy structure for EV customers is not very conducive to faster EV uptake. Participants informed that the monetary subsidy provided by the central government had been discontinued much earlier, whereas state government subsidies provide some form of relief to customers. Given the higher purchase price of EVs compared to conventional vehicles, this subsidy shortfall is expected to negatively affect EV adoption among Indian car buyers. For instance, it was noted by an EV salesperson from Varanasi:

'....in our brand, the price difference between EV and ICE in the same model is over 3 lakhs....the state government subsidy is 1 lakh....nobody knows when that will be stopped too....how is this going to bring a price parity....'

In Delhi, the situation is further complicated, as evident from the following response:

'....the previous government had a different policy on subsidy....the government has changed and so have their subsidy policies....sometimes it seems really frustrating to understand all these....why can't we have a clear-cut national policy on subsidy....'

Overall, given that EV adoption remains at a relatively early stage, the withdrawal of central subsidies may have had implications for market momentum. Previous research suggests that financial incentives under the FAME policy played a significant role in reducing upfront costs and improving price parity between EVs and their ICE counterparts (Patil, 2020).

Additionally, limited temporal consistency in subsidy policies has created challenges for market participants. Frequent changes and evolving timelines have made it difficult for automobile dealerships and other stakeholders to plan and align with subsidy frameworks.

2.4.2. How Barriers are Translating into Divides Among Consumers and Resulting in Marketing Challenges

a. Affluence Drives Adoption

Interviews with dealership individuals revealed that the early EV adopters in India are principally the second- and third-time car buyers. People who already have at least one Internal Combustion Engine (ICE) vehicle in their homes can only be inclined towards EVs.

'....almost all the EV customers are re-buyers...they will at least have one ICE car, but in most of the cases they have more than one car...'

Although in the long run, the operating costs of EVs are considerably lower than those of ICE vehicles, car dealerships still find it very difficult to convince first-time car buyers on these terms. In a developing country like India, where, on the one hand, the car ownership rate is very low, on the other hand, the lion's share of car-owning families have only one car (Dash et al., 2013; Gupta, 2023), marketing EVs thus presents some real challenges for automobile dealerships. This is probably why almost all the interviewees have indicated that it is nearly impossible to convince a first-time car buyer to purchase an EV, even if the person may not use the vehicle for very long-distance commutes, and thereby vehicle range is not a concern for him/her.

'....we cannot drive those customers towards EVs who come to purchase base models....even if I leave the customers aside, for a while, most of the car companies do not even have EVs in base models, they have EVs in premium models only....now you may understand who the targeted customers are....'

'....EVs were supposed to be preferred by those who care a lot about money... this is where the lower operating cost would matter... but now see... middle-class people are rarely buying EVs...EVs are brought by those who already have two to three cars, who barely care about money...'

Thus, satisfying the needs of middle-class customers – the principal economic cohort of car buyers in India – emerged as a recurring challenge for many of the car dealerships. This challenge exists, on the one hand, in correspondence with the psychological constraint that prevents a middle-class Indian from investing heavily in new technologies like EVs; on the other hand, it is directly attributable to the higher purchase price of EVs compared to conventional vehicles. In other words, the desirability of EVs among most car buyers is essentially constrained by the existing price disparity. Such a finding is consistent with previous empirical research, which repeatedly emphasized the compromised distributive fairness of e-mobility options among different segments of car buyers (Mullen & Marsden, 2016; She et al., 2017; Yadav & Yadav, 2024).

b. The Rural-Urban Divide

There is a small but growing body of scholarly literature in the field of transport geography that has highlighted the exclusion of rural communities in the wake of EV proliferation, particularly in urban areas (Sovacool et al., 2019; Sbrocchi et al., 2025). In the present study, interview participants also expressed that it is extremely difficult to draw the attention of rural residents to EVs, let alone sell such vehicles to buyers living outside cities. Regardless of economic conditions, people from rural areas are often more opposed to EVs. Such discouragement is primarily due to the lack of charging infrastructure in rural areas, as well as the unavailability of an uninterrupted electric supply system in rural areas of India. Interviewees noted that though petrol pumps or gas stations are also not ubiquitous in rural localities, nevertheless, since ICE vehicles are part of a long-established technology, the availability of fueling stations matters less to them. This resonates with the following response that EVs are still marked as 'city-people'-car', where a large segment of rural car buyers are still alienated from EV technologies:

'....it is very difficult to convince people who come from villages to buy an EV....in most of the cases they have never heard about such vehicles...and even if they are aware, they will never buy an EV....there is no charging infrastructure in villages, you have frequent incidents of power-cut as well....'

Therefore, the unique social, economic, and infrastructural geographies of rural India require special policy attention for EV uptake.

2.5. Discussion: The Motivation-Dilemma for Automobile Dealerships

The previous sections have sought to shed light on the wide range of challenges that automobile dealerships face in marketing EVs, as well as the diverse range of retail experiences they have gained in dealing with their customers. Of course, the challenges dealerships face and the barriers to EV adoption and use among Indian automobile users are not uniform across different geographies in India. The country reflects diverse yet sometimes overlapping marketing trajectories for EVs, with each state and city experiencing its own confluence of challenges, barriers, and outcomes. Nevertheless, amidst such incredible diversity, this research reflects on several shared experiences of automobile dealerships that, in turn, explain the root causes of their motivation and/or demotivation to continue with EV marketing and sales (Figure 2). For instance, the dealership heads (e.g., general managers, sales managers) interviewed acknowledged that they often have to pursue profit cuts when selling EVs to offer more discounts to customers and thereby bring EVs to price parity with ICE vehicles. This not only reduces their sales-related profits but also induces some sense of demotivation to invest further in EV sales. Many respondents reported selling EVs at a subsidized price by cutting profits to increase sales volume and thus receive monthly sales-volume-based bonuses from manufacturers. Such practice was found to be identical across car franchises.

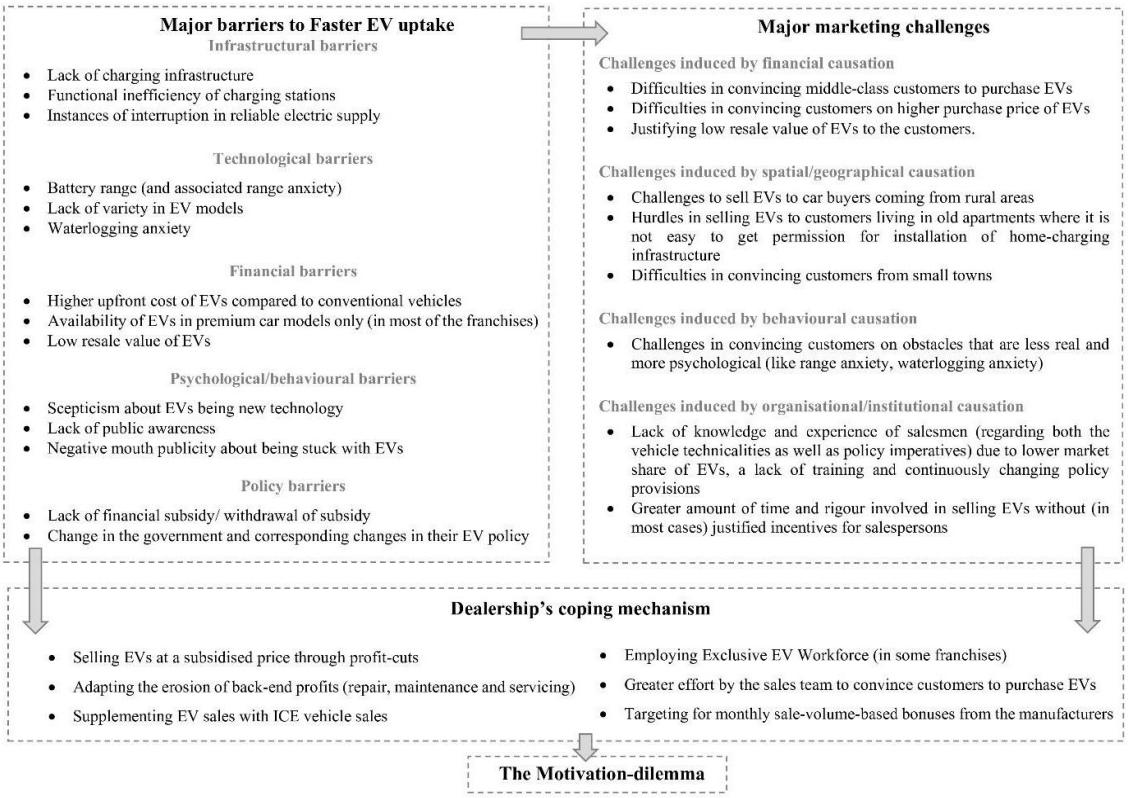


Figure 1: Barriers to EV adoption, corresponding marketing challenges, and the resulting motivation-dilemma for automobile dealerships (Source: Based on primary data collected for the project)

It is widely accepted in the academic literature that back-end profits derived from parts, repair, and services are often more important than sales-oriented sources of income for dealerships (Cahill et al., 2014; De Rubens et al., 2018). The amount of income from back-end sources usually plays a very

important role in guiding dealership heads and salespersons to direct customers towards a specific set of choices (Tromaras et al., 2017). There was an undeniable consensus among the dealership professionals interviewed in the present study that a large-scale transition towards EVs will reduce their back-end profits, as EVs provide fewer servicing and repair opportunities for dealerships. Such a dilemma has been proven detrimental to EV sales, particularly in dealerships where the same sales team handles both EV and ICE sales.

Moreover, another factor in line with the preceding one is the time and effort required to sell an EV compared to conventional ICE vehicles. One of our respondents from Ahmedabad said:

'....we can sell three ICE cars in the time it takes to sell only one EV....'

This simply indicates that a salesperson or a sales team needs to put much more effort into selling EVs, whereas selling ICE vehicles is much easier due to established conventions. Thus, in dealerships where the EV sales team is not separately designated, a longer transaction time for EVs appears to directly demotivate sales personnel, often leading them to push customers towards ICE vehicles rather than EVs.

Furthermore, the experience and knowledge of the salespersons, discussed in the context not only of vehicle technicalities but also of laws, subsidies, and other policy provisions, also seem to be a major motivation-dilemma for dealerships. Interviews show that the absence of a well-trained Exclusive EV Workforce at many dealership outlets has led to unsatisfactory EV sales compared to their ICE counterparts. While manufacturers' exhaustive training of salespersons – arguably – can have a more effective impact on their confidence, knowledge, and ultimately sales capabilities, the interviews provided deeper insights into an overarching sense of a lack of confidence among salespersons, attributed to manufacturers' inadequate training. This, however, varied largely among manufacturers and their franchised dealerships. Since there is a strong association between the training and knowledge of salespersons and their capability as well as motivation to influence car buyers to purchase a new product like EV (Evarts, 2014), a lack of training and/or absence of an exclusive EV sales team may have a detrimental impact on potential car buyers.

2.6. Conclusions from the Section

The present research draws on interviews with dealership individuals in three cities of Delhi, Ahmedabad, and Varanasi to understand the marketing challenges and perceived barriers to EV adoption in the Indian automobile market, and thereby addresses an important research gap. Given how little is known in the academic literature about dealerships' perspectives on challenges to EV sales and barriers to their adoption, this research contributes to the existing EV literature by uncovering the perceptions of dealership professionals – those with first-hand experience in EV marketing and sales. It appears from the interviews that the barriers our respondents have perceived are not typically distinct from those widely discussed in the academic literature, which primarily reflect experts' opinions or user perception surveys. Nevertheless, dealership heads and salespersons offered a distinct perspective on EV adoption barriers, shaped by their long-standing experience with customer dynamics and by their role as pivotal agents working in conjunction with both manufacturers and customers.

The empirical investigation identified critical elements obstructing faster EV uptake in India and their multifarious implications for both existing and potential car buyers, as well as automobile dealers. These obstructions, on the one hand, are translating into some instances of class-disparity among EV buyers and a rural-urban gap in EV adoption, among others; on the other hand, they are inducing some de-motivational effect for automobile dealers to continue with EV marketing and sales. To overcome such obstructions, at least in part, customized policy solutions for automobile dealers are much needed. Along with the faster construction of charging infrastructure in rural and small-town settings, the provision of greater subsidies to customers that can help reduce the upfront cost of EVs, and other demand-supply side interventions, it is recommended to make allowances for modest government incentives for automobile dealerships. Counting on an accessible public funding system, a more staggering approach would be to support EV dealers and their salespeople with financial incentives that, in turn, could be tied to comprehensive training, capacity building, and improved sales performance. The worth of such a financial incentive-based plan of action is that its carriers' potentials to address the core of dealerships' motivation-dilemma – that considering the infancy of EV market in India, prior to the full realization of sales economies, automobile dealerships have very little inducements to make adjustments with EV sales and corresponding practices until more healthy and robust market for EVs become apparent that can rationalize the heavy investments.

Furthermore, given the small number of EV sales and the higher level of rigor that is required to sell EVs, manufacturers must ensure two things: first, each dealership must have an Exclusive EV Workforce, and second, EV salespersons need to be rewarded with higher incentives on each vehicle sale directly by the manufacturers. The interviews indicate that, excluding TATA Motors, in other franchised dealerships, salespersons are not generally directly incentivized by manufacturers for EV sales. Therefore, such a two-fold modification approach by manufacturers would not only reduce the likelihood of EV customers being pushed towards ICE vehicles but also enable EV salespersons to be more enthusiastic in serving potential customers with more rigorous information and consistent support.

3. Revisiting Customer Segmentation in an Emerging Market for Electric Vehicles: New Perspectives from Automobile Dealerships in India

The post-hoc exploratory approach to customer segmentation has largely gone unnoticed by academic scholarship on Electric Vehicles (EVs). For the vast majority, the scholarly literature on understanding customer heterogeneity in the EV market draws on customer perception- and preference-based segmentation, with little attention to other actors who may have a differential perspective on customer profiles and the segmentation that accompanies them. The present study seeks to address this gap by examining the segmented nature of the EV market in a developing country from an alternative positionality. To advance this dialogue, this research focuses on automobile dealerships, i.e., outlets where the EVs are retailed to the customers. We argue that professionals working at automobile dealerships represent an extremely important yet understudied point of contact between manufacturers and customers. Our analysis draws on 32 semi-structured interviews conducted at car

dealership outlets across three metropolitan cities: Ahmedabad, Delhi, and Varanasi. In essence, the thematic analysis of interview responses indicates diversity in preferences across heterogeneous consumer segments in the EV market, suggesting that demand for electric cars has been driven by niche consumers and will continue to be so as the market matures. The analysis unfolds one more layer of the segmented EV market in India, identifying six consumer sub-groups consisting of both actual and potential customers, called 'subsidy dependents, symbolic go-getters, acquisitive enthusiasts, middle class aspirers, urban indifferents, and rural conservatives' - identified by dealership professionals based on their experiences of customer profiling. This, in turn, underscores the diverse impact of decisive factors on purchase decisions across consumer segments. All countries in general, but developing countries in particular, committed to sustainable transitioning of road transport sector toward e-mobility alternatives might find the outcomes of this study useful to understand different customer segments for EVs from a differential perspective, to focus on customized policy addressal to diverse needs of different customer segments as well as to rule out any prevailing form of self-reinforcing mechanism between social inequality and EV adoption.

3.1. Introduction

The road transport sector is presently experiencing one of the most crucial transformations in its history, i.e., a large-scale transition from energy-intensive modes to e-mobility alternatives (Gupta and Anand, 2025). Electric vehicles (EVs) have been transforming the road transport landscape over the past two decades, emerging as a viable alternative to internal combustion engine (ICE) vehicles dependent on fossil fuels. As such, EVs are increasingly recognized as an integral component of the sustainable mobility transition aimed at reducing the environmental impacts of the transport sector, particularly road transport. Globally, interest in EVs has been driven by several factors, including climate change concerns, the finite nature of fossil fuels, oil price volatility, and growing consumer environmental awareness (Oliver and Rosen, 2010; Morton et al., 2017; Krishna, 2021).

While a considerable number of EVs have been placed into operation across the world, globally, the distribution of such vehicles is extremely heterogeneous. Where some north and north-west European countries like Norway, Sweden, and the Netherlands have no less than 15,000 EVs per million population, the figures turn into less than a hundred EVs per million population in developing countries like India, South Africa, and Brazil (Gupta and Anand, 2025). Such heterogeneity has lately motivated researchers to look at the idiosyncratic market conditions for EVs in developing countries and associated challenges and barriers to mass EV adoption. In India, for instance, the current market share of electric cars is nearly 2.7%, where the union government has set up an ambitious goal of attaining 30% market share of EVs by 2030 (Munshi et al., 2022; EVreporter, 2025). Despite a congenial policy environment, Indian consumers' inclination toward electric cars has been limited, to a certain degree, by infrastructural, financial, and other barriers, as well as because of perceived risks that people attach to new technologies like EVs (Roemer & Henseler, 2022; Yadav & Yadav, 2024). Nevertheless, Indian car buyers are showing increasing interest in purchasing electric cars, as evident from the growth of EV penetration in the Indian automobile market from 1.3% in 2023-24 to 2.7% in 2024-25. The absolute number of sales of electric cars during the same period has increased from 54,272 (2023-24) to 115,800 (2024-25) (EVreporter, 2025). Such burgeoning interest by policymakers and increasing attention of consumers on such vehicles concurrently indicate substantial market potential for EVs in the forthcoming years.

The diffusion of EVs among Indian car buyers is still in its infancy, albeit with differences between and within provinces, cities, and most inevitably customer segments (Jaiswal et al., 2022; Bhat et al., 2024). The heterogeneities in demand and differential adoption rates of a technology like EV among different consumer segments, is largely attributed to the diversities inherent in a number of interrelated course of actions including - acquiring primary knowledge of the technology, developing a positive attitude toward it, coming to a consensus on its adoption, modifying the behavior accordingly, and continuing with the decision (Rogers, 1995; Westin et al., 2018). In simple terms, the adoption imperatives for EVs vary largely among customer segments. This is probably the reason that one of the major arguments for facilitating faster EV uptake, in India or otherwise, has been to address the differential needs of diverse customer segments with customized policy solutions (Huang et al., 2021). Understanding market segments, their structure, and context of segmentation has therefore been contended to be essential for policy formulation, albeit with diverse claims on the suitable parameters for segmentation (Gärling, 2000).

As for market segmentation, as early as 1956, Smith pointed out the need for segmentation, where he highlighted the role of diversity in demand among different consumers and the corresponding need to adopt diverse supply mechanisms to attain balanced market conditions (Smith, 1956). Given the assertion that segmentation of customers would provide policymakers and manufacturers with a more comprehensive understanding of market heterogeneities, both in terms of supply imperatives and policy needs, scholarly attention is shifting toward appraising the stratified nature of the EV market (Morton et al., 2017). Market segmentation thus has emerged as a significant tool to target and position marketing strategies for an emerging transport technology like EV, especially in a country like India where the EV market is still at its infancy, so as to formulate policies to tap the potential and actual 'innovators, early adopters, and early majority' (Rogers, 1995) and thereby, to explore and guide the extensive future adoption of such vehicles (Singh et al., 2020; Jaiswal et al., 2022). With the significance of addressing the typical characteristics of different segments in the EV market being well-acknowledged (Saarenpää et al., 2013; Bhat et al., 2024), it is largely assumed that exploring the idiosyncrasies of different market segments will facilitate a larger number of actors, including policymakers, manufacturers, retailers, and others.

Nevertheless, to date, the growing body of scholarly literature encompassing the field of customer segmentation in the EV market largely drew on stated and/or revealed preference-based enquiries, addressing both actual and potential EV consumers. Such a stream of research, being methodologically robust and empirically sound, has produced valuable insights into the segmented nature of the EV market, based on either a priori approach (Huang et al., 2021; Jaiswal et al., 2022) or a post-hoc approach (Kennedy et al., 2019). In other words, to a vast majority, scholarly literature on understanding customer heterogeneity in the EV market is grounded on customer perception and preference-based segmentation with little attention to other actors who may have a differential perspective on customer profiles and accompanying segmentation. Such a gap motivates us to investigate the perception of actors other than actual or potential buyers on customer structure in an emerging market for EVs in India. To advance this dialogue, the present study focuses on automobile dealerships, i.e., the outlets where the EVs are retailed to the customers. Our analysis is grounded on the perspective of dealership individuals, i.e., people who represent an extremely important but equally understudied point of reference between the manufacturers and customers (De Rubens et al.,

2018) on the segmented nature of the EV market in India and corresponding challenges to attain a desired level of mass adoption as previously anticipated by policymakers.

The specific research questions addressed are: (1) How do professionals at automobile dealerships, as significant actors in the retail business of electric vehicles, perceive the emerging market of EVs in India, and what factors do they believe influence the choice of EVs among early adopters? (2) How do dealership individuals perceive and construct alternative categories of customer segmentation based on their experiences of customer profiling? (3) What insights can such alternative perspectives on customer segmentation offer for informing more customized transportation policymaking that can address the inherent heterogeneities among both actual and potential EV consumers?

3.2. Literature Review on Customer Segmentation for EVs

Academic interest in EVs as a viable technology for decarbonizing the automotive sector has grown significantly since the 1990s. Early research on EV marketing and demand, primarily using econometric techniques, examined a range of adoption barriers and marketing challenges specific to different geographic contexts (Bunch et al., 1993; Kurani et al., 1996; Sierzchula, 2014). However, it was not until a decade ago that academic attention, at large, shifted toward understanding and acknowledging the prevailing heterogeneities and dynamics of the EV market. Since it is well established that various groups in the transport market have unique characteristics and corresponding heterogeneities in demand (Barr & Prillwitz, 2012; Fürst, 2014), examining how different consumer segments react to EVs is expected to yield valuable insights (Morton et al., 2017; Griva et al., 2024). There is a growing body of research in the stream of market segmentation that seeks to furnish a detailed profiling of homogenous customer subgroups in the EV market. Such a strand of literature provides important insights into the ways the customer subgroups vary in their ancillary characteristics and thereby informs manufacturers and retailers to develop tailored submarket strategies aimed at responding to the heterogeneous needs and demands of different customer subgroups. Conceptually, this body of research draws on several behavioral theories including diffusion of innovation theory (Rogers, 1995), technology acceptance model (Davis, 1989), theory of reasoned action (Ajzen and Fishbein, 1975) and others, where these theories have been widely used to understand and conceptualize the behavioral intent as well as revealed behavior of EV customers in a given market condition. Grounded on the diffusion of innovation theory (Rogers, 1995), for instance, researchers have very often segmented automobile users in any given spatial context into 'innovators, early adopters, early majority, late majority, and laggards' (Rogers, 1995; Miller, 2015; Wolf & Kovács, 2024). Similarly, studies based on the technology acceptance model elaborate on the extent to which 'perceived ease of use' and 'perceived usefulness' of electric cars can decisively influence the behavioral intent of different consumer groups toward such vehicles (Roemer & Henseler, 2022).

Methodologically, as Jaiswal et al. (2022) emphasize, researchers have employed two partly overlapping approaches to customer segmentation in the EV market: a priori and post hoc. Literature based on the a priori approach utilizes a predefined set of segmentation criteria, including gender, age, education, economic status, and others, and subsequently profiles the consumer groups based on several measured variables (like psychographic, behavioral, etc.) (Plötz et al., 2014; Lee et al., 2019; Wolf & Kovács, 2024). This approach to market segmentation is more explanatory in nature. Contrariwise, in post-hoc approaches, the consumer groups are segmented based on a thematic

analysis of the relationship among measured variables (Kennedy et al., 2019). This group of research is more exploratory in nature.

Existing segmentation studies for the EV market, mostly following an explanatory-priori approach, focus on specific segmentation types, such as behavioral/psychographic, demographic, and/or geographic. Offering some elementary guidance on this subject, the reflexive empirical study by Kurani et al. (1996) on the automotive market in California has found a substantial potential for EV adoption among car-owning families and segmented them as 'Hybrid Households' owing to the ability of such families to incorporate an EV into their multicar fleet. Recent studies on customer segmentation have mostly addressed the empirical condition of mature to early-mature EV markets, usually in developed economies like Norway (De Rubens, 2019), Sweden (Jansson et al., 2017), Germany (Roemer & Henseler, 2022), the USA (Lee et al., 2019), the United Kingdom (Morton et al., 2017), and others. A German study by Plötz et al. (2014), for instance, employed psychographic and socio-demographic measures as segmentation themes and found that potential EV buyers were mainly educated middle-aged men living in comparatively larger suburban or rural households, associated with technical professions. Similarly, a 2015 study on Ontario, USA, forecasted EV adoption rates between 2012 and 2050 and showed that men are more likely to adopt EVs than their female counterparts (Ahmadi et al., 2015). Among the major socio-economic, demographic, behavioral, psychological and geographical attributes - at a synoptic scale - education level, income, young to middle age, rural or sub-urban living, acquisitive innovativeness, environment-oriented life principals and green lifestyles are positively correlated with the actual behavior and/or potential intent to adopt EVs (Westin et al., 2018; Plananska & Gamma, 2022; Roemer & Henseler, 2022; Wolf & Kovács, 2024).

A stated preference choice experiment encompassing 2729 individuals in the UK with recent experience of purchasing a car has elaborated on several interrelated factors, both positive and negative, which contribute to the segmented nature of the market for electric cars (Anable et al., 2011). The study found that while lower operating costs and environmental benefits contribute to a positive perception of EVs among car buyers, a host of factors, including range issues, higher upfront costs, charging time, etc., have greater power to push consumers towards the negative end of the spectrum. Furthermore, based on 106 attitudinal statements 8 consumer groups were identified by the study such as, 'plug-in pioneers, zealous optimists, willing pragmatists, anxious aspirers, uninspired followers, conventional sceptics, image conscious rejecters, and company car drivers' (Anable et al., 2011, 2016), where it was highlighted that while a small group of EV buyers - known as 'plug-in pioneers' - are happy to pay extra for environmental benefits and more fuel-efficient cars, a much larger group called 'image conscious rejecters' are strongly opposed to adopting such vehicles due to concerns about vehicle image. Moreover, reflecting on an empirical study conducted in two UK cities (Dundee and Newcastle upon Tyne), Morton et al. (2017) identified five distinct segments in the early market for EVs: environmental cynics, weekend drivers, keen greens, early adopters, and car enthusiasts. Thus, the authors have noted heterogeneity in preferences across customer groups, indicating that demand for electric cars is expected to stem from a diverse set of customer segments as the market evolves toward maturity. A recent econometric study by Wolf and Kovács (2024) in the Hungarian context, have used the framework of technology acceptance model and segmented potential EV buyers of Generation Z into three successive clusters of 'sunshine generation' – people whose highest motivation to adopt EVs is driven by perceived ease and enjoyment and not necessarily by environmental concerns; 'petrol heads' – individuals more influenced by the perceived risks of using

an EV and with least environmental awareness; and 'environmentalists' – respondents whose interest and knowledge on EVs as a subject are limited but their inclination toward EVs is largely driven by environmental concerns.

While the methodological spectrum to study the subject of customer segmentation in the EV market has expanded in recent years with the incorporation of new segmentation themes like cultural values and self-image (Jaiswal et al., 2022), it is arguably evident that empirical studies, to a vast majority, follow *priori* approaches and thereby draw on consumer preference-based econometric methods like cluster analysis. Additionally, we observed a dearth of studies on customer segmentation in emerging EV markets in developing countries like India. The overwhelming majority of empirical studies based on Indian case evidence largely address EV adoption barriers from different perspectives (Bansal et al., 2021; Krishna, 2021; Munshi et al., 2022; Yadav & Yadav, 2024). We could find only two studies on customer segmentation for EVs so far, both grounded in Indian cases and both drawing on perceptions of potential consumers. In one of the studies, the authors have segmented 563 potential EV buyers in India (NCR Delhi) into three categories of 'Conservatives, Indifferents, and Enthusiasts', based on behavioral, psychographic, and socio-economic attributes as pre-decided segmentation parameters (Jaiswal et al., 2022). Moreover, drawing on an online survey-based econometric approach, Bhat et al. (2024) provide a case study of 660 young students from a technological university in India as future EV buyers, wherein the potential customers are segmented into three groups of "'innovation adoption leads', 'innovation adoption indifferents', and 'innovation adoption idlers'" (p. 101147).

The present research, therefore, seeks to partly address both these gaps simultaneously by examining the emerging customer segments in an infantile EV market from an alternative positionality. We follow a post-hoc, exploratory approach to segmentation and ground our analysis on the perception of individuals at automobile dealerships in India.

3.3. Conceptual Background: Why are Dealerships Important?

Electric cars represent a significant breakthrough in vehicle technology that brings about not only cutting-edge engineering innovations by firms but also fresh marketing approaches and competencies to sell them. In a franchised dealership model for vehicle marketing and sales, most popularly adopted in India or otherwise, independently owned business outlets called dealerships may exert direct control on how electric cars are retailed to both actual and potential customers (Cahill et al., 2014). Existing scholarship suggests that factors such as customers' experience in automobile dealerships, including retail services and after-sales support, are the main drivers of brand loyalty and eventually vehicle adoption rates (NRC, 2013; Tromaras et al., 2017). Nevertheless, automobile dealerships stand for an important yet equally under-researched intermediary between the producers of high-end technological products such as electric cars and their consumers (De Rubens et al., 2018). A small body of contemporary studies has emphasized that intermediaries such as automobile dealerships could be instrumental in the vehicle selection process by informing customers on various attributes of electric cars, advising them on their purchase decisions, and thereby, influencing the immediate retail experience of customers (Matthews et al., 2017; Wolf & Kovács, 2024). This way, such an intermediary system can make a direct impact on EV adoption rates. Studies have again emphasized that a lack of training among salespersons concerning the technical attributes of electric vehicles, insufficient financial and knowledge support from manufacturers, and corresponding lack of willingness among

dealership owners and managers to sell EVs to mainstream customers may have a direct negative bearing on the purchase decision of both potential and actual EV buyers (Matthews et al., 2017; De Rubens et al., 2018).

Therefore, dealership outlets have emerged as important sites in the marketing and sales of electric cars, operating as localized business nodes that bridge the gap between manufacturers and consumers. They are not mere retail shops where transactions tend to take place, but spaces where retailers develop a close understanding of who their customers are and what they prefer. In other words, dealerships are not only intermediate places where vehicles are retailed to the customers but also points where retailers build an intense, day-to-day awareness of heterogeneous customer groups - their demographic, social, economic, and other characteristics – through a detailed profiling of individuals and families visiting such dealerships.

Against this backdrop, the present study takes an exploratory path to study the experience and perception of professionals working at automobile dealerships to make sense of the prevailing heterogeneity in the emerging market for electric cars in India. Professionals at automobile dealerships interact with a wide variety of customers every day, observing patterns that might not be reflected through customer surveys or sales data alone. Given that this research aims to shed light on the segmented nature of the EV market in India and associated factors, it makes sense to pay attention to how dealership individuals themselves perceive and interpret their customers.

3.4. Data and Methods

3.4.1. Selection of Case Cities

To develop a geographically diverse perspective on the segmented nature of the EV market in India, this study grounds itself empirically in automobile dealerships in three metropolitan cities: Delhi, Ahmedabad, and Varanasi. These three cities not only represent three different sizes of demographic clusters but also have heterogeneous market structures, regional backgrounds, and policy environments. Delhi – the capital of India - is presently the largest city of the country with a population of nearly 29 million in its agglomeration, second largest in the world, and as the 2018 revision of the ‘World Urbanization Prospect’ indicates, by 2030, Tokyo will be outnumbered by Delhi as the largest megacity of the world (UN, 2019). The size of the population, directly analogous to the EV market's prospects, is reflected in the current figures for electric car sales in Delhi. During the financial year 2024-25, around 6,900 electric cars were sold in Delhi, placing the city in second position in terms of EV four-wheeler sales in the country, only behind Bengaluru (EVreporter, 2025). Thus, the megacity of Delhi stands for, at least in India, one of the most prosperous and potent EV markets with very high potential for rapid uptake in the near future.

Moreover, Ahmedabad, a medium-sized metropolitan city with a 2015 agglomeration population of nearly 7.11 million (UN, 2018), recorded 2353 electric car sales in 2024-25, making it the eighth-largest EV market among Indian cities (EVreporter, 2025). The rapidly increasing population of Ahmedabad and a largely automobile-oriented urban transportation landscape (Joshi, 2022) have substantially contributed to the city's expanding EV market. Finally, Varanasi, a small metropolitan city with approximately 1.54 million residents in 2015 (UN, 2018), represents a very different kind of EV market niche compared to Delhi and Ahmedabad. In the financial year 2022-23, only 138 electric cars were

accommodated in Varanasi (Ernst & Young LLP, 2024). While Varanasi's internal market for EVs may appear limited - largely due to its relatively modest population - this view risks overlooking the city's wider regional role. Varanasi is closely connected to a cluster of nearby towns such as Jaunpur, Sonbhadra, Mirzapur, Bhadohi, and others, each with populations between 0.1 and 0.2 million and situated within a 100-kilometre radius from Varanasi (Singh, 1988; Banerjee and Saha, 2024). Judging the city's market potential in isolation can therefore be misleading; what may seem marginal at first glance is in fact embedded within a broader network of small but interlinked urban centers.

The chief objective here is not to facilitate any comparative assessment between the select cities, but to gather as much diverse information as possible concerning the subject of study. In other words, by explicitly considering automobile dealerships serving three different types of EV markets, located in three different states with varied EV policies, we seek to capture as much diverse information as possible on the emerging EV market in India, its segmented attributes, marketing challenges, policy implications, and a host of other interrelated themes.

3.4.2. Interviews at Automobile Dealerships

The findings of the present study draw on 32 in-depth semi-structured interviews conducted at automobile dealerships in Ahmedabad (12 interviews), Delhi (11 interviews), and Varanasi (9 interviews). Considering the research gap discussed in section 2, a predominantly qualitative research design, partly supplemented with a small number of quantitative observations, was deemed most suitable for the present study as it helped the researchers to analyze, in-depth, several interrelated subjects including the relative importance of factors that play a decisive role (as both enablers and barriers) in EV adoption among consumers, segmented nature of the EV market and derive policy implications accordingly that can inform not only policymakers but also vehicle manufacturers.

The interviews at automobile dealerships were conducted in person. They were semi-structured in nature and therefore guided by a pre-drafted interview schedule. The interview guide consisted of both open and closed-ended questions, divided into five consecutive parts. In this study, we used findings from two major parts of the interview schedule: the first was narrative, and the second accommodated several closed-ended ranking questions. The open-ended questions were asked to understand the perspective of dealership professionals on the segmented nature of the EV market in their respective cities. They were also asked to draw some small anecdotes from their past experiences in customer profiling, considering both EV buyers and non-buyers. Thus, through interviews at automobile dealerships, a dense set of detailed information on different customer segments, their idiosyncratic characteristics, heterogeneities in demand, and the ways these demands can be effectively addressed was recorded in handwritten interview notes. The interview transcripts were coded manually using a post hoc, inductive approach to thematic analysis (Nowell et al., 2017; Peace et al., 2023). From this large empirical dataset, consisting of interview material, we have drawn specific observations and insights to demonstrate the ways dealership individuals, as automobile retailers, make sense of the segmented characteristics of the emerging EV market in India.

3.4.3. Analysis of Ranked Responses

As discussed earlier, one section of the interview schedule included ranked-response questions, supplemented by corresponding open-ended questions. Participants were asked to rank a set of

factors from a pre-defined list. The initial list was developed through an exhaustive review of the literature and was refined and finalized following the pilot survey.

Following Finch (2022) and Yu et al. (2019), the mean rank of each factor was calculated based on the frequency with which respondents assigned each possible rank. A lower mean rank indicates that a factor was generally positioned higher by respondents.

To assess whether the observed differences in rankings were statistically meaningful, a chi-square goodness-of-fit test was conducted (Alvo & Xu, 2017, p. 20; Yu et al., 2019; Finch, 2022). The test evaluates whether the factors received similar rankings overall, as would be expected if respondents ranked them at random.

The null hypothesis was that all factors had identical mean ranks and that the observed differences in rankings were not statistically significant. If the resulting p-value was less than 0.05 at the specified degrees of freedom (31), the null hypothesis was rejected. This would indicate that the rankings were not random and that some factors were consistently ranked higher or lower than others by the study participants.

3.5. Results and Discussion

3.5.1. What Matters to Customers the Most?

The analysis of interview responses from 32 dealership managers and sales personnel revealed that a multitude of factors, with varying levels of importance, influence customers' attitudes towards electric cars. Table 1 shows the ranking of factors that, according to respondents, matter most to vehicle buyers when deciding to purchase an EV. For the variations in mean ranks assigned to each factor in the list, the results are statistically significant with a p-value of nearly 0.00, thereby rejecting the probability of randomness in ranking the listed variables. With the lowest mean rank of 2.38, *battery range* appeared to be the most important factor influencing customers' decision to purchase or bypass an EV when they visit the automobile dealerships. Battery range is closely followed by *purchase price, charging time,* and *charging-station availability, respectively, as essential factors with greater importance than others in influencing customers' decisions* (Table 1). Interestingly, such findings are largely consistent with the profound argument made by scholarly literature in the field of EV adoption barriers, where it has been repetitively emphasized that higher purchase price, longer charging duration and a lack of charging infrastructure are principal barriers to faster EV uptake in India as well as globally (Munshi et al., 2022; Sbrocchi et al., 2025).

Table 1: Relative importance of factors influencing decision-making among consumers

Factors	**Mean rank***	**Final rank**
Purchase price of the vehicle/ upfront cost	2.91	2
Charging time	3.00	3
Maintenance cost	6.47	6
Aesthetics of the vehicle model	7.19	8

Driving technicalities	8.06	9
Battery range	2.38	1
Fuel (electricity) cost	7.13	7
Availability of charging stations	3.88	4
Speed range/ top speed	10.03	11
Subsidy	9.59	10
Environmental benefits	10.97	12
Resale value	6.23	5

Source: Based on primary data

** N = 32; df = 31; Chi-square statistics value = 232.094; Critical value = 26.217; p-value = 0.00*

On the other end of the scale, out of 12 factors, *environmental benefits,* and *speed range*, with their respective mean ranks of 10.97 and 10.03, are deemed least important for consumers when they choose to buy an EV. Even though EVs are promoted principally on the premise of their environmental efficiency, at the ground scale, the environmental benefits of using such vehicles matter the least to consumers. Since the distribution of material wealth is highly unequal in India (Gupta and Anand, 2025) and most of the car buyers are middle-income groups, economic and social odds are stacked against environmental consciousness among Indian car buyers. Such perceptions of professionals working at automobile dealerships can also be juxtaposed with the arguments made by Munshi et al. (2022) based on their study of potential EV buyers in Hyderabad, India, that the environmental benefits of electric cars had not been a decisive factor among potential buyers. One of the interviewees from Delhi highlighted the issue while stating that:

'....nobody asks about the environment while purchasing a car, EVs or ICE, no matter what they are buying...I have never encountered any question from an EV buyer related to environment...what they care about is upfront cost, subsidy, charging infra, and everything but the environment....'

This section unpacks another layer of dimensions that indicate the inherent heterogeneity among EV buyers and the segmented nature of the emerging EV market in India, where different customer segments assign varying importance to different factors. In other words, though in general some factors appeared to be more important than others, their relative importance varies widely across consumer groups. Based on our discussions with dealership managers and salespersons, we seek to shed light on different customer segments and understand the complexities of different groups buying electric cars.

3.5.2. Segmented Nature of EV Market

Research on customer segmentation in the automobile market has long suggested that, in an emerging EV market, initial demand may arise from distinct niche consumer groups that differ in certain attributes yet are similar in others (Anable et al., 2016; Morton et al., 2017). Our findings share similarities to such literary insights where interview responses largely indicate that segmenting potential and actual early adopters of electric cars into subgroups of niche consumers may help

illustrate a diverse pattern of behavioral elements, perceptual factors, and lifestyle profiles, potentially emphasizing that the factors enabling and/or restricting the purchase decision of EVs might have varied orders of importance across different segments of vehicle buyers. Based on the thematic analysis of interview responses, several segmentation criteria have emerged, including customers' economic and occupational profiles, place of residence (rural/urban), age profile, attitudes towards and knowledge of EVs, environmental consciousness, and social awareness. In line with these subjectively perceived segmentation criteria, six distinct consumer sub-groups were identified. A name has been assigned to each of the six segments to elucidate the results, as depicted in Table 2, along with the basic characteristics of each segment.

Table 2: Overview of the customer segments for Electric Vehicles

Customer segments	**Salient characteristics**	**Most important factors influencing decision-making**
Subsidy dependents	• People who purchase the base models • Middle-income families • Urban residents • Attach a high symbolic value to the government subsidy	• Purchase price • Subsidy • Resale value • Battery range
Symbolic go-getters	• Wealthy families with more than two vehicles in the household. • Urban residents • Purchase premium vehicle models • Consider EVs as symbolic of their status • Pose low to moderate product-specific knowledge	• Aesthetics of the model • Speed range • Driving technicalities • Battery range
Acquisitive enthusiasts	• High to middle-income individuals/families • Highly educated mid-aged consumers • Individuals associated with the service economy/ white-collar occupation • Acquire most of the knowledge about EVs at the dealership • Environmentally conscious • Urban residents	• Charging time • Battery range • Driving technicalities • Environmental benefits
Middle-class aspirers	• Small town dwellers • Middle-income households • Modest product-specific knowledge • Willing to purchase an EV because of perceived benefits, but unable to do so because of infrastructural deficiency	• Purchase price • Battery range • Charging time • Availability of charging stations

Urban indifferents	• Follower of the most popular norms • Low product-specific knowledge • Older adults • High-income households with more than two cars in the family	• Availability of charging stations • Battery range • Charging time • Driving technicalities
Rural conservatives	• Mostly wealthy rural households. • Weekend drivers and/or occasional users of the vehicle • Use the car occasionally for long-distance travel • Subjective norms about the symbolic value of a vehicle and social pressure from the reference group are struck against EVs. • Attach high value to the perceived risks of purchasing an EV • Very low product-specific knowledge • Least conscious about the environment	• Availability of charging stations • Driving technicalities • Purchase price • Resale value

Source: Based on primary data

a. Segment 1: Subsidy Dependents

The most dominant group of EV buyers, as experienced by the dealership individuals, consists of middle-income families living mostly in urban areas and can thereby be segmented as 'subsidy dependents'. Most respondents agreed that the government 'subsidy', no matter how small in comparison to the car price, does bear a significant psychological and economic value for this group of consumers. Here, it is important to understand the perspective of informants in relation to the franchise that they are working for. For instance, regarding EV sales, the cumulative market share of TATA Motors and JSW MG Motors is more than 82% in India (EVreporter, 2025), and these two manufacturers offer electric cars in base models that are easily accessible to middle and lower-middle income groups. Therefore, 'subsidy dependents' have been perceived as the most dominant customer segment for electric cars by individuals working in these two dealerships in general, as illustrated by the following response:

'...the EV sale is highest in the low-cost category, most of the people who purchase an EV go for the base-model...these models cost less than a million rupees, thus, around 20 per cent of the cost is covered by subsidies and tax exemptions of various kinds....'

Shifting the focus to the factors that bear significant influence on the decision of 'subsidy dependents', the purchase price of the vehicle and subsidy appeared to be the most important. As a respondent in the context of Ahmedabad has illustrated:

'....not everyone cares about subsidy, but some people really do....if somebody is spending 30 lakhs to buy an EV then a subsidy of 1 lakh wouldn't matter much to him...but in our brand, we have most of the customers willing to spend no more than 10-12 lakhs to buy new products like EVs, for them even 1 lakh matters a lot....'

b. Segment 2: Symbolic Go-Getters

The symbolic anatomy of understanding the value of cars in Indian society has been crucial in shaping the perception of dealership individuals, ultimately leading to the emergence of a customer segment that can be called 'symbolic go-getters'. The narratives from most interviewees, regardless of the franchise they work for, revolved around how a small but important segment of customers attaches high symbolic value to new products like EVs, even with little prior knowledge of such vehicles or their functionalities. 'Symbolic go-getters' in all probability consider EVs to stand for the symbolic status of their (mostly wealthy) identity as well as a fount of positive emotions. Customers placed into this segment are most likely to buy premium cars, where symbolic factors like the aesthetics of the model and speed range play a significant role in choice-making. In some cases, it was argued that this segment largely comprises young adults from wealthy families, with individuals likely to have a strong predisposition to buy an EV. This is evidenced by the following response:

'....there is section of rich people, at least in Delhi, who already have 3-4 cars in the family but want to buy a new one may be because one of their kids have turned 18 and now can officially drive a car...the kid wants something that he/she can show among friends with pride, a car which, irrespective to other functions, looks premium, elite and new...then he/she chooses to buy an EV....'

c. Segment 3: Acquisitive Enthusiasts

In contrast to the previous subgroup, this segment, called 'acquisitive enthusiasts', consists of people with the lowest likelihood of having a strong preoccupation with purchasing an electric car when they visit dealerships for the first time. A similar pattern is observed among dealership professionals in all three cities: highly educated individuals and/or families acquire most of their information about EVs at car dealerships, corroborate that information with their prior knowledge of e-mobility alternatives, and finally conduct a cost-benefit analysis between ICE vehicles and EVs right at the dealership. There was nearly complete agreement among interviewees that the educational, demographic, and economic status of this group tends to correspond with popular perception about EV buyers that they are highly educated, middle-aged, technologically proficient, white-collar working professionals, in need of a second or third car in the family, mostly for intra-city travels:

'....we have customers who came to our outlet to buy an ICE car, but we convinced them to buy an EV...they are like doctors, professors, and other higher-middle-class people wanting an additional car...they get inclined towards EVs mostly because of the vehicle features like smooth driving, no pollution, etc...'

Furthermore, 'acquisitive enthusiasts' appeared to be the sole group in which individuals are most likely to hold a pro-environmental attitude. Mentions of the environment in many conversations between salespersons and customers can be attributed to the educational backgrounds and urban living of the individuals in this segment. In addition, the interviews revealed that 'acquisitive enthusiasts' seemed to dominate female car buyers compared to other segments.

d. Segment 4: Middle-Class Aspirers

This distinct sub-group of customers has emerged as the most important segment among potential EV buyers, principally comprising two groups: small-town dwellers and people living in apartment blocks in large metropolitan cities like Delhi and Ahmedabad. Discussions with dealership professionals highlighted that middle-income individuals, mostly associated with the service economy, who visit car

dealerships from small towns near metropolitan cities are the most potent buyers of electric cars, especially when they are searching for an additional vehicle for their existing family fleet. Some informants emphasized that this group of customers possesses substantial knowledge about EVs, their attributes and advantages, but are unwilling to purchase one because of limited EV-supporting infrastructure and after-sales service facilities in small towns. In reference to the subject of infrastructural deficiency, one informant from Varanasi noted that:

'....we have several customers coming from nearby cities like Bhadohi, Jaunpur etc., who are educated and knows a lot about EVs...sometimes they opt for test driving an EV and give positive feedback based on their experiences...but ultimately they chose ICE cars saying "petrol pumps and mechanics for ICE vehicles are available in our town but there is not a single charging station available, neither do we have mechanics ready to take care of even any minor fault in the electric vehicle"...'

A similar pattern of preferences and attitude towards electric cars, as dealership professionals have experienced, could be seen among middle-income families living in apartment blocks within larger cities. This segment consists of single-family, young adult, apartment-dwellers with more than one working member in the household. The EV is more likely to be the second car in the family, brought for the female member to aid home-to-workplace commutes. During the interview discussions, several participants described how the densely populated apartment housing, combined with restrictions from their housing societies, effectively rules out the possibility of installing home charging infrastructure. Moreover, in several old buildings, the parking space is already saturated, with little space for new additions, let alone leaving space for the installation of vehicle charging units. The following response of an interviewee from Delhi illustrates that the attitude towards EVs, being subjected to different sources of volatility including social desirability biases, cannot be understood as a positive or negative outcome of demographic and economic factors solely, but rather must also be comprehended relative to the residential context effects:

'....every day we get to deal with customers who live in flats [apartment complexes]*...living in flats is more common in Delhi than anything else...while living in such places, how a person is supposed to buy an EV even if he wants to, even if he has substantial knowledge about the benefits of using electrics* [EVs]*...he will not get permission to install charging points in his apartment...the residential societies will immediately start raising objections...'*

Therefore, it is essential to note that residential contexts, despite other conditions being favorable, can come in the way of acceptance of electric cars.

e. Segment 5: Urban Indifferents

This cluster has emerged as the only distinctive group dominated by older individuals, visiting the dealership with a preoccupation to purchase popular premium models in ICE vehicles. In a few instances, professionals at dealerships detailed their interactions with mostly wealthy, older customers, with more than two vehicles in the family and living in urban or suburban single-occupancy houses. In much of the discussions, this group has been identified as 'indifferents' with modest product-specific knowledge, low environmental consciousness, but high perceived EV-risk surrounding charging infrastructure deficiency, longer charging duration, and range anxiety. As an interviewee from Varanasi has argued:

'....it is difficult to convince older people for high-tech products...it's not that they don't know about EVs, they do...they may have money, already 2-3 cars, own house with no parking issue, but still they will not be convinced...their third or fourth car would also have to be an ICE car, in some cases the same model that they are already driving....'

Deeply rooted in social conservatism and a preference for established norms, many older customers at the dealership approach technology with a cautious pragmatism. They favor widely used and familiar vehicle models over newer innovations, and often express their willingness to purchase new kinds of vehicles (like EVs) until such technologies become socially entrenched, as illustrated by the following quote from a sales manager working in an automobile dealership in Delhi:

'....many wealthy customers, mostly a little old, say EVs are still not that popular...they will opt for EVs if others around them will do so....'

Hence, the perceived ease of using EVs reflected through the favorable attitude of older individuals from high income families that using EVs as a high-end technological product will ease the driving process, and probably cause less mental and physical fatigue, is somehow overturned by indifference towards environmental externalities of vehicle usage, lack of consciousness about emerging technologies, long-standing orthodoxies in favour of ICE vehicles and age-induced technophobia.

f. Segment 6: Rural Conservatives

The last segment can be termed as 'rural conservatives', which accommodates individuals and groups with an extremely unfavorable perception towards electric cars. Respondents were of the view that car buyers in this segment, living in rural areas, have low product (EVs)-specific knowledge, a lack of technological awareness, and a low level of environmental consciousness. Their overarching attitude towards electric cars centers on perceived risks, including negative beliefs about the usefulness of EVs, their advantages, and attributes. This is attributed to a number of factors, including - near unavailability of charging infrastructure in rural areas, occasional use of the vehicle by rural households, and most inevitably, the popular perception about EVs as 'city people's car'. This finding partially corresponds with the arguments made by Sbrocchi et al. (2025) in the context of Canada that rural communities largely perceive EVs as cars made for urban areas. Rural people's vehicle preferences, usage of such vehicles, pride attached to a car, and associated trade-offs were stressed by an interviewer from Varanasi, and how such factors in combination are at odds with the decision to purchase an EV:

'....for most of the village people in this region, a car is a big deal...in villages, if a family has a car then they have a very high social status, you know right!...this is the reason rural people are very conservative about their choices....they are likely to choose the models that are conventionally popular...'

Similarly, another professional working at a dealership in Delhi reasoned that if people living in interior rural areas decide not to purchase an EV, it is because of a long-standing trajectory of advertising and promoting high-end technological products like EVs as urban artefacts. She further argued:

'....we cannot even mention an EV to a customer coming from villages...many of them have never even heard about an EV, those who have heard have never seen one....how can you even possibly ask them to buy one....'

3.6. Need for Customized Policies

The principal aim of this research is to understand whether and how the emerging market for electric cars in India is segmented across different groups of actual and potential adopters, which, in turn, can help lay the groundwork for customized policy formulation to address the heterogeneous needs of different consumer segments. Our analysis is informed by insights gathered from interviews with professionals at automobile dealerships. The six customer segments identified in conversations with dealership personnel in Delhi, Ahmedabad, and Varanasi have substantial potential to provide a range of policy insights to effectively address the heterogeneous structure of the emerging EV market in India. In essence, the thematic analysis of interview responses indicates diversity in preferences across heterogeneous consumer segments in the EV market, suggesting that demand for electric cars has been driven by niche consumers and will continue to be so as the market matures. Moreover, the analysis adds another layer to the segmented EV market in India, underscoring the diverse impact of key factors on purchase decisions among both actual and potential customers.

The findings indicate that subsidy withdrawal may have a significant negative impact on the sale of base models, whereas the sale of premium models may remain unchanged if the market is slightly mature. Since the EV market in India is still at its infancy and a sound proportion of customers are 'subsidy dependents' who assign higher value to factors like purchase price and financial support from the government, only a fairly high amount of subsidy would allow for the proliferation of 'low type EV market share' (Chen et al., 2018) embraced by middle income customers. We found that the wealthiest consumers may purchase high-end electric cars without paying much attention to financial subsidies, but middle-income urban families – especially those in search of a second car in the household – are likely to be inclined towards base-model EVs only when the subsidy is large enough. Given the impact of financial aid on the sale of low-end electric cars, subsidy policies of both the central and state governments must align with vehicle models to ensure that a higher proportion of the upfront cost is covered by subsidy support for the base models. Manufacturers, in this regard, are encouraged to add more diversity to the models in the base category, as we have noticed in several franchised dealerships that EVs are available solely in premium categories, with vehicles accessible to wealthy consumers only.

Drawing on their long-standing experience of vehicle sales, dealership professionals emphasized that for 'symbolic go-getters', the factors related to vehicle attributes like aesthetics, battery range, ease of driving, and others bear a more significant imprint than others. The primary motivation for this segment to consider buying an electric car is likely to originate from the symbolic value that they attach to high-end technological products, and is unlikely to originate from their environmental consciousness and degree of innovativeness. Considering the particulates of this segment, manufacturers would increasingly need to focus on technological enhancements in vehicle attributes. Enhancement of symbolic features like the aesthetics of premium vehicle models may prove to be beneficial for manufacturers to address the preference of potential 'symbolic go-getters' in the future.

It appears from the interviews that several barriers, both actual and perceived, are obstructing faster EV uptake among apartment dwellers in large metropolitan cities, residents of smaller urban bodies, and rural communities. Since in many instances apartment dwellers are prohibited from installing their own charging facilities, local and state governments may consider improving the physical layout of apartment compounds through planning interventions and collaborating closely with real-estate firms

to support the strategic installation of charging infrastructure both in existing apartment blocks as well as in those under construction. Through better land use planning, it is also important to create new parking spaces and serve the old ones with public charging facilities.

Across the case cities, a recurring perception among dealership individuals suggested that the lack of public charging infrastructure is a common barrier to mass EV adoption everywhere in India, but the extent to which such an infrastructural void is experienced outside large metropolitan cities – in small towns, peri-urban localities, and rural areas - is often more severe. Our findings further indicate that 'middle-class aspirers' in small cities are more open to EV adoption than 'urban indifferents' in larger metropolitan cities and conservatives in rural areas, suggesting that the potential growth in demand for electric cars may emerge from smaller urban settlements. However, it is noteworthy that in smaller cities located away from metropolitan agglomerations, several odds, including relatively modest household income levels, a preponderance of short-distance commutes, insufficient public charging infrastructure, a shortage of parking spaces, and a lack of after-sales support, are stacked against the demand for electric cars. Thus, it is recommended that urban local bodies in small municipalities, supported by the central and state governments, may run marketing campaigns through rigorous collaboration with vehicle manufacturers and service providers to raise awareness among residents. To increase demand for EVs in small towns and build awareness, it is certainly important to invest in public charging infrastructure and an after-sales support network. It is also essential to encourage vehicle manufacturers to design, manufacture, and offer a wide variety of base-model, low-cost EVs tailored to the road and parking conditions in small cities and their niche markets.

Finally, our findings on the pessimistic perception of vehicle buyers coming from rural areas, as experienced by dealership individuals in all three cities, indicate that low public awareness concerning e-mobility alternatives, lack of environmental consciousness, and unavailability of public charging infrastructure have somehow impeded the initial interest of rural communities in the idea of EVs. To break through such conservative norms, at least in part, the government, along with stakeholders at both central and state levels, should continue marketing campaigns to raise awareness, spark public interest, and inform citizens by emphasizing the economic benefits of using electric vehicles and their positive environmental impacts. Investment in such planned promotional efforts, as Jaiswal et al. (2022, p. 102969) would argue, 'can also convince the "Conservatives" and the "Indifferents" to adopt EVs as their forthcoming choice'.

3.7. Conclusion

The present study explores whether and how the market for EVs is segmented across both actual and potential early adopters in a developing country experiencing rapid rates of motorization, particularly over the last three decades. Altogether, the findings substantiate that a meaningful degree of stratification prevails in reference to the emerging market for electric cars in India. The customer sub-groups identified not only vary in terms of the characteristics of individuals constituting such segments but also demonstrate a strong geographic effect that is captured by the rural-urban and small town-big city binaries in terms of the locations where actual and potential consumers live. This research thus opens significant avenues for future work – to ask how geographical divides, especially the contrast between big city and small town as well as between urban and rural areas, come to bear on the idea of EVs as a feasible alternative for sustainable mobility transition.

One of the novel contributions made by the study reported in this section is a detailed profiling of identified customer segments through an examination of factors that play a decisive role in their purchase decisions. Conceptually, this research contributes to an alternative understanding of customer segments prevailing in an emerging EV market by putting automobile dealerships at the frontline. The findings, though, are based on Indian cities and have wider academic and policy implications, given the ubiquitous existence of franchised dealerships across the world as an ideal business model for EV sales. Thus all countries in general, but developing countries in particular, committed to sustainable transitioning of road transport sector toward e-mobility alternatives might find the outcome of this study useful to understand different customer segments for EVs from a differential perspective, to focus on customized policy addressal to diverse needs of different customer segments as well as to rule out any prevailing form of self-reinforcing mechanism between social inequality and EV adoption.

4. Key Takeaways from the Chapter

For policymakers committed to achieving India's ambitious goal of 30% EV sales by 2030, the findings from this chapter, which focused on dealer interactions and consumer ground realities presents a clear mandate for implementing customized policy solutions. The overall challenge is two-fold: addressing the external market barriers experienced by customers, and resolving the internal "motivation-dilemma" faced by automobile dealership professionals, who are important intermediaries in the EV sales ecosystem.

A major policy implication revolves around rationalizing the financial landscape for both consumers and dealerships. Policymakers must confront the prevailing subsidy-insufficiency and the inconsistency of current subsidy structures. Since many middle-income buyers, or subsidy dependents, are price-sensitive and prioritize the upfront cost of the vehicle, subsidies must be substantial enough to significantly reduce the price difference between EVs and conventional Internal Combustion Engine (ICE) vehicles. To unlock demand from the crucial middle-class segment, subsidies can be designed to cover a higher proportion of the upfront cost for base-model EVs. Bringing temporal consistency to subsidy policies is also necessary, as the frequent changes in government schemes create confusion and frustration for dealerships and customers alike.

Beyond financial incentives for customers, policies must directly address the dealership motivation dilemma. Dealership professionals are demotivated by profit-cuts on EV sales and the severe reduction in back-end profits from servicing and repairs. Given the greater time and rigor required to sell an EV, policymakers should consider allowances for modest government financial incentives for automobile dealerships, linked to sales performance and capacity building. Simultaneously, manufacturers, potentially encouraged by policy, must ensure that EV sales personnel are rewarded with higher direct incentives per vehicle sale and that dealerships establish an Exclusive EV Workforce to prevent salespersons from steering customers towards ICE vehicles, which offer higher back-end income.

Policymakers must also adopt a holistic approach to infrastructural development that recognizes geographic diversity. The lack of public charging infrastructure is not a uniform problem; while large cities like Delhi have a reasonable quantity of stations, the key impediment in mega-urban agglomerations lies in the inability to install home charging facilities in old housing societies. Local

governments and planning bodies must intervene to improve the physical layout of these residential contexts and mandate the strategic installation of charging infrastructure to support "middle-class aspirers" who live in dense housing complexes. While in smaller cities like Varanasi and surrounding rural areas, policymakers must prioritize addressing unreliable power supply, which causes interruptions in home charging and induces high perceived risk among potential users.

The policy framework must be tailored to address the highly segmented nature of the emerging EV market. The insights from dealership professionals reveal that purchase motivations vary widely:

For "middle-class aspirers" in small towns and apartment dwellers, policies need to focus on extending public charging infrastructure and after-sales support networks outside of major metropolitan areas.

For wealthy "symbolic go-getters," who prioritize vehicle aesthetics and status, policymakers can influence manufacturers to focus on technological enhancements in vehicle attributes and symbolic features of premium models.

To counter the extreme pessimism of "rural conservatives," who view EVs as "city-people's-cars," the government must continue marketing campaigns to raise awareness, emphasizing the economic benefits of using EVs and countering misinformation and skepticism.

By moving away from generalized national schemes and towards customized policy addressal that considers the heterogeneous demands of specific customer segments, policymakers can more effectively navigate the complexities of India's early-stage EV market and rule out the self-reinforcing mechanism between social inequality and EV adoption. This approach of integrating both demand-side incentives and supply-side support for the dealer network is essential for a successful transition to greener mobility alternatives

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Chapter 9

India's E-Bus Transition: Opportunities and Challenges

Chapter Summary

Content:

1. Reviews the global and Indian e-bus landscape, national schemes, cost structure, charging, and grid implications, and synthesizes these with case studies and policy analysis.
2. Presents technical, financial, and operational assessments (battery and charging specifications, depot, and route planning, TCO) and primary qualitative insights from consultations with STUs, OEMs, and operators.

Findings:

1. Upfront capital and battery costs drive an 80-lakh-plus price gap (e-bus ≈₹1.2–1.5 crore; battery ≈30–40% of cost), higher operating cost per km, and financing/tendering frictions that constrain procurement.
2. Deployment is uneven: charging- and grid-capacity shortfalls, fragmented policy implementation, limited depot land, and a shortage of trained workforce limit scale-up despite supportive schemes.

Takeaways:

1. Accelerating e-bus adoption requires integrated policy and financing packages that include depot land reservation, targeted operational subsidies/PSM design, and transparent performance auditing to bridge TCO and payment risks.
2. Standardized charging protocols, BOT/BOT-like procurement to bundle vehicles + infrastructure, dedicated bus lanes, and large-scale skilling are essential to move from pilots to sustainable, city-wide e-bus systems.

1. Introduction

1.1. Background

The global shift toward electric mobility is no longer a distant goal but a high-speed reality in the bus sector. While China dominates, accounting for 90% of the world's e-buses, regions like the EU are hitting major milestones. In 2023, electric buses surpassed diesel for the first time, accounting for 36% of new city bus sales in the EU. Canada is matching this ambition with a $2.75 billion commitment to procure 5,000 buses by 2025.

In India, the stakes are equally high. The nation aims for 30% e-bus sales by 2030, yet the "entry price" remains the primary hurdle. An e-bus costs approximately ₹1.2 to ₹1.5 crore, nearly three times the ₹45 lakh price tag of a diesel bus. The "heart" of this expense is the battery, which accounts for 30% to 40% of the total vehicle cost.

Today, 90% of India's fleet is driven by State Transport Undertakings (STUs), with the remaining 10% forming a "green belt" of private corporate transport. Transitioning to a net-zero future requires more than just new vehicles; it demands the development of an entire ecosystem, including grids, depots, and the skills needed.

Building upon the broader decarbonization goals discussed in the preceding chapters, this chapter aims to provide a broader assessment of the e-bus sector's unique technical, economic, and institutional landscape in India. The insights offered in this chapter move beyond high-level targets to reconcile the ₹80 lakh price gap between conventional and electric fleets with real-world operational data and frontline stakeholder perspectives. By synthesizing national policy analysis with direct insights from transit authorities and manufacturers, this chapter aims to identify the systemic shifts required to move from pilot-phase adoption to a self-sustaining, scalable e-bus ecosystem in India.

The rest of the chapter is designed as follows: Section 1 provides a bird's-eye view of the e-bus transition, presenting case studies from global leaders to India's 2030 targets. Section 2 explains the planning, financial, policy, and charging aspects of e-buses by breaking down the 3x price gap, battery costs, and the financial strain on transport undertakings while providing a synthesized assessment of policies with a focus on national schemes like FAME II, PM e-Bus Sewa, and Payment Security Mechanism (PSM). Section 3 aims to address the technical, maintenance, and reskilling aspects of e-bus procurement and operations by exploring battery tech (LFP vs. LTO), charging protocols, and the massive power demand on urban grids. Section 4 provides an overview of users' perceptions of the e-bus and the social considerations required for long-term e-bus planning. Section 5 provides insights from stakeholders working with government and private-sector players in India's e-bus space. Section 6 presents recommendations for policymakers to accelerate e-bus adoption by addressing issues such as "range anxiety," depot land scarcity, and the need for 200,000 skilled EV workers by 2030. Finally, Section 7 outlines recommendations and the path forward for India's e-bus transition, proposing strategic roadmaps for TCO parity, integrated urban planning, and the future of clean mobility.

1.2. Global Landscape of E-buses

By 2024, electric buses accounted for nearly 100% of new bus sales in China (Sustainable Bus, 2024), while the government had set a target for approximately 72% of the country's total public bus fleet to be electrified by 2025 (Transformative Urban Mobility Initiative, n.d.). With the global landscape of e-bus adoption in public transport evolving, 90% of the world's electric buses are operational in China. (Sustainable Bus, 2024). 10% of public buses in the Netherlands are electrified, with a future agreement to purchase electric buses for public transport from 2025. London's bus fleet aims to be fully electric by 2037, reducing annual CO_2 emissions by 57,000 tons. At the same time, Canada has committed nearly 2.75 billion dollars to procure 5,000 electric buses by 2025 (Transformative Urban Mobility Initiative, n.d.).

Interestingly, while the world bus market was stable, sales of e-buses grew by 40% compared to the previous year (Blackridge Research & Consulting, 2025). Latin America has experienced substantial expansion in its e-bus fleets, with nearly 5,900 e-buses operating across 41 cities in 12 countries within the region in July 2024 (Sustainable Bus, 2024). Europe's fully electric bus sales have risen quickly, from 5% in 2016 to 10% in 2021 (Blackridge Research & Consulting, 2025). Likewise, the EU accounted for 36% of new city electric bus sales in 2023, marking the first time electric buses surpassed diesel as the primary fuel type in this segment. Based on this growth rate, it has been projected that all new EU city buses could achieve zero-emission status by 2027 (Molliere, 2024). Moreover, electric vehicles accounted for over 70% of four-wheeled passenger-vehicle imports in Nepal in 2024, including minibuses. This figure places Nepal among the global leaders in electric vehicle importation rates (Pattisson, 2025). Meanwhile, West Africa recently inaugurated its 18.3-kilometer, fully electric Bus Rapid Transit (BRT) system, marking Africa's first such system. The system is equipped with 144 e-buses, capable of serving almost 3,00,000 passengers daily (Tam, 2024).

In India, 50% of e-buses operate only in Pune and Delhi (Blackridge Research & Consulting, 2025). Annual E-Bus sales are expected to reach 30% by 2030 nationwide (Transformative Urban Mobility Initiative, n.d.). However, addressing chronic challenges is critical for accelerating this growth, as only an estimated 4,000 e-buses are operational in India (IEA, 2024).

The transition does not involve simply replacing ICE buses with electric buses. Rather, a successful deployment of e-buses requires integrating charging infrastructure, energy grid upgrades, financing mechanisms, and workforce reskilling into a coherent ecosystem. Local and regional differences in the adoption of electric buses highlight the need for less fragmented policies and stronger financial capabilities. This approach is crucial to ensure that electrified public transport becomes a universally accessible solution, rather than remaining exclusive to more developed regions. Ultimately, the increasing presence of electric buses also positions public transport as cleaner and quieter, boosting the country's overall sustainable development goals.

2. Planning Considerations

2.1. Cost Economics of E-Buses

The shift to e-buses in India poses significant financial challenges, primarily due to the initial, unavoidable capital investment. In 2023, a 12-meter-long electric AC bus cost roughly INR 1.5 crore, depending on specifications and the manufacturer (Singh, 2024). This exceeds the cost of conventional diesel buses, which are priced at approximately INR 45 lakh. For instance, the Pune Mahanagar Parivahan Mahamandal Limited (PMPML) operates a fleet of nearly 1,465 buses. Replacing these diesel buses with electric buses would require an investment of over INR 1,758 crore, underscoring the economic burden imposed on regional transport agencies in adopting e-buses (Jaywant & Kanitkar, 2022; Punepulse, 2020).

Simultaneously, the costs associated with installation, battery procurement, and maintenance remain significantly high, with the battery pack accounting for roughly 30–40% of the overall vehicle cost (Punepulse, 2020). Furthermore, the infrastructure required to support electric buses is also financially burdensome (Gopi R et al., 2024). Insufficient funding alternatives, including subsidies and incentives, further exacerbate the prevailing cost difficulties (Gopi R et al., 2024; Spena et al., 2016). Nonetheless, the government, along with its supporting schemes and funding initiatives, has been promoting the procurement of e-buses across all states. Initiatives like FAME and PM e-bus Sewa, to name a few, have been streamlining the process in this regard. On the other hand, the majority of STUs endure the financial strain, with only a few attaining profitability. This financial instability impedes their capacity to invest in e-bus acquisition and associated infrastructure development.

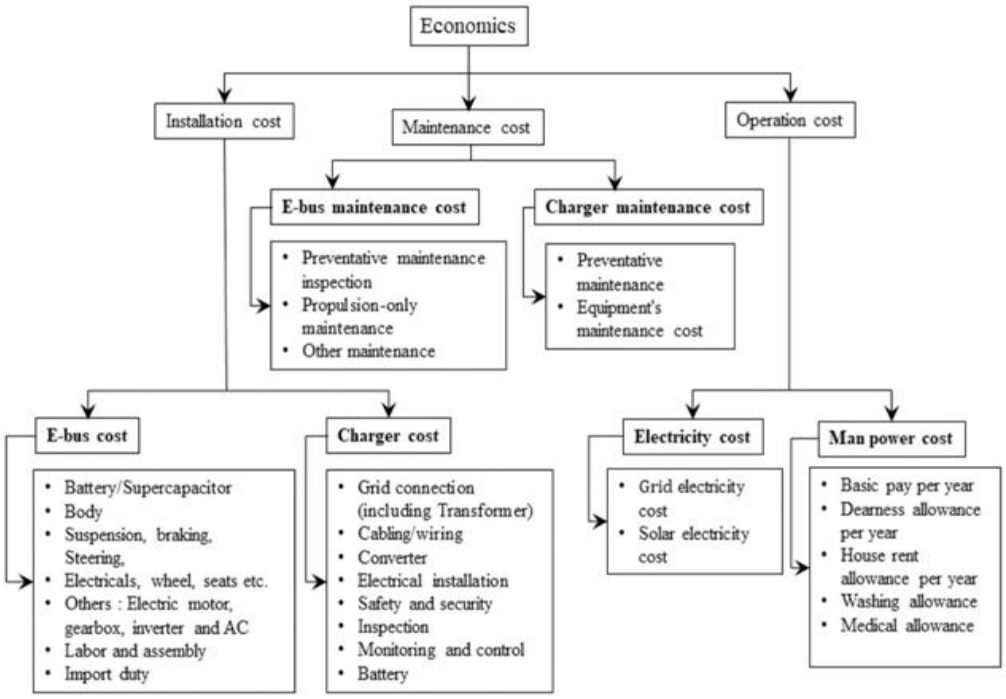


Figure 1: Components of the electric bus cost structure

Source: Majumder et al., 2021

The net loss of about 58 SRTUs surged to INR 30,191.93 crore in FY22, marking a 68% increase over the past 3 years (Mishra, 2025). This escalation is attributed to reduced fleet utilization, rising fuel costs, and the implementation of free-ride schemes in several states without adequate compensation to SRTUs. Furthermore, the pandemic led to a significant decrease in passenger numbers, with an occupancy rate of nearly 72.3%, down from the pre-pandemic level of almost 88%. Consequently, the number of buses operated by SRTUs declined from 1.52 lakhs in 2018-2019 to 1.47 lakhs in 2021-2022 (Dash, 2025). Under these challenging circumstances, investing in e-buses and associated infrastructure development is difficult. However, government initiatives such as the National Electric Bus Programme (NEBP) have demonstrated efficacy in facilitating the acquisition of e-buses (Energyworld, 2023).

The state's acquisition and adoption of e-buses are carried out through a PPP model, requiring private entities to secure bank financing to achieve the objectives. However, banks are hesitant to extend loans to private players or e-bus manufacturers due to concerns about incurring debt (Singh, 2022). This is primarily because diesel buses are priced significantly lower than electric buses, making them more secure for banks, as they can repossess the asset and redeploy it in case of a default. On the contrary, e-buses require charging and additional infrastructure that may not be easily accessible. Moreover, past instances of deferred payments from public transport authorities have placed financial strain on operators. Consequently, the higher financing costs are reflected in the higher bid rates submitted by the operators (Chatterjee, 2024).

In an attempt to address this, the adoption of the Payment Security Mechanism (PSM) under the PM-eBus Sewa Scheme ensures timely payments to manufacturers and operators in instances of default by Public Transport Authorities (PTAs), but it also presents challenges. The initiative, with a budget of approximately INR 3,500 crores, aims to deploy nearly 38,000 e-buses across India from the year 2024-25 to 2028-29 (Khare, 2024; MHI, 2024). The financial instability of numerous STUs raises concerns about the efficacy of the PSM. Private operators/players are reluctant to participate in the Gross Cost Contract (GCC) model due to concerns about delayed payments and the risk of defaults by financially unstable STUs (ETGovernment, 2024). Thus, the success of the PSM depends on efficient replenishment of the security fund and on financial discipline by the STUs, both of which are difficult to implement consistently across states.

2.2. Technical and Operational Specifications for E-bus Deployment

2.2.1. Bus-Specific Requirements:

Electric buses in India have battery capacities ranging from 250 to 500 kWh, providing a driving range of 150-300 km on a single charge. These batteries cost between INR 25 lakh and INR 50 lakh, contingent on the capacity, brand, and type (e.g., Lithium-ion or LFP), a major influence on the overall price of the bus (Singh, 2025b). However, a chronic challenge faced by e-bus operators is range anxiety (Singh, 2025a). In context, fast charging enables e-buses to reach 80% charge in 60 minutes, thereby reducing operational downtime (Singh, 2025b).

In the Indian context, the prevailing battery and charging technology for e-buses primarily involves 150–180 kWh Lithium Iron Phosphate (LFP) batteries, usually paired with plug-in charging. In the absence of sufficient daytime charging, it is difficult for e-bus batteries to cover the required daily operational distances, leading to diminished bus efficiency and reduced passenger capacity. However, implementing Lithium Titanium Oxide (LTO) batteries with pantograph charging systems is a viable solution to enhance operational efficiency without compromising service levels (Goyal, 2022).

2.2.2. Battery and Charging Specifications:

The infrastructure of e-bus charging requires sufficient battery capacity, roughly between 100 and 200 kWh, in conjunction with high-power chargers rated between 120 and 300 kW. This necessitates specialized software solutions for load balancing, grid integration, and extensive operational monitoring. As a result, these systems require a greater capital investment than other vehicle segments. (EVreporter, 2020). Electric buses are typically charged via wired connections, using either AC or DC power. AC charging technology is utilized when a bus is fitted with an onboard charger; in contrast, DC chargers are located externally to the vehicle. A study revealed that Indian bus makers primarily opted for 70kW DC charging for their buses. Whereas, globally, the predominant technique for bus charging employs DC plug-in technology operating at 50 kW or more. High-power DC charging of 150 kW or more is typically used for rapid charging at intervals in the international market. This high-power DC charging requires specialized pantograph systems rather than traditional cable connections (Marndi & Sasidharan, 2021).

2.2.3. Route Planning:

Electrifying public bus transportation is crucial for achieving India's net-zero goals, necessitating the introduction of more than 1,00,000 electric buses by 2030. However, prominent challenges arise in route-level planning, particularly in assessing operational and budgetary feasibility. WRI India designed a guidebook and a Route Evaluator Solution to address these concerns. Route EValuator is an Excel-based decision-making framework developed to be intuitive, with real-time updates and the ability to plan diverse operating scenarios. These tools have been designed to help transit authorities in the optimal planning and execution of deploying electric buses (WRI India, 2022). Mofussil (non-urban) routes under 120 km were deemed profitable for 9m and 12m e-buses, while longer routes were not viable without high daily usage. Hilly routes were identified as profitable for 9m e-buses due to lower costs enabled by regenerative braking (Khanna et al., 2024).

Acknowledging the value of rural and intercity bus services, UITP India issued a knowledge brief outlining a feasible approach to selecting depots, routes, and charging stations for the electrification of long-range buses. The brief uses the example of the state of Karnataka in India to demonstrate how this may be executed (UITP India, 2022).

2.3. Charging Infrastructure: Status, Gaps, and Way Forward

E-buses provide a sustainable substitute for traditional diesel buses. Nevertheless, their widespread adoption depends on the availability of efficient and accessible charging infrastructure. E-buses accommodate more passengers, alleviate traffic congestion, and reduce carbon emissions on a larger

scale than private EVs and taxis. Global initiatives and efforts have been promoting and expanding the e-bus fleet to achieve the Net Zero Target. Considering both financial and ecological parameters, the implementation of electric buses yields substantial benefits, exceeding those of CNG buses by 21.6% (Debnath et al., 2024; Topal & Nakir, 2018).

However, a primary constraint impacting the full adoption of e-buses is the insufficient and ineffective public charging infrastructure. Achieving large-scale deployment of electric buses to meet sustainability goals requires substantial investment in charging infrastructure. Despite lower operating costs than diesel buses, recent procurement tenders have seen low participation rates, thereby slowing the pace of acquisition. (Chatterjee, 2024). Contextually, a few plausible explanations for the same ensue.

For instance, the lack of resilient charging infrastructure engenders hesitancy among operators. (Sisodia, 2024). Further, unlike private electric vehicles, which are commonly charged at residences or offices, electric buses use specialized charging terminals and depots. (Shams Ashkezari et al., 2024). Typically, an 18-meter electric bus with a 300-350 kWh capacity offers a range of approximately 190 kilometers. (Sustainable Bus, 2023) and takes 46 to 50 minutes to fully charge (EVBox, 2022). Given the operational demands of public transport, e-buses necessitate complete charging cycles to ensure an adequate daily operating range. Consequently, designated depots to facilitate continuous service availability for scheduled hours become imperative.

However, India's power demand rose by 12% in the first half of 2023, placing a significant burden on the national power grid. Buses require more energy and take longer to charge than passenger EVs, worsening the pressure and causing frequent power outages (HT Auto, 2024). Establishing electric vehicle charging infrastructure requires technical expertise to address impediments such as voltage fluctuations, overcurrent conditions, frequency discrepancies, and ground defects (Quince Market Insights, 2022). Concurrently, establishing a depot for a fleet of 100 e-buses can incur costs of up to INR 50 million, with potentially half of this expenditure allocated as a security deposit to the power distribution entity by transit authorities. This financial outlay renders the installation and establishment of charging infrastructure an economically draining undertaking. (Dhole, 2022). Alternatively, even with an available requisite land area of 70–120 square meters (Gandhi et al., n.d.), the substantial expense associated with land lease rentals (Nitish & Raman, 2019) raises concerns about the economic feasibility of establishing charging stations (Gowande, 2024).

Additionally, compatibility issues across a variety of electric vehicle models are exacerbated by the absence of standardized charging protocols (Saxena, 2025). Manufacturers frequently implement proprietary technologies, leading to a loss of uniformity. This lack of standardization compounds operational inefficiencies and impedes the deployment of universally accessible charging stations (TechSci Research, 2024).

Despite these limitations, targeted strategies, effective policies, and government support can accelerate the development of public charging infrastructure, potentially stimulating the adoption of e-buses. Industrial facilities have the capacity to produce large numbers of electric buses and their charging stations. Moreover, a variety of allied sectors can facilitate and catalyze this process. Concurrently, the execution of such an elaborate structure requires a significant workforce, thereby fostering job possibilities (Debnath et al., 2024).

Contextually, Tata Power Renewable Energy Limited (TPREL) has built more than 850 charging stations for e-buses in India (Parikh, 2024), facilitating over 2,300 public e-buses nationally by strategically positioning charging ports in more than 30 bus depots across major cities. The extensive bus charging network has effectively resulted in a reduction of almost 1,00,000 tons of tailpipe CO_2 emissions (Tata Power, 2024). On the other hand, the Delhi Transport Corporation (DTC) is implementing a smart charging system using AI to optimize charging schedules, reduce grid demand, and minimize electricity costs. The experiment is being executed at the Rajghat bus depot, which accommodates about 150 e-buses, wherein 35 e-buses can be charged simultaneously (Sinha, 2023). In addition, the Bangalore Metropolitan Transport Corporation (BMTC) is augmenting its EV charging infrastructure by establishing charging stations at 5 bus terminals, including Shivajinagar, Bannerghatta, Mallasandra, BTM Layout, and Kalasipalya, to support its expanding fleet of electric buses (Vivan et al., 2023). Similarly, the Himachal Road Transport Corporation (HRTC) is constructing 5 additional charging stations to facilitate over 70 electric buses in Shimla, with a financial commitment of INR 3.63 million for the construction of requisite transformers (Economic Times, 2023).

The advancement of India's public electric bus ecosystem is invariably linked to the development of a robust, efficient charging infrastructure. Sustained emphasis on government support, financial frameworks, and infrastructure development will be essential to achieving the nation's electric mobility objectives.

At the same time, it is crucial to look at the insufficient charging infrastructure. E-buses generally require high-capacity DC fast chargers (180 to 240 kW), enabling charging times of about 1 to 1.5 hours (Tata Power, 2024.), whereas e-buses utilizing AC chargers typically demand 2 to 3 hours for a complete charge (Olectra, n.d.), which is comparatively longer than the charging time needed for electric four-wheelers. Furthermore, the concurrent charging of many electric buses may impose stress on local power systems, potentially resulting in voltage fluctuations and heightened load during peak hours (Nath & Garg, 2021). Conversely, electric four-wheelers, due to their reduced power requirements, impose less strain on the grid and can be charged more frequently at residential or public charging stations without substantial infrastructure enhancements.

Although India has made progress in expanding its EV charging infrastructure, the expansion has not kept pace with rising demand. As of December 2024, India possesses 25k+ public charging stations, with Karnataka at the forefront with 5.5k+ stations, followed by Maharashtra with nearly 3.5k+ stations, and Uttar Pradesh with nearly 2k charging stations (Scott, 2025). To achieve the ideal proportion of 1 charger for every 40 electric vehicles, India must create around 4,00,000 charging stations each year, targeting a total installed capacity of 13.2 lakh charging stations by 2030 (ITDP India, 2025).

In addition, the standard range of an e-bus in India is roughly around 150–250 km per charge, contingent upon factors such as battery capacity and operational conditions (SAREP., 2024). This necessitates an increase in the number of recharge stations, as the current range is insufficient for public transportation vehicles. Although frequent charging can adversely affect the power grid, particularly during peak hours, leading to significant interruptions (SAREP., 2024; Castellino, 2025).

2.4. Electricity Demand and Grid Readiness

India's electricity demand is projected to rise by 7%-10% by 2025, straining the power grid. Adding EVs to the system could exacerbate the situation, causing more power outages, especially in rural areas. The demand for electricity to sustain EVs specifically is projected to surge to over 640 TWh by 2030 to satisfy the EV30@30 initiative (Setrans Mobility, n.d.). Amidst this challenging situation, India's escalating electricity consumption increased by 12% in the first half of 2023, placing significant strain on the power grid (HT Auto, 2024).

Electric buses have distinct charging characteristics, as they require substantial power for charging their batteries (A. L. P. Rodrigues & Seixas, 2022; Mohamed et al., 2017; Carrilero et al., 2018). The linear charging process requires slow plug-in chargers at bus depots and rapid plug-in chargers at bus stops. (Gönül et al., 2021; Lyu et al., 2020). Moreover, the total load required for a depot serving ICE buses exclusively generally ranges from 30 kW to 50 kW. However, the power demand for a single slow electric bus charger installed is 80 kW. A single fast charger has a capacity of 150 kW; however, a depot housing approximately 90 electric buses may require a targeted load of up to 4,000 kW from the power distribution company (Dhole, 2022).

2.5. Policy Framework and Governance

2.5.1. FAME I

From April 2015 to March 2019, the Government of India administered the FAME I plan through the Ministry of Heavy Industries, allocating INR 895 crores to address the initial cost of electric vehicles and encourage their adoption across multiple sectors, including public transportation. A total of 465 electric buses were approved for deployment in 11 Indian cities as a part of the initiative. (Suresh, 2024). By the end of this initiative, 11 cities had successfully implemented the subsidy, resulting in the deployment of 425 e-buses. However, estimates from the Ministry of Housing and Urban Affairs indicate a far higher need, suggesting the necessity of around 60 buses per 1 lakh population, resulting in an additional requirement of nearly 1.45 lakh buses to sufficiently address urban transport needs.

Additionally, 520 charging stations were sanctioned under FAME I, out of which 452 were implemented. Operational challenges were observed in some areas; for instance, in Nagpur, almost 34% of the electric bus fleet remained non-operational due to insufficient charging infrastructure (Suresh & Godwin, 2024). The policy permitted STUs to select between direct procurement and the GCC model, with demand incentives correlated to the degree of localization, ranging from INR 1 crore for 35% localization to INR 85 lakh for 15%, applicable to e-buses priced between INR 75 lakh and INR 1.75 crore (Soni, 2022). Cities such as Bengaluru, Mumbai, Hyderabad, Ahmedabad, and Jaipur originally solicited GCC bids, whilst others, such as Indore, Lucknow, Kolkata, Jammu, and Guwahati, chose to proceed with outright purchases. Nonetheless, execution varied inconsistently among states. In cities that predominantly used the GCC model, the tenders were ultimately rescinded, resulting in operational delays. In contrast, Hyderabad emerged as a significant exception, successfully deploying buses (Soni, 2022).

2.5.2. FAME II

The second phase of India's Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles scheme (FAME II), which was initiated in April 2019 with an initial budget of INR 10,000 crores and subsequently revised to INR 11,500 crores, was completed in March 2024 (Kohli, 2024). By 2024, only 4,766 of the 7,262 electric vehicles intended for this initiative had been deployed (Kohli, 2024). Private buses, which account for 93% of India's total bus fleet, were excluded from the initiative, which, despite its ambition, had a limited overall impact on nationwide electrification (Kohli, 2024). 61% of FAME II's financial support was allocated to demand incentives, 35% to capital asset creation, such as electric transportation and charging infrastructure, and the remaining funds to miscellaneous expenditures (Kohli, 2024). The scheme offered INR 20,000 per kWh of battery capacity for e-buses, capped at 40% of the ex-showroom price. This incentive applied to vehicles priced up to INR 2 crore. The initial objective was to procure 7,090 electric buses; however, this was subsequently altered to 7,262 (Kohli, 2024). As of July 31, 2024, only 5,135 e-buses had been dispatched to various cities and government entities under intra-city operations (MHI, 2025). Additionally, only 2,877 of the 7,580 e-bus stations have been sanctioned, of which only 148 are currently operational (Suresh, 2024), underscoring the barriers to infrastructure deployment.

Several states encountered substantial implementation challenges at the regional level. The KSRTC in Kerala withdrew from the FAME II tenders, citing the subsidy conditions being financially unviable. These conditions called for an INR 55 lakh subsidy contingent on buses covering 9.1 lakh km over 12 years, despite a cost of INR 75.90/km and revenue of only INR 38/km. Consequently, the tenders were canceled, and state-funded alternatives were implemented (Mathrubhumi, 2022). In the same vein, Tamil Nadu suspended tenders for 525 e-buses in cities including Coimbatore and Trichy after discovering that the central subsidy of INR 35–55 lakhs per bus was inadequate to counterbalance acquisition costs of INR 1.2 crore (Sundaram, 2021). In Delhi, the Finance Department withdrew INR 285 crore in subsidy funding, despite the Cabinet's sanction to procure 579 e-buses under FAME II, causing deployment delays (Mani, 2023).

2.5.3. PM e-Bus Sewa Scheme

The PM e-Bus Sewa Scheme, approved in August 2023, is an iconic endeavor of the Government of India. It is designed to introduce 10,000 e-buses in cities with populations exceeding 3 lakhs. The scheme is backed by central funding of INR 57,613 crore, which includes INR 20,000 crore in direct subsidies over 10 years (Times of India, 2023). Moreover, the scheme is expected to generate 45,000 to 55,000 new employment opportunities (Ministry of Housing & Urban Affairs, 2023). Further, it is operated under a PPP model using a Gross Cost Contract (GCC). Private OEMs or operators maintain and operate the buses, while Public Transport Authorities (PTAs) pay a monthly service fee. A Payment Security Mechanism (PSM) comprising an INR 3,435 crore corpus, governed by Convergence Energy Service Limited CESL, ensures that payments are made on time even if PTAs default (Khare, 2024). Major OEMs, including Tata Motors, Switch Mobility, JBM, and PMI, have been heavily participating in tenders for the first wave of 3,825 e-buses under the PSM's support since the beginning of 2024 (Vijay M, 2024). JBM Auto Limited, in particular, has received an order for 1,021 e-buses valued at INR 5,500 crore, to be delivered across 19 cities in Gujarat, Haryana, and Maharashtra. These buses are expected to generate 32 billion passenger e-kilometers and reduce CO_2 emissions by more than 1 billion tons

over a 12-year period (Mahajan, 2025). On the other hand, Chartered Bus runs more than 900 e-buses in 13 cities across 3 states, providing daily service to almost 2.9 lakh travelers and creating jobs for over 2,000 people (EnergyWorld, 2025).

In Nagpur, supplementary help has been obtained by requesting 240 new e-buses, in addition to expenditures in depot charging and the decommissioning of older diesel fleets (Chakraborty, 2025a). The Center has sanctioned 100 e-buses and allocated land for a new depot in Gurugram. However, deployment was postponed due to outstanding tendering processes, delays in technical authorization, and the absence of agreements with transport authorities (Gupta, 2025). Furthermore, only 28% of Bhopal's population uses private transportation, underscoring the importance of the public transportation system. In the midst of this, the Bhopal municipality ceased distributing operator subsidies, a component of the PSM. At the same time, over 149 buses were left out of service for 8 months, indicating that the public transport system is experiencing persistent financial duress (Agrawal, 2024).

2.5.4. PM E-DRIVE Scheme

The scheme has secured INR 10,900 crore in funding over 2 years, from 2024 to 2026. There is a provision of INR 4,391 crore to help PTAs deploy 14,028 e-buses (Ministry of Heavy Industries, 2025). The scheme has assured an allocation of 4,500 buses to Bengaluru, 2,800 to Delhi, 2,000 to Hyderabad, 1,000 to Ahmedabad, and 600 to Surat (Kumar, 2025). Further, the scheme encompasses the Electric Mobility Promotion Scheme (EMPS), which offered incentives for several EV categories (Ministry of Heavy Industries, 2025). The scheme prioritizes 9 major cities, including Mumbai, New Delhi, Bengaluru, and Kolkata (Dudhat, 2024).

Karnataka has sought nearly 7,000 e-buses for the Bengaluru Metropolitan Transport Corporation (BMTC) through this scheme (Money Control, 2025). In contrast, the Maharashtra government decided to cancel a large order of about 5,150 e-buses due to inordinate delays in delivery. Eventually, only about 250 e-buses were deployed (Bhattacharya, 2025). Despite such policy-level momentum, challenges persist, with the supply chain affecting market penetration of e-bus sales. Market sales of e-buses declined in FY2025, to 4.72%, indicating persistent challenges in uptake and deployment at the ground level (Pimpalkhare, 2025).

2.5.5. National Electric Bus Program (NEBP)

The NEBP, initiated in 2022, aims to deploy 50,000 e-buses by 2030, with a primary focus on intracity routes. (Ministry of Road Transport & Highways, 2024). However, e-buses comprised merely 1.25% of the 3,59,432 licensed buses as of May 2023 (Thomas, 2023). In addition, only 4,901 e-buses are operational as of 2024, accounting for only 10% of the established target (Castellino, 2025). Further, Convergence Energy Services Ltd (CESL) was appointed as the program manager to streamline purchase orders across localities and STUs to achieve economies of scale. (Ministry of Road Transport & Highways, 2024). Furthermore, the Gross Cost Contract (GCC) model entails the e-bus OEMs leasing electric buses, with payment based on the number of kilometers traveled (Jena & Trivedi, 2023). The initiative aims to assist Delhi by deploying 2,400 buses. Likewise, Telangana and Kerala will deploy 775 and 1,500 e-buses, respectively (Yadav, 2023).

Yet, prominent domestic manufacturers have been hesitant to participate in CESL tenders due to concerns about financing and supply capacity (UITP, 2023). In total, 56 SRTUs have a debt of INR 380 billion, according to figures from the Ministry of Road Transport and Highways. Furthermore, they declared an aggregate net loss of roughly INR 180 billion during the fiscal year 2018-19 (Jena & Trivedi, 2023). Moreover, the mechanical department of the Vadodara Municipal Corporation presented an outline for launching 200 electric buses within the NEBP, but the project was delayed (The Indian Express, 2023).

2.5.6. Delhi Electric Vehicle Interconnector (DEVI) Scheme

The Delhi Electric Vehicle Interconnector (DEVI) program aims to install 2,180 nine-meter e-buses by the end of 2025 to mitigate operational issues encountered by standard 12-meter buses in small or congested urban environments. These compact buses are better suited to Delhi's congested areas and are expected to enhance last-mile connectivity across the city. Each depot within the DEVI system is engineered to house up to 100 vehicles, with each bus expected to traverse a 12-kilometer route to enable short, intra-urban transportation (Sinha, 2025a). In this gradual deployment, 400 DEVI buses have been started in East and West Delhi, with the rest of the buses scheduled for deployment by the completion of 2025 (Times of India, 2025). To enhance last-mile connectivity, 255 of these buses have been assigned for short-distance feeder lines inside the urban transportation network (Sinha, 2025a). Each DEVI bus accommodates 23 seated passengers, with 6 seats designated for female passengers, and accommodates 13 standing passengers, thus promoting both capacity and inclusion in its design (Sinha, 2025c). A notable step under the DEVI plan is the incorporation of female bus drivers, representing an important breakthrough in promoting women's involvement in India's green mobility workforce and advancing gender parity in the public transportation industry (Singh, 2025).

Although the DEVI program signifies a missed potential for income enhancement. The Delhi Transport Corporation (DTC) did not leverage advertising earnings from Bus Body Wraps (BBW), leading to an anticipated loss of INR 40.57 crore from 2015 to 2022 due to unfulfilled contracts. Advertising exclusively on DEVI buses is anticipated to yield INR 13 crore every year, with a possible total revenue of INR 1,200 crore if implemented across DTC’s fleet of roughly 3,000 buses, based on an average yearly income of INR 4 lakh per bus (Sinha, 2025b).

Table 1: Proportion of Currently Operational e-Buses in India

City	Operational fleet size	Source
Bengaluru	1,436	(The New Indian Express, 2025)
Delhi	1,970	(Mishra, 2024)
Hyderabad	254	(Romeo, 2025)
Mumbai	1,003	(Shah, 2025)
Nagpur	260	(Chakraborty, 2025b)
Pune	490	(Tigga, 2025)

Ahmedabad	200	(Gujarat Samachar, 2024)
Surat	449	(Surat Municipal Corporation, 2025)
Lucknow	140	(India, 2024)
Indore	70	(Sustainable Bus, 2025)
Chennai	120	(K, 2025)
Jammu	100	(Sharma, 2025)
Srinagar	100	(Sharma, 2025)
Guwahati	356	(The Assam Tribune, 2025)

2.6. Summarizing Challenges in E-Bus Adoption

Policy-Level Challenges	**Manufacturing-Related Challenges**
1. High Upfront Capital Costs 2. Complex and Delayed Tendering Process 3. Weak Charging Infrastructure Planning 4. Land Availability for Depots 5. Lack of Institutional Capacity at Urban Local Bodies 6. Revenue Risk & Financial Viability for Operators 7. Fragmented Governance & Lack of Coordination 8. Inadequate Data and Route Planning Tools 9. Delayed Subsidy Disbursal 10. Policy Bias Toward Big Cities	1. Limited Domestic OEMs 2. Production Capacity Constraints 3. Low Local Manufacturing of Key Parts 4. Limited E-Bus Testing Facilities 5. Weak After-Sales Network 6. Shortage of Skilled Workforce 7. Lack of Component Standardization 8. Depot Electrification Gaps 9. Grid Load Constraints 10. Unclear Charging Standards 11. Poor Charging Infrastructure Planning 12. Slow Installation Timelines 13. Heavy Import Dependence for Battery Cells 14. High Battery Costs 15. Low R&D in Battery Tech 16. Lack of Climate-Tuned Batteries 17. Slow Progress in Cell Manufacturing (Gigafactories)

Challenges Faced by Government Authorities & ULBs in E-Bus Adoption
1. Limited Technical Expertise 2. Inadequate Institutional Capacity 3. Lack of Dedicated EV Cells or Nodal Officers 4. Financial Constraints 5. Delayed Subsidy Disbursal 6. Inflexible Tendering and Procurement Processes 7. Lack of Long-Term Planning or Data 8. Land Availability Issues 9. Weak Monitoring & Enforcement of Contracts 10. Limited Awareness of New Models (GCC, PPPs) 11. Coordination Challenges Between State & City-Level Agencies 12. Regulatory & Policy Uncertainty

3. Service, Maintenance, and Operational Considerations

3.1. Skilling and Training for Workforce Transition

Insufficient training could lead to increased maintenance problems. Comprehensive training ensures that operators can manage e-buses effectively, optimizing battery longevity and safeguarding passenger safety. A survey found that only 38% of technicians had the necessary expertise for e-bus operations, underscoring the pressing need for specialized training programs to address these shortcomings (GIZ, 2021). In this context, the Indian government recognizes the crucial role of skilled personnel in deploying e-buses and has initiated several capacity-building programs, including the PM e-bus Sewa, for which a corpus of INR 3,435.33 crores has been allocated. Apart from facilitating the deployment of more than 38,000 e-buses in the country, the initiative seeks to support capacity building and training, fostering the adoption of innovative technologies by PTAs to optimize electric bus operations (Ministry of Heavy Industries, 2024-b). The Heavy Motor Vehicle (HMV) training institute in Odisha has trained at least 20 women (The New Indian Express, 2023). A comparable project is underway in Calcutta, where e-bus drivers received enhanced training employing modules developed by the Automotive Skill Development Council (ASDC), a government initiative under the National Skill Development Council (NSDC) (The Telegraph, 2022). On similar lines, UITP India, with support from PMPML, conducted a two-day training program on ‘Deployment and Infrastructure Management for Electric Buses’ in Pune on June 27–28, 2024. The event hosted 36 participants from

16 organizations, including eight public transport authorities. Seven national and international experts delivered sessions on key topics, including charging infrastructure, performance evaluation, safety, and asset management for e-buses (UITP India, 2024). Additionally, "Mastering Electric Bus Safety" was launched in Delhi to equip people from the public transport agency and other stakeholders with the necessary skills to mitigate hazards such as fire outbreaks and other issues associated with electrically powered buses (ETAuto, 2023).

Moreover, electric bus operators and mechanics need expertise in battery management systems, electric drivetrains, and high-voltage safety. Many STUs lack trained and experienced staff in these fields. This skill gap hinders e-bus adoption by causing operational inefficiencies, downtime, and safety concerns. Contextually, the EV sector in India is anticipated to necessitate around 2,00,000 trained workers, particularly in technology, manufacturing, and after-sales services, by 2030, to achieve the government's objective of 30% EV adoption (Kumar, 2024). The current annual influx of trained EV personnel is 15,000; it must be increased to 30,000 to further support the complete localization of EV components by 2030. An estimated investment of nearly INR 13,552 crore is projected for the recruitment and training of the personnel (Economic Times, 2024).

In an attempt to expedite this, the Ministry of Skill Development and Entrepreneurship (MSDE) has implemented measures to ensure that educational institutions incorporate electric-vehicle-specific courses, including mechatronics, battery technology, and charging infrastructure, into their curricula. (Dave, 2024). Moreover, UITP India organized a two-day training session in March 2025 on 'Emerging Practices in Electric Bus Management and Sustainable Operations,' aimed at enhancing the competencies of key stakeholders and providing insights into sustainable planning, operational optimization, financing strategies for electric buses, and charging and battery management (UITP India, 2025).

Thus, a dedicated and focused approach incorporating governmental initiatives, academic improvements, and industry partnerships is vital to cultivate a proficient workforce capable of sustaining the EV ecosystem (Prashant, 2025).

3.2. Technology for Smart Operations

The battery lifecycle is roughly 5 years, creating economic challenges because battery replacements account for a substantial share of the overall cost of ownership. (Singh, 2022). In light of this, models are being created to optimize battery storage capacity and performance. (BFH, 2025)to prolong battery lifespan and improve the economic feasibility of electric buses.

At the same time, increased temperatures are a primary factor in battery deterioration, particularly in regions as warm as India. Lithium-ion batteries are sensitive to heat, which accelerates internal chemical reactions and increases the rate of deterioration. This leads to diminished charging efficiency, decreased battery capacity, and a truncated overall lifespan (Lean Watts, 2024). The National Program on Advanced Chemistry Cell (ACC) Battery Storage, part of the PLI plan, seeks to enhance battery manufacturing capabilities in India by maximizing domestic value addition (Ministry of Heavy Industries, 2023a).

Alternatively, to lower operating costs, India is establishing regulations on swappable e-bus batteries to ensure interoperability and facilitate battery replacement. Concurrently, there is an emphasis on

developing universal swapping depots for all e-buses to alleviate range anxiety. This would enhance overall efficiency while mitigating limitations on infrastructure and operational costs (Gowande, 2024). Investment in charging infrastructure and standardized battery specifications will thus be crucial to achieve the aspirational target of 800,000 e-buses by 2030 (Singh, 2024).

4. Public Perception and Social Considerations

Research indicates that environmental awareness does not consistently correlate positively with the intention of employing an electric vehicle (Adnan, 2014). For instance, in Sweden, e-buses are favored over diesel buses due to their 75% reduced noise levels, enhanced comfort, 25% lower cost, and 8% decreased energy consumption (Herrenkind et al., 2019; Sunitiyoso et al., 2022), implying consumers generally favor solutions that offer financial or comfort-related advantages.

In addition, (Palma et al., 2025) revealed that utilizing public transport is more burdensome for high-income groups than for lower-income persons. The same effect is absent in private modes, suggesting a preference for them among higher-income individuals. However, a Stated Choice experiment conducted in Ahmedabad revealed that individuals with limited financial resources tend to favor public transportation when buses are electric and fares are reasonable.

Moreover, psychological impediments occasionally arise from accessibility challenges. A nationwide assessment from 2023 revealed that only 29% of buses are partially accessible, while a mere 6% are totally accessible (Lok Sabha Secretariat, 2023; Sharma & Jain, 2024). Psychological barriers associated with e-buses can occasionally discourage state transport agencies from expediting procurement and their willingness to electrify. Furthermore, a pilot study based in Kolkata revealed that, unlike traditional diesel buses, e-buses represent an emerging technology, and private bus agencies lack expertise in their operation and maintenance. Additionally, they lack awareness of the savings in diesel and operational and maintenance costs, which generates concerns about adopting the electric alternative (Ghosh et al., 2024). In Maharashtra, passengers and transport specialists have expressed apprehensions regarding the inconsistent pricing of identical e-bus services under MSRTC, characterizing the tariffs as confusing and inequitable, thereby undermining trust (Times of India, 2025).

5. Key Insights Obtained from Stakeholder Consultations in e-Bus Space

Interviews were conducted to further enhance the technical assessments and policy reviews in this chapter, which map operational reality. This section aims to draw on direct consultations with key stakeholders who lead the e-bus transition from the frontlines of both government-led transit management and the private manufacturing industry. These interviews were structured to move beyond theoretical targets and uncover the latent "choke points" in financing, grid integration, and fleet maintenance that determine the success of e-bus deployment at scale. By understanding the perspectives of stakeholders who procure and manage fleets alongside those who design and

manufacture them, this section aims to identify the necessary shifts from a procurement-centric to an operations-centric ecosystem.

5.1. Consulted Stakeholders

The insights synthesized in this chapter are derived from in-depth dialogues with the following high-level representatives:

1. Senior Management from a government body representing the public sector and State Transport Undertakings (STUs) responsible for one of India's Urban Bus Rapid Transit Systems (BRTS).

2. Top management from a leading Original Equipment Manufacturer (OEM) providing a perspective on the economic and technical hurdles of vehicle production and private market penetration.

Table 2: Stakeholders' Profile

Code	Designation	Organization	Region
P8.1	General Manager	Urban Bus Rapid Transit Public Authority	City
P8.2	Regional Sales Manager (West)	Electric Bus Original Equipment Manufacturer	National

5.2. Insights from Public Sector Leadership

The consultation with the government body reveals a city that has crossed the "confidence threshold," transitioning from small-scale pilots to viewing electric buses as a mainstream capacity solution.

1. **The Post-Pilot Reality**: With over 500 e-buses operational and hundreds more under procurement, the technology is now considered stable enough for long-term capacity planning. However, stakeholders emphasize that public transport electrification must lead the market, as private EV adoption often lags due to distinct economic drivers.

2. **The Cost-Efficiency Paradox**: According to a city's STU, a critical operational pain point is the cost differential: Their GCC contract leads to electric buses currently costing approximately ₹30 per kilometer, whereas CNG buses operate at nearly ₹18 per kilometer. While e-buses offer superior lifecycle durability and lower vibration-related wear, the short-term energy economics, specifically high electricity tariffs and demand charges, currently favor CNG.

3. **Infrastructure as the Primary Constraint:** Depot readiness is identified as the single most important bottleneck for scaling. Meaningful operations require a minimum of 11 kW of power supply per bus, which must be available at subsidized rates. Furthermore, financial friction arises from the heavy security deposits required by power distribution companies, which lock up capital that could otherwise be used for fleet expansion.

4. **Operational Shifts**: Leadership suggests that the focus must shift from procurement incentives to post-procurement operational support, such as charging subsidies. They advocate for a "stations

first, services second" planning model, where charging infrastructure and depot siting are embedded into the initial urban design rather than added as an afterthought.

5.3. Insights from Industry Leadership

The manufacturing perspective highlights a market deeply skewed toward public procurement and constrained by the fundamental economics of battery technology.

1. **Market Imbalance:** Currently, 90% of all e-buses are owned and operated by STUs, driven almost exclusively by government subsidies. The remaining 10% forms a "green belt" of private adoption, largely restricted to corporate staff transport and IT parks where sustainability goals overlap with branding.

2. **The Weight of Battery Economics:** The battery pack is the decisive factor in the vehicle's cost structure, accounting for 40% of the total cost. This creates a massive upfront burden: an electric bus costs approximately ₹1.2 crore, nearly three times the ₹40 lakh price tag of a diesel bus. This high value also inflates Annual Maintenance Contracts (AMC) due to the factored risks of battery degradation.

3. **The Power of State-Level "Shocks":** While national policies set the framework, state-level interventions drive actual momentum by creating "adoption shocks". For example, Maharashtra's use of road tax exemptions, toll waivers, and electricity-metering benefits has been more effective at catalyzing the market than national mandates alone.

4. **Push vs. Pull Strategies:** Industry leaders argue that mandates without favorable economics are ineffective. Instead, they suggest disincentivizing diesel through higher taxation or operational restrictions to create a natural "market pull" toward electric alternatives. They also emphasize standardization over battery swapping, noting that swapping is operationally complex for buses and that shared, standardized charging protocols are the more viable path forward.

5.4. Synthesized Key Findings: Bridging the Implementation Gap

An analysis of both consultations reveals three critical pillars that must be addressed to ensure the e-bus transition is both scalable and sustainable:

1. **Bridging the ₹80 Lakh Gap:** The most urgent policy intervention is to systematically bridge the cost differential between diesel and electric buses. This requires a combination of direct subsidies, toll waivers, and road tax exemptions to achieve Total Cost of Ownership (TCO) parity.

2. **Integrated Planning and BOT Models**: Fragmented contracting (vehicle supply, charging, and operations handled separately) increases risk. Moving towards holistic Build-Operate-Transfer (BOT) models, in which STUs assist operators in securing depot land and power infrastructure, would attract greater private participation and reduce execution delays.

3. **Standardization and Auditing:** To avoid "operational silos," there is a pressing need for standardized charging protocols across different OEMs. Additionally, stakeholders advocate for regular bus health audits that include not just mechanical checks but also cybersecurity and body safety, reflecting the increasingly digital nature of modern e-bus fleets.

The current e-bus transition is like introducing high-speed rail to a city that only has tracks for steam engines. While the "trains" (the buses) are technologically superior, they cannot run effectively until the "tracks" (the grid and depots) are completely upgraded and the "fuel costs" (electricity tariffs) are made competitive with the old system. Buying the trains alone is not enough; the entire supporting infrastructure must also be redesigned to enable their operation.

6. Policy Recommendations

a. Public-Private Fleet Entity

An effective approach to address the financial and procurement challenges of adopting electric buses is to advance a public-private partnership model. Creating a dedicated entity for collaboration between government agencies and corporate stakeholders would shift responsibility for purchasing, operating, and leasing buses away from manufacturers. This model allows manufacturers to focus on electric vehicle production instead of operating fleets. The new entity would be able to seek investment from banks, thereby increasing the availability of the required capital. Furthermore, this model allows for measures, such as payment guarantees, thereby enhancing security for all stakeholders. In conclusion, this approach provides public transport manufacturers with the necessary adaptability, equitable risk-sharing, and collaborative partnerships that accelerate the adoption of cleaner public transport (IEA, 2024).

b. Transparent Performance Auditing

A national framework that mandates a separate group to periodically monitor bus operations and make the outcomes publicly available is needed. Cities deploying e-buses under national or state-level programs should engage independent evaluators who periodically assess bus availability, charging downtime, operational costs, route electrification, and passenger satisfaction, among other metrics. All this data should be publicly available, enabling bus operators from different cities to benchmark, learn, and improve from the metrics. Transport for London and others have already adopted this approach, using daily data and primary metrics, and have implemented automated systems for basic issue resolution and proactive maintenance. (Transport for London, n.d.). This framework would also issue rewards to the top performers and mandate corrective actions to those failing to meet the set benchmarks. Thus, this transparent framework would address the lack of public oversight and scattered data, raising the delivery and effectiveness of electric buses.

c. Role of Dedicated Bus Lanes in Accelerating E-bus Adoption

Investing in Dedicated Bus Lanes (DBLs) could significantly increase the use of electric buses by making public transport more efficient and reliable. DBLs help ease gridlock and improve the predictability of travel times. This improves passengers' confidence and enables more seamless travel, which is crucial for electric buses with limited range. Moreover, studies indicate that regular lanes consume nearly 25% more energy than dedicated bus lanes. (Sun et al., 2024). Moreover, uniform speeds achieved

through reduced traffic and smoother driver operations improve battery efficiency and extend vehicle range. (B. G. Rodrigues, 2025). The BRT systems in the Pune Metropolitan Area showcase these advantages by reducing average passenger wait times by 50% and ensuring that more than 85% of riders wait less than 10 minutes, a significant change from earlier systems. (ITDP, 2014). In addition, reducing DBL's stop-and-go traffic mitigates battery drain, reducing the size of required battery packs and extending operational range on a single charge. Hence, integrating DBLs into the urban transit system goes beyond alleviating traffic; it also facilitates the effective integration of e-buses, particularly in densely populated cities in India with limited operational flexibility.

d. Reserve Urban Land for Public E-bus Charging

Limited availability of public land for operational charging stations poses a considerable challenge for electric bus deployment in densely populated metropolitan areas. Moreover, in urban planning frameworks, it is not yet mandatory to incorporate charging stations into land-use planning, transportation plans, or zoning. To fix this, the policy should mandate that urban local bodies reserve land for charging stations at bus depots and along main e-bus corridors as fast-charging hubs in their master plans. Without reserved land, e-bus chargers tend to be placed at sub-optimal locations, leading to poorly planned access points that greatly undermine route and battery-use optimization. If such policies are mandated, the time and cost needed for e-bus deployment will be substantially reduced.

e. Capital Lock-in with Utilities

A specific policy barrier identified is the heavy security deposit required by power distribution companies (like Torrent in Ahmedabad), which ties up capital for operators. Future policy frameworks should advocate for deposit exemptions or state-backed guarantees to release this capital for fleet expansion.

f. The "Green Belt" and Private Sector Exclusion

Current national policies, such as FAME II, largely exclude private buses, which make up 93% of the fleet. Findings from this chapter highlight the stakeholder observation of a 10% "green belt" (corporate/staff transport) that is currently driving adoption without sufficient policy support compared to the 90% STU-dominated market

7. Way Forward

The adoption of electrification for public transport, especially buses, in Indian cities will require financial, operational, structural, and spatial incentives. The creation of public-private fleet corporations is a critical solution to fragmented ownership, inefficient procurement, and a lack of private-sector involvement in e-bus operations, as it enables fleet management. Centralized fleet management would be essential to maintaining cost control and operational uniformity across regions.

On the other hand, the enforcement of clear performance audits, similar to Transport for London’s operator league tables, can enhance service responsibility by providing clear KPIs, such as bus uptime, charging efficiency, and passenger satisfaction. Moreover, transparent data and performance monitoring can improve service delivery and operational performance, as well as build public trust.

Additionally, the quality of infrastructure and the level of service provided are equally important. Improving the average journey times, schedule adherence, and energy efficiency of public transport relative to private transport can be achieved by providing electric buses with dedicated bus lanes, which have been observed to increase ridership and operational efficiency in cities that adopted them alongside fleet electrification.

For financing e-bus procurement models, a move beyond the GCC model is needed, and a shift towards Build-Operate-Transfer (BOT) models, where the government assists operators in securing depot land and power infrastructure, rather than treating vehicle supply and infrastructure as separate silos, can be considered. In addition, to secure the long-term viability of e-bus investment, a performance auditing framework should be expanded to include specialized health audits. Stakeholders have already emphasized that as buses become digitally integrated, audits must cover cybersecurity and structural body safety alongside traditional mechanical checks.

Instead of only providing "push" incentives for EVs, the policy recommendations should include disincentivizing diesel buses through higher taxation or operational restrictions to naturally shift the economic calculus in favor of electric. The transition should emphasize a shift in urban planning hierarchy. Electrification must be embedded into the Master Plan level, prioritizing the installation of charging infrastructure and depot siting before defining service routes, particularly for Tier-2 cities.

In outlining the provision of urban land for bus depots, it is important to integrate the location reserved for fast charger installations into the city's development control regulations to avoid stalling the longer-term plans of fast charger deployment. In the absence of designated land for charging infrastructure, especially in highly populated city centers, projects face elevated transaction costs and deployment delays. In conclusion, a clear action plan, strong partnerships, and dedicated reforms will pave the way for cleaner, more efficient, and future-ready public transport systems in Indian cities.

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Chapter 10

Electrifying Last-Mile Delivery Fleets in Urban India

Chapter Summary

Content:

1. Reviews literature to frame urban-logistics electrification as a policy–operations–organization systems problem, grounded in multi-level governance and logistics planning.
2. Presents a qualitative–comparative, interview-based study across four logistics segments (food delivery, grocery, cold chain, parcel) to assess readiness, barriers, and operational realities.

Findings:

1. Electrification progress is uneven: rapid in platform-driven 2W/3W segments, slow in LCV and cold chain due to infrastructure unreliability, financing frictions, and operational constraints.
2. Policy fragmentation, inadequate charging visibility and reliability, and behavioral/organizational gaps significantly limit adoption despite improving TCO economics.

Takeaways:

1. Successful fleet electrification depends on aligned policy packages, dependable charging infrastructure, viable financing mechanisms, and organizational readiness rather than vehicle technology alone.
2. India requires coordinated institutional architecture, segment-specific pathways, and integrated planning across policy, operations, and behavior to scale urban logistics electrification.

1. Introduction

India's EV transition has largely focused on passenger mobility, while urban freight and last-mile logistics offer an important opportunity for further policy focus. Given their high mileage intensity, emissions impact, and commercially driven decision-making, these segments offer significant potential for accelerating decarbonization efforts. In dense Asian cities, freight contributes disproportionately to $PM_{2.5}$ and NO_x concentrations, particularly during peak delivery windows (UNEP, 2024). Electrifying delivery fleets can yield broader sustainability gains by combining predictable duty cycles, depot return patterns, and platform-coordinated operations with supporting commercial incentives (e.g., service-level reliability, fuel cost hedging). These sectoral characteristics ensure that a near-term pathway to visible climate and air-quality benefits can be achieved in the urban logistics fleet space if policy, infrastructure, and firm strategy are aligned. This chapter, therefore, proposes urban logistics electrification as a system transition problem that links vehicle technology to logistics planning, energy systems, and multi-level governance.

1.1. Problem Statement and Scope

In India, despite technical readiness across multiple light- and medium-duty categories, uptake in urban freight remains patchy. Evidence from comparative policy studies indicates that single, isolated incentives rarely shift behavior at scale. Instead, configurations of measures that jointly affect the Total Cost of Ownership (TCO), access, and charging availability lead to the tipping point of adoption. The crucial research problem, thus, is: What combinations of policies, infrastructure, organizational change, and business models can unlock sustained electrification across distinct logistics segments (food-delivery 2-wheelers, grocery-delivery operator fleets, cold-chain LCVs, parcel vans)? Addressing this problem requires an integrated approach that goes beyond techno-economic modeling to include stakeholder behavior, policy, firm capacities, and operations planning, which is central to urban logistics.

1.2. Research Scope

To scope the study conducted in this chapter within a guided framework, we define urban logistics as inter-city first-, middle-, and last-mile freight movements undertaken by organized fleets or platform-coordinated operators using two-wheelers, three-wheelers, and light commercial vehicles (≤3.5 t GVW), long-haul HCVs, and intercity LCVs. Electrification is defined to include only Battery-Electric Vehicles (BEVs), and no hybrid vehicles are considered. Policy factors considered span fiscal measures (purchase and usage incentives), infrastructure provisions (public and depot charging), and regulatory mechanisms (access rules, designated zones, and parking or kerb management), covering all relevant stakeholders.

1.3. Analytical Framing Adopted in this Study

We combine the above research questions into an Urban-Logistics Electrification Framework flowing within three interacting layers:

1. **Policy–Market Layer (city + state + national):** fiscal support, access rules, parking/kerb policy, and procurement mandates that are assessed as configurations rather than single levers.

2. **Operations–Infrastructure Layer (firm):** routing, dwell-time charging strategies, fleet scheduling, depot/public charging mix, and grid interface planning.

3. **Organization–Behavior Layer (stakeholders):** managerial risk calculus, driver acceptance/training, vendor ecosystem readiness - prioritizing the primary qualitative data to complement secondary metrics.

This framework aims to guide instrument design and evidence synthesis (segment-wise suggestions), ensuring that policy recommendations later in the chapter are operationally grounded rather than technology-only.

2. Literature Review

2.1. Overview and Purpose

Urban freight transport is an increasingly decisive sector in transport decarbonization. While the literature on passenger EVs has evolved significantly, the literature on electrified urban logistics systems remains comparatively nascent and fragmented. Systematic reviews by Gillström et al. (2024) identify that only 62 peer-reviewed studies explicitly address the electrification of logistics operations through a management lens. That is less than 10 percent of the total EV-related research. The literature review presented here, therefore, aims to fulfill three objectives:

1. To map how global research frames the policy, technological, and operational aspects of freight electrification;

2. To trace how these frameworks have been adapted or neglected in developing-country contexts such as India, and

3. To derive conceptual and methodological gaps that inform the empirical design of this research.

2.2. Policy and Governance Frameworks

A literature review on evidence-based policymaking in advanced economies shows that fleet electrification uptake depends on bundled policy packages rather than isolated policy levers. A cross-national qualitative-comparative analysis of 15 European cities demonstrated that EV penetration was highest where national-level fiscal incentives (purchase subsidies, VAT waivers) were combined with municipal push-measures (low-emission zones, access privileges, free parking) (Held & Gerrits, 2019).

A past study by Hanna L. Breetz & Deborah Salon (2018) developed a multi-criteria evaluation framework for city-logistics policies in China, quantifying environmental effectiveness, cost efficiency, and behavioral feasibility. The study concluded that fleet-specific charging infrastructure and time-window access regulations outperform blanket subsidies in achieving fleet conversion. Global research

emphasizes that city-level logistics electrification succeeds only when planning, transport, and energy departments operate through unified governance frameworks (GIZ, 2022).

However, in comparison, emerging-economy literature remains sparse. The Fleet Electrification in India report (CII & Invest India, 2023) notes that while national programs like FAME II offer purchase incentives, state-level implementation diverges sharply and seldom targets logistics fleets specifically. This policy fragmentation discourages long-term investment planning for logistics operators and charging providers.

2.3. Operational and Technical Optimization

Fleet-conversion research often revolves around optimization problems such as the Fleet Size and Mix Vehicle Routing Problem (FSMVRP) and its electric variant (E-FSMVRPTW). Janse van Rensburg and Joubert (2024) apply an agent-based FSMVRP model to a South African pharmaceutical distributor and show that depot-based charging and high route density yield up to 25% cost savings relative to ICE baselines. These findings show that charging strategy and route configuration, not vehicle price alone, determine viability.

Schmidt et al. (2021) proposed a Decision-Support System (DSS) that integrates empirical mobility patterns, depot-charging assumptions, and operational foresight to help fleet managers gauge the potential for electrification. They found that fleets returning daily to a base can electrify without relying on public chargers, making them priority candidates for early adoption. Studies show that the absence of dedicated logistics charging hubs significantly slows the electrification of 2W/3W and LCVs in emerging markets (Grütter, J. M., 2019).

Together, these studies mark a shift from abstract techno-economic modeling to data-driven operational simulation, but they still under-represent organizational and behavioral variables that shape real-world adoption.

2.4. Organizational and Behavioral Dimensions

Stakeholder perspectives remain an under-examined domain in research on urban logistics electrification. Gillström et al. (2024) found that past studies have relied heavily on secondary datasets and mathematical modeling, neglecting qualitative methods such as interviews or workshops that could reveal how logistics firms, shippers, and drivers experience the transition. The synthesis of previous research identifies major gaps, such as: (1) insufficient focus on organizational change and collaboration among stakeholders; (2) lack of multi-stakeholder comparison between logistics providers, customers, and regulators; and (3) limited empirical understanding of how fleet electrification reshapes roles, routines, and supply-chain coordination. In terms of finance, lenders' credit risk perception remains high for commercial EVs, with financing rates often 200–300 basis points above those for comparable ICE vehicles (KPMG, 2024).

These findings motivate the interview-based, multi-stakeholder methodology adopted in this study, which aims to capture decision logics, capability gaps, and behavioral readiness across distinct logistics segments.

2.5. Socio-Environmental Impacts

Previously conducted quantitative research confirms that logistics fleet electrification yields not only climate benefits but also public health and welfare gains. A Greek urban-area simulation estimated that full electrification could avert over 10,000 years of life lost due to particulate pollution and produce €730 million in cumulative social benefits by 2050 (Kouridis & Vlachokostas, 2022). This quantification reinforces the need for policy frameworks that internalize health externalities within logistics-sector decision-making.

2.6. Indian Context

In emerging economies like India, electrification of logistics fleets must contend with infrastructure asymmetry and institutional complexity. The IEA Global EV Outlook Report (2021) highlights that municipal coordination is critical for aggregating fleet demand and ensuring grid readiness. Urban freight in India is dominated by micro-fleet owners, with nearly 80% operating fewer than five vehicles, limiting technology adoption and capital investment (DPIIT, 2025). These lessons are transferable to India's city-state governance landscape. Indian policies (Government of NCT of Delhi, 2020; Government of Maharashtra, 2021; Ministry of Heavy Industries, 2024) mandate fleet targets but lack uniform standards for depot electrification or access regulation. Policy gaps include the absence of a unified national logistics electrification strategy and charging norms aligned to last-mile operational realities.

2.7. Section Findings

The literature reviewed in this chapter converges on three key aspects: (i) policy coherence across levels; (ii) operational integration of charging into logistics planning; and (iii) stakeholder-centric behavioral transition. This convergence establishes the study's Urban-Logistics Electrification Framework, linking policy–operations–behavior and ensuring that subsequent empirical analysis in Indian cities contributes to both global theory and local practice.

3. Stakeholder Consultation

3.1.1. Primary Data – Semi-Structured Interviews

Between August and November 2025, six semi-structured interviews were conducted with stakeholders across the freight value chain. Respondents included:

Table 1: Stakeholders' profiles

Code	Designation	Organization Type	Region
P9.1	Manager, Mid-Mile Logistics	Major Indian E-commerce and Food Delivery Platform	Urban (National)
P9.2	Head, Engineering – Logistics Division	Large Infrastructure and Engineering Conglomerate	National

P9.3	Head, Sustainability	Leading Indian E-commerce and Digital Retail Company	National
P9.4	Associate Director, Corporate Affairs and Government Relations	Major Indian E-commerce Platform	National
P9.5	Executive Director, Transport and Logistics	Global Professional Services and Consulting Firm	National
P9.6	Partner, Transport Consultancy	Global Consulting Firm	National

Interviews ranged from 30 to 45 minutes and were conducted online. The key insights from the interviews were recorded with the experts' consent. The semi-structured format allowed respondents to describe operational realities, strategic priorities, and institutional constraints in their own terms, while permitting cross-interview comparability.

3.1.2. Secondary Data – Policy, Regulatory, and Academic Sources

A structured literature review was undertaken, covering:

1. International freight-electrification reports (International Transport Forum, 2020; 2023).
2. Indian EV policies and city action plans.
3. Academic publications analyzing behavioral and organizational dynamics of freight electrification (Breetz & Salon, 2018; Schmidt et al., 2021; Gillström et al., 2024).
4. Industry white papers and EV-charging standards literature (IEA, 2023; WRI India, 2023; ICCT, 2023).

Secondary sources were used for triangulation, contextualization of interview insights, and validation of operational claims (e.g., trip lengths, downtime patterns, charging distribution).

3.2. Instrument Development and Analytical Pillars

The interview protocol was structured around five analytical pillars:

1. **Strategic Orientation**: Organizational sustainability objectives, transition timelines, fleet strategy, and perceived strategic advantages of electrification.
2. **Operational Feasibility**: Payload dynamics, route structure, downtime constraints, ecosystem bottlenecks, and reliability expectations under Indian operating conditions.
3. **Economic and Financial Dynamics**: Total Cost of Ownership (TCO), leasing vs. ownership preferences, access to finance, battery residual value, and business-model flexibility.
4. **Policy and Infrastructure Interface**: Impact of central and state EV incentives, city-level charging visibility, land-use constraints, and policy certainty.
5. **Behavioral and Organizational Readiness**: Driver acceptance, training needs, skill transitions, and quality of operational management systems.

These pillars specifically align with analytical frameworks used by the World Bank and ITF in low-emission freight studies (World Bank, 2023; International Transport Forum, 2023).

3.3. Validity, Reliability, and Ethical Considerations

The study employed several measures to strengthen methodological rigor:

3.3.1. Validity

Validity was addressed through source triangulation using multiple respondent types, including platforms, logistics operators, and consultants, as well as method triangulation by combining interviews with secondary datasets. Member validation was also undertaken, with selected respondents reviewing thematic summaries for accuracy.

3.3.2. Reliability

Reliability was ensured through coding consistency achieved via iterative recoding and peer checks. In addition, audit trails were maintained at each stage of the analysis.

3.3.3. Ethical Protocols

The methodology adheres to ethical guidelines consistent with International Transport Forum (ITF) and World Bank research standards. Ethical protocols included obtaining informed consent for all interviews, applying data anonymization to protect organizational confidentiality, and securely storing all recordings and transcripts on institute servers.

3.4. Limitations of the Methodology

The findings should be considered, considering a few limitations:

1. Urban focus: The interviews primarily reflect urban logistics and may not fully capture peri-urban or long-haul operations.

2. Sample size: Although the interviews provide useful insights, six interviews cannot capture the full diversity of India's freight ecosystem.

3. Self-reported information: Some information on operational performance is based on respondents' experiences and perceptions rather than independently verified data.

4. Limited quantitative data: The study does not include detailed vehicle-level or operational datasets, limiting the scope for quantitative analysis.

4. Results and Discussions

The findings presented in this chapter synthesize interview-based insights, secondary evidence, and cross-segment comparative analysis to understand India's evolving landscape of urban logistics electrification. Rather than treating adoption as a linear function of TCO decline, the findings show the need for a multi-tiered transition shaped by infrastructure readiness, platform governance, fragmented value chains, and institutional capacity. A consistent observation is that electrification is progressing not uniformly but selectively, concentrated in segments with high trip density, predictable routing, or strong platform influence, while energy-intensive and asset-heavy segments remain hesitant.

The findings below are organized into thematic clusters emerging from the analytical framework, but with an emphasis on a narrative that reflects the complexity of India's freight ecosystem. The results obtained spanned across regulatory gaps, operational frictions, emerging digital practices, and organizational behavior themes.

4.1. Strategic Orientations: How Firms Conceptualize Electrification

Across all stakeholders, electrification is no longer perceived as a peripheral sustainability exercise. The electrification of fleets is increasingly embedded in corporate strategy. Delivery platforms and e-commerce firms state electrification as a competitive differentiator, particularly in metro cities where customer expectations for "green deliveries" are rising and where visibility of clean fleets offers a brand advantage.

In contrast, asset-heavy players such as large 3PLs or traditional logistics firms view electrification primarily through the lens of cost mitigation and operational reliability. Their orientation remains cautious as the strategic horizon is long, but the pace of transition is coupled to infrastructure availability, policy certainty, and guaranteed uptime.

The strategic orientations across stakeholders can be summarized as follows:

Table 2: Observations Among Stakeholder Groups

Stakeholder Type	**Core Strategic Driver**	**Degree of Electrification Commitment**
Delivery Platforms (Food & Grocery)	Cost efficiency, customer branding, and regulatory compliance	High and accelerating
E-Commerce Parcel Firms	Network optimization, sustainability positioning	Moderate-to-high
Cold Chain Operators	Technology reliability, thermal load management	Low-to-moderate
Traditional 3PLs	TCO uncertainty, route variability	Low
Urban Transport/Planning Experts	Air-quality mandates, modal integration	Supportive but concerned about institutional gaps

Interestingly, consultants and urban mobility experts highlighted a divergence between national EV ambition and city-level logistical readiness. Several respondents described the transition as "two-speed," where platform-driven 2W and 3W fleets move rapidly, while LCV and truck segments lag due to financing hurdles, uncertain residual value, and limited charging options.

Across diverse stakeholder groups, the central finding is that strategic commitment to electrification is real, but strategic certainty is not currently a function of fragmented policies, unclear financial pathways, or infrastructure asymmetry across cities.

4.2. Operational Feasibility: The Architecture of Day-to-Day Constraints

4.2.1. Range, Charging, and Route Structure

Two- and three-wheelers face few operational constraints as their average daily range requirement (40–80 km) remains comfortably below the usable range of modern EVs, enabling them to operate largely without mid-day charging. This helps explain the rapid adoption across two- and three-wheeler EVs and why platforms increasingly mandate EV usage in select clusters.

LCVs, however, present a sharply different picture. Operators consistently emphasized:

1. Limited access to fast charging on predictable nodes,
2. High downtime penalties, particularly for gig and contracted drivers,
3. Thermal energy load in the cold chain, which significantly reduces the effective range.

Cold-chain operators highlighted cases in which 40–50% of battery capacity is diverted to refrigeration systems, which is an operational dynamic inadequately addressed in policy discourse or R&D space.

4.2.2. Infrastructure Reliability and Location Optimization

The most persistent operational barrier is not the number of installed chargers, but their reliability, availability, and locational logic. Stakeholders across segments described:

1. Chargers located in areas with a poor turning radius for LCVs,
2. Chargers installed without load assessment, resulting in voltage drops,
3. Nighttime downtime patterns are misaligned with logistics-operator shifts.

Platforms reported developing internal charging maps to compensate for inadequate public data, revealing a lack of integrated, real-time infrastructure visibility for commercial users.

4.2.3. Driver Behavior, Skill, and Adaptation

All stakeholders agreed that driver behavior, with emphasis on charging discipline, willingness to alter routes, and battery-health practices, can significantly shape EV performance. Some operators have begun deploying:

1. App-based nudges to signal optimal charging windows,
2. Incentive structures for maintaining battery health,
3. Targeted training for first-time EV drivers.

However, training remains ad hoc. Consultants noted that without structured, large-scale driver capacity building, India risks creating an "EV-illiterate labor force" unable to harness the efficiency potential of electrified fleets.

4.3. Economic and Financial Dynamics: The Limits of TCO-Led Narratives

4.3.1. TCO Parity is Necessary but not Sufficient

While stakeholders acknowledged declining TCO for 2W and 3W EVs, they stressed that cash-flow stability matters more than spreadsheet parity. Particularly in gig economies, operators require:

1. Predictable monthly outflows,
2. Guaranteed uptime,
3. Flexible leasing models.

Several interviewees emphasized that TCO parity collapses when downtime is unpriced, a critical gap in the literature.

4.3.2. Financing Frictions: Perceived Risk and Asset Uncertainty

Lenders remain wary of EV assets. The three systemic financial barriers that emerged are:

1. Residual-value uncertainty for batteries and LCVs.
2. Limited underwriting frameworks for gig workers and micro-fleet owners.
3. High-risk perception among banks and NBFCs, causing elevated interest rates.

Green financing instruments exist in principle, but operators described them as procedurally heavy and poorly targeted. MDBs (World Bank, ADB) often offer high-cost, short-duration loans for EV programs due to their technology risk classification, making them less attractive than diesel.

4.3.3. Business Models and Emerging Innovations

A clear consensus emerged that electrification requires ecosystemic business models, not isolated incentives. The following are among the most promising business models:

1. Battery leasing for high-utilization fleets.
2. Energy-as-a-service models for logistics hubs.
3. Anchor-tenant led charging development, where a large platform guarantees utilization for private charging investors.

However, no model has yet achieved commercial maturity across cities.

4.4. Policy and Institutional Interface: The Missing Architecture

4.4.1. Fragmented Governance and Absence of a Nodal Logistics-EV Authority

Stakeholders consistently attributed delays in EV adoption to fragmented institutional responsibilities across multiple levels of government. Cities control land allocation and parking; DISCOMs determine electricity provisioning; state transport departments regulate vehicle permits; and central ministries define incentives and the broader national EV vision. This dispersion of authority leads to weak coordination among infrastructure planning, fleet operations, and regulatory processes. Experts therefore emphasized the need for a single institutional locus, potentially the Ministry of Heavy Industries or the National Urban Freight Mission, to provide unified oversight and coordination of infrastructure development, fleet standards, and data protocols.

4.4.2. Policy Overemphasis on Private EVs

Interviewees noted that Indian EV policy remains fundamentally consumer-centric, with a predominant focus on cars and two-wheelers, rather than logistics-centric, despite freight contributing disproportionately to urban emissions. They noted that existing incentive structures do not adequately address key logistics-related requirements, including the electrification of light commercial vehicles, research and development in cold-chain technologies, the establishment of charging visibility standards, and the definition of operational reliability benchmarks.

4.4.3. Need for Charging Standardization

Operators stressed that fragmentation in charging infrastructure across connectors, power levels, and payment systems creates significant operational friction. They highlighted the need for uniform charging protocols, interoperable payment systems, and mandatory reporting of charger uptime and pricing. One expert described chargers as needing to be “as ubiquitous and standardized as grocery shops.”

4.5. Behavioral and Organizational Readiness: Human Systems in a Technical Transition

4.5.1. Organizational Change Management

Large platforms demonstrate stronger readiness for EV adoption because they possess digital routing systems, data-driven operational management capabilities, and internal sustainability mandates. In contrast, traditional operators lack such institutional mechanisms and therefore perceive the EV transition as burdensome rather than transformative.

4.5.2. Workforce Behavior and Acceptance

Drivers expressed a mix of enthusiasm (lower driving fatigue, smoother experience) and anxiety (range, downtime). Many require high-touch behavioral nudges during early adoption phases, underscoring the need for national-level EV driver-skilling programs.

4.6. Cross-Segment Analysis: Comparative Readiness Matrix

Table 3: Segment-wise Electrification Readiness Assessment

Segment	Operational Readiness	Economic/Financial Readiness	Behavioral Readiness	Overall Stage
Food Delivery (2W)	High	Moderate	High	Mature
Grocery Delivery (3W)	High	Moderate	Moderate	Emerging–Mature
Cold Chain (LCV)	Low	Low	Moderate	Nascent
Parcel/E-commerce (LCV)	Moderate	Low–Moderate	Moderate	Emerging

The analysis suggests a dual-speed transition:

1. Gig-driven segments (2W/3W) form the leading edge.

2. Asset-heavy, energy-intensive segments (LCVs) remain structurally disadvantaged.

4.7. Synthesized Findings: The Systems Diagnosis

Three system-wide findings emerge:

a. Electrification is progressing faster where platforms, not policies, govern behavior.

Platform algorithms, incentive structures, and clustering allow 2W/3W transitions to scale rapidly, independent of city governance.

b. Infrastructure is abundant on paper but unreliable in practice.

Locational mismatches and inconsistent uptime appear more influential than absolute charger counts.

c. Policy architecture does not reflect freight realities.

Indian EV policy continues to privilege private mobility; freight electrification requires:

a. Differentiated incentives,

b. Standardized charging protocols,

c. Coordinated digital infrastructure.

5. Conclusions and Future Scope

India's urban logistics sector is undergoing a profound structural shift, in which electrification is increasingly understood not as a purely technological upgrade but as a complex socio-technical transition. Across interviews, literature, and segment-level analysis conducted in this chapter, the research findings indicate that the move towards electric fleets occurs through the interaction of economic incentives, infrastructural conditions, institutional capacities, and behavioral readiness.

5.1. Reframing Urban Logistics Electrification as a Socio-Technical Transition

The findings align closely with transition theory, which emphasizes that technological change emerges from the simultaneous evolution of markets, policies, user behavior, and infrastructures (Breetz & Salon, 2018). Stakeholder interviews conducted in this study strongly support this view. Operators described electrification as occurring within an environment of interdependent stakeholders, including gig workers, logistics platforms, OEMs, energy utilities, municipal regulators, financiers, and digital service providers. Each stakeholder is shaping the feasibility and speed of adoption. Rather than a linear diffusion curve, the transition is a multi-stakeholder choreography in which disruptions in one part of the chain (for instance, charger downtime or insurance frictions) directly implicate the operational reliability, TCO expectations, and driver acceptance.

The segment-comparative analysis reinforces this systemic character. Food-delivery two-wheelers display almost complete operational-fit readiness, while grocery-delivery three-wheelers are in an accelerated but still maturing stage. Parcel-delivery LCVs show promising economics but proportionally higher infrastructural and financing risks. Cold chain operations remain technologically constrained due to dual energy loads and thermal requirements. Electrification is therefore uneven by design, guided not by policy aspiration but by task intensity, payload complexity, urban topology, and economics. Understanding this unevenness is key to realistic policy design.

5.2. Segment-Specific Implications

While the policy architecture must be national, the electrification journey remains segment-contingent. Food-delivery fleets require interventions focused on driver safety, income stability, and

pathways for battery upgrades. Grocery-delivery 3W fleets benefit most from depot-level charging clusters embedded within retail supply chains. Parcel-delivery LCVs need high-reliability charging infrastructure in urban logistics corridors and risk-sharing instruments to address the uncertainty of asset depreciation. Cold-chain fleets require targeted R&D incentives and structured pilot programs in key metros before large-scale deployment is feasible.

These differentiated strategies reaffirm that India's electrification trajectory is unlikely to follow a uniform diffusion pattern. Tailored, segment-specific pathways are necessary for achieving systemic change.

5.3. Implications for Policy, Industry, and Urban Governance

The findings collectively suggest that policy must transition from a vehicle-centered logic to a value-chain-centered logic. For government agencies, this means designing coherent, long-term institutional frameworks that integrate freight into urban mobility planning. For the industry, it underscores the need for data-driven fleet optimization, multi-energy strategies, and adoption of digital tools to minimize operational uncertainty. For urban governance systems, the transition demands embedding freight and charging considerations into zoning regulations, land-use planning, and municipal service delivery.

The broader implication is that electrified urban logistics can yield not only emissions reductions but also lower operating costs, improved road safety, reduced noise pollution, and more predictable livelihoods for gig workers—provided that institutional coherence and financial de-risking accompany technological diffusion.

5.4. Key Takeaways from the Chapter

The transition to electric urban logistics in India is both inevitable and uneven. This study demonstrates that successful electrification hinges on four interconnected elements: operational suitability, financial viability, infrastructural readiness, and institutional coherence. The structural bottlenecks identified, such as fragmented policymaking, unreliable infrastructure, financing frictions, and behavioral barriers, must be addressed through an integrated national strategy. If India builds a mission-oriented governance model, strengthens financing structures, embeds charging into urban planning, and supports technological innovation, it can create a logistics system that is cleaner, more cost-efficient, worker-friendly, and globally competitive.

Electrification is therefore not merely a mobility reform but an opportunity for urban transformation. One that requires deliberate coordination, targeted incentives, and sustained institutional commitment.

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Chapter 11

Planning Cities for Convenient EV Charging

Chapter Summary

Content:

1. Reviews national charging guidelines, urban planning instruments, and state-level policy frameworks shaping EV charging deployment in Indian cities.
2. Assesses city-level plans, regulatory provisions, and comparative case insights to evaluate how policy translates into on-ground infrastructure outcomes.

Findings:

1. Planning–implementation gaps persist: many studies and draft strategies lack statutory backing, defined institutional ownership, and dedicated budgets, limiting execution.
2. Deployment remains uneven due to grid constraints, land and retrofit challenges, fragmented institutional capacity, and weak integration of demand-based siting into planning processes.

Takeaways:

1. Strengthen accountability by embedding charging provisions into statutory instruments, assigning empowered nodal agencies, and linking plans to budgets and monitoring frameworks.
2. Shift toward demand-led siting and delivery: Use spatial and temporal demand data for context-sensitive placement, establish clear retrofit pathways and equity safeguards, and define financing models and enforceable performance metrics to ensure plans translate into implementable infrastructure.

1. Introduction

Cities are major contributors to climate change, accounting for an estimated 70 percent of global CO_2 emissions. Transport and buildings together account for the largest share of these emissions, with road transport alone responsible for roughly 20–30 percent of urban air pollution, according to the International Energy Agency.

Urban planners worldwide often rely on the Avoid–Shift–Improve framework to rethink mobility. This includes: Avoid – designing compact cities that reduce the need for motorized travel, Shift – promoting public transport and active mobility, and Improve – enhancing vehicle and fuel efficiency.

While Indian cities make attempts and grapple with the first two pillars, the third, 'Improve,' has gained new importance as governments chase net-zero commitments. Nearly every Indian state has now announced an Electric Vehicle (EV) policy with adoption targets, fiscal incentives, and broad roadmaps.

Urban centers are the natural focus of this transition, given their vehicle density and pollution levels. Yet, to make the transition real, cities must move beyond policy intent and adopt frameworks that make them EV-ready.

As state electricity boards and urban local bodies prepare, the urban planning fraternity carries a growing responsibility: determining where charging infrastructure should be located, whose land it occupies, how it is accessed, and who manages it. The Ministry of Power's recent guidelines recommending one public charging station in every 1 × 1 km grid (Ministry of Power, 2024) provide technical direction, but city planners must contextualize this within local land use, accessibility, and travel behavior patterns.

To understand how Indian cities are operationalizing this transition, it is important to examine the planning instruments that govern the built environment. The following sections examine how both statutory and non-statutory tools, ranging from development control regulations and master plans to comprehensive mobility plans and specialized city-level frameworks, have begun to incorporate provisions for electric mobility. Together, these instruments reveal how planning practice is gradually responding to the technological and policy momentum driving the EV transition.

1.1. Background

The integration of electric vehicles into India's urban-planning discourse has evolved over the past decade in parallel with national and state policy developments. The National Electric Mobility Mission Plan (NEMMP) and the Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME I and II) schemes marked the first generation of national interventions, aimed at stimulating demand and supporting domestic vehicle manufacturing.

Subsequent measures have deepened this ecosystem. The Production Linked Incentive (PLI) schemes for Advanced Chemistry Cell (ACC) batteries and automobile components strengthened the supply side by promoting local manufacturing and technology development. On the infrastructure front, the Ministry of Power (MoP) has periodically issued guidelines and standards for EV-charging infrastructure, defining norms for charger types, tariff determination, public accessibility, and the designation of state nodal agencies. The latest version (Ministry of Power, 2024) recommends one

public charging station per 1 × 1 km grid cell in urban areas and one every 20–25 km along major roads, and provides technical guidance for deployment.

More recently, the PM E-Drive scheme has been representing the national-level funding and facilitation initiative to accelerate EV adoption and public charging infrastructure. For charging, guidelines (Ministry of Heavy Industries, 2025) have been published under this scheme to provide capital subsidies for upstream electrical infrastructure and chargers, and to delineate nodal agencies for state-level demand aggregation and siting exercises.

Meanwhile, the Ministry of Housing and Urban Affairs (MoHUA) has sought to integrate EV readiness into the city planning process. The 2019 amendments to the Model Building Bye-laws (Ministry of Housing and Urban Affairs, 2019) and the Urban and Regional Development Plan Formulation and Implementation (URDPFI) guidelines (Ministry of Housing and Urban Affairs, 2019) introduced explicit provisions for EV charging infrastructure in buildings and urban areas. They have also issued a supplementary guideline to integrate EV considerations into city-level Comprehensive Mobility Plans (GIZ, MOHUA, 2022). These interventions have collectively shifted EV integration from a solely transport- or energy-sector issue to a broader spatial planning concern, creating an enabling environment for cities to plan, regulate, and manage charging infrastructure.

2. Development Control Regulations (DCRs)

Development control regulations are among the most direct levers available to embed EV provisions into city-planning frameworks. Recognizing this, the Ministry of Housing and Urban Affairs amended its Model Building Bye-laws in 2019 to include guidelines for installing EV-charging infrastructure in new buildings and urban areas. (Ministry of Housing and Urban Affairs, 2019).

Following this amendment, some states adopted the model provisions verbatim, others customized them, and a few have yet to act. The review of provisions in selected states shows that most have approached EV charging readiness through parking norms, which are easier to enforce during the building approval process for new developments. However, retrofitting existing buildings poses a major implementation challenge, as compliance would require technical feasibility assessments, and possibly incentives for adoption. Beyond parking norms, DCRs often specify grid-based targets, such as 1 km × 1 km or 3 km × 3 km spacing for public charging stations (adopted from national-level MoP guidelines), which risk remaining aspirational unless linked to actionable criteria. These include identifying suitable land parcels, aligning with land-use zoning, prioritizing high-demand locations such as commercial hubs or transport nodes, and factoring in traffic volume patterns. Without such specificity, targets may fall short of creating an accessible, equitable charging network in practice.

State	Amended	Parking norms	Statutory	Actionable	Jurisdiction	Implementing Authority
Delhi	2019	Based on occupancy and total parking provisions for each building type, EV charging infrastructure shall be provided for 20% of the total vehicle holding/parking capacity.	Yes	Yes	NCT	Municipal Corporations, Delhi Development Authority
Gujarat	2021	(i) For Residential use, parking spaces shall have 100% of demarcated ECS, 'eV Ready' with conduits installed. (ii) For Non-Residential use, parking space shall have 20% of demarcated ECS, 'eV Ready' with conduits installed. Where, ECS = Equivalent Car Space."	Yes	Yes	Gujarat Industrial Corp. area, Municipality, and gram panchayat areas that are notified as 'development' areas.	Municipal Corp., Development authority, Industrial authorities
Haryana	2024	Minimum 2 Electric Vehicle charging points per 100 ECS (Equivalent Car Space) shall be made mandatory in Group Housing, Commercial, and I.T. buildings.	Yes	Yes	Entire State	Municipal Corp., Development Authority
Karnataka	2021 (draft)	Based on occupancy and total parking provisions for each building type, EV charging infrastructure shall be provided for 20% of the total vehicle holding/parking capacity.	No (Draft)	No (Draft)	Municipal Corporations	Municipal Corporations
Kerala	2020	All buildings requiring parking shall have facilities for charging electric vehicles. The government shall notify the number of charging points to be provided in accordance with the size and occupancy of the building, as required from time to time.	Yes	No	All Municipal Areas in the state	Municipal Authorities

Odisha	2020	To cater to the requirements of charging for electric vehicles, a minimum 30% of parking spaces of new developments in certain types of buildings should have facilities to enable Electric Vehicle charging points, and such points shall be shown clearly in the building plan with proper indexation.	Yes	Yes	All 'development areas' are notified under the Odisha Development Authorities Act, 1982.	Municipal Authorities
Uttar Pradesh	2021	The Expressways Industrial Development Authority (UPEIDA) mandates 20% of parking spaces for upcoming big housing and commercial projects for EV charging.	Yes	Yes	UPEIDA notified Areas	UPEIDA

Table 1: Comparative Analysis of Parking Norms in State Development Control Norms

3. City Masterplans

City masterplans, as statutory documents that guide land allocation and infrastructure development, carry legal authority. Integrating charging infrastructure provisions within them can turn broad recommendations into enforceable, on-ground actions. Keeping this in mind, the Ministry of Urban and Housing Affairs issued an amendment in the Urban and Regional development plan formulation and implementation (URDPFI) guidelines in 2019, which is a key reference document used by planners while drafting masterplans.

A lot of cities either have outdated master plans or none at all. According to Niti Aayog, nearly 65% of India's 7,933 urban settlements operate without masterplans. (NITI Aayog, 2021). Combined with long notification processes and extended horizon periods, this makes masterplans one of the most potentially actionable yet challenging avenues for EV charging integration, especially since volatile EV demand is difficult to estimate over the typical 20-year planning period.

City masterplans have the potential to integrate EV-charging infrastructure within their transport and mobility chapters. This is where studies on traffic volumes, travel demand, and vehicle usage patterns can be analyzed spatially to estimate the projected need for chargers. The resulting demand assessment can, in turn, inform the identification and earmarking of suitable land parcels for charging stations. This approach mirrors the way other public services, such as schools, healthcare centers, or parks, are spatially planned in master plans, based on population thresholds and service catchments, ensuring that facilities are distributed equitably across the urban area.

Of the master plans we studied for EV integration, four out of five are still in the draft stage and yet to be notified. In several cases, such as Delhi, Bengaluru, and Thiruvananthapuram, the provisions serve more as broad guidance to steer authorities in a certain direction rather than as straightforward, actionable measures. Thane does identify 30 specific points, which makes it more actionable. Kochi, meanwhile, has tied EV charging integration to a specific project at a transit hub and references ongoing initiatives by KSEB. Notably, its recommendation to integrate charging stations with ward/cluster-level facilitation centers at the Health Circle level, if implemented, could help decentralize the charging network in the city.

Some cities that were found to incorporate charging considerations in their (draft or notified) planning documents are mentioned in the table below:

Table 2: Comparative Analysis of EVCI Considerations in City Masterplans

City	Plan	EVCI Considerations	Masterplan Notified (Y/N)	Types of Vehicles Considered	Land earmarked/ allotted	The implementing agency specified	Budgetary Allocation	Monitoring/ Evaluation
Delhi	Draft Delhi Masterplan 2041	“At least 1 Public Charging Station is to be available within a grid of 3Km x 3Km.”- as per the older version of MOP Guidelines – 2022. Also mentions in the document itself that “DDA should include land planning for the creation of Charging Infrastructure for EVs in the Master Plan of Delhi 2041."	No	All (PCS)	No	Yes	No	No
Thane	Draft Revised Development Plan - Thane 2026-2046	Under the head 'Status of Environment' (9.2, pg 110): "To mitigate the issue of air pollution, Thane Municipal Corporation has identified 30 spots for electric vehicle charging stations across the city and is planning to develop the same." The plan has also specified land parcels for the same purpose.	No	All (PCS)	Yes	Yes	Yes	No
Bengaluru	Draft BDA Revised Master Plan 2031	Under the "11.4 Approach to Traffic and Transport Planning of the BMA' section (page 96): 'Minor bus terminals are being provided in all areas to ensure that a feeder system can be operated. These can be fitted with charging ports to facilitate Electric Vehicles (EV’s).'	No	City Bus	No	No	No	No
Thiruvananthapuram	Draft Thiruvananthapuram Master Plan 2040	In Volume-2, under the Fiscal requirements of the Energy Sector, INR 15 lakh per charging station, excluding land lease/purchase cost, has been earmarked. KSEB (Kerala State Electricity Board) is designated as the responsible and funding agency for the project. The project is to identify locations in the city, such as	No	All (PCS)	No	Yes	Yes	No

		parking areas at the Corporation Office, College campus, Major Government Offices, Tourist destinations, Bus Depots, Railway Stations, and other multi-level parking facilities, for installing such a facility. Mentions mapping and dissemination of information of the same through online apps (pg. 933) The document also specifies that 'Electric charging stations for vehicles may be permitted in all zones other than Conservation zone, Water body, and Buffer zones of Water body' (Pg 1000)						
Kochi	Masterplan for Kochi Municipal Corporation Area 2040	1. A Public EV charging station proposed at Vyttila, which is a prominent Transit hub. earmarked INR 900 lakhs (400 in the first phase and 500 in the second) for the same. 2. Pole-mounted charging stations are proposed by KSEB in 121 locations within the Ernakulam district, and the work is in progress. 3. Fast charging stations are in 10 locations within the corporation's limits. More such charging stations need to be installed by the KSEB, in association with petrol pumps or on parcels of land along main transport corridors, to encourage the use of electric vehicles. 4. EV Charging station points proposed at the ward/cluster level, and a facilitation Center at the Health Circle level. 5. The document also mentions that 'Electric charging stations for vehicles may be permitted in all zones other than Buffer (Water bodies) Eco-sensitive areas and Mangalavanam bird sanctuary."	Yes	All (PCS)	No	Yes	Yes	No

4. Comprehensive Mobility Plans

Another important avenue where planners can contribute to electric mobility infrastructure is through the Comprehensive Mobility Plan (CMP). GIZ, with the Ministry of Housing and Urban Affairs (MoHUA), has even issued a supplementary guideline to its original CMP framework, specifically aimed at integrating EV considerations into these plans (GIZ, MOHUA, 2022).

Some cities have made modest additions to address EVs in their CMPs, while others, such as Lucknow and Bhubaneswar, have gone a step further by preparing dedicated Electric Mobility Plans. At the same time, there are examples where EVs remain absent, as in the case of Greater Mumbai's CMP.

One major limitation of CMPs is their lack of statutory authority. Originally envisioned to be prepared by Unified Metropolitan Transport Authorities (UMTAs) with legal backing and alignment with the city masterplan, they are now often drafted by metro rail corporations in partnership with private consultants. In many cases, the exercise has been reduced to a procedural requirement to secure central funding for metro projects.

The legitimacy of the ridership projections in these documents has also been questioned, with concerns that they may be prepared in self-interest. (Kalra, 2020). Such practices raise broader questions about the institutional credibility of the agencies preparing CMPs, and whether their priorities truly align with the city's long-term mobility needs or are instead skewed toward advancing their own project-specific interests.

Some cities, such as Chennai and Hyderabad, have initiated efforts to institutionalize coordinated transport planning by setting up Unified Metropolitan Transport Authorities (UMTAs) through state legislation. These bodies are intended to bring together multiple agencies involved in transport, land use, and infrastructure planning under a common framework. Hyderabad's UMTA, for instance, has begun organizing EV-awareness workshops, conducting preliminary online demand-assessment surveys, and exploring provisions for charging facilities. (Lakshmi, 2021). Although these efforts are piecemeal, they signal a move toward a more integrated governance model. If operationalized effectively, UMTAs could help streamline decision-making and reduce the coordination gaps that currently hinder the rollout of EV infrastructure.

Table 3: Comparative Analysis of EVCI Considerations in City Comprehensive Mobility Plans

City	Prepared by	EVCI Considerations	Land earmarked/ allotted	Types of Vehicles Considered	The implementing agency specified	Budgetary Allocation	Monitoring/ Evaluation
Bareilly	Bareilly Municipal Corporation, UMTC	Analyzes and proposes City bus charging facilities at city bus/ISBT terminals and their cost estimate for the city	No	City Bus	No	Yes	No
Kochi	Kochi Metro Rail Limited, UMTC	It earmarks locations and charging facilities at IPT stops in phases (for E-rickshaws and 3-seater autos). Quantity, Phasing, and budget mentioned	Yes	IPT Auto Rickshaw	Yes	Yes	No
Kozhikode	Kochi Metro Rail Limited, UMTC	Outlines the locations and charging facilities in IPT stops in phases (3-seater rickshaws). Quantity, Phasing, and budget are mentioned. 70 new public charging stations are proposed, along with their locations, budgets, and phasing.	Yes	IPT Auto Rickshaw	Yes	Yes	No
Bengaluru	Bangalore Metro Rail Corporation Limited, DULT, Infrastructure Development Corporation Karnataka (iDeCK)	Strategy 9 covers 'Promoting use of electric and cleaner fuel vehicles'. It also earmarks INR 1,600 crores for 'Bus depots/terminals/charging infrastructure'.	No	City Bus	No	Yes	No

5. Other City-Level Charging Infrastructure Plans/Guidelines/Studies

When we examine these standalone city-level documents, a largely piecemeal approach to EV planning becomes apparent. Different cities prioritize different aspects of the transition rather than following a shared planning framework. Although many of these documents engage a wide range of actors and propose detailed, actionable measures, such as technical specifications, pilot projects, institutional roles, and indicative budgets, their uneven scope, non-statutory nature, and varied formats limit their ability to guide a coordinated or scalable rollout across cities.

For instance, Lucknow's Comprehensive Electric Mobility Plan (NITI Aayog & Asian Development Bank, 2022), is among the most detailed examples. It outlines almost every step the city needs to take for electric mobility, including spatial projections for charging infrastructure and site identification. The report also lists possible funding sources, cost estimates, and responsible agencies. However, its lack of legal anchoring within a statutory planning instrument weakens its enforceability.

Pune's EV Readiness Plan (Pune Municipal Corporation, 2022), by contrast, is structured around explicitly numbered challenges and solutions, with clear agency responsibilities and implementation timelines. However, the plan does not specify associated budgetary allocations. Similarly, a study in Hyderabad (NRDC & ASCI, 2022) identifies 34 potential charging-station locations based on feasibility criteria, including costs, land availability, accessibility, traffic, power connections, etc., and provides detailed annexures for each site. Some other documents, although they do not include actionable measures, do provide methodological support for future decision-making. Bhubaneswar's document, on the other hand, while ticking all the boxes on legitimacy, is essentially an expression of interest to the Ministry of Heavy Industries (MHI) for FAME grants and also includes the city's electric mobility plan in the annexure. The measures in the plan, although not numerous, are detailed in terms of planning and cost estimation, and even include MOUs to demonstrate the city agencies' intent to adopt EVs.

These documents illustrate the strength of localized analysis and tailored solutions emerging from city-level collaborations with think tanks and technical agencies. However, for such work to meaningfully influence implementation, public planning instruments must draw upon these analyses while carrying statutory legitimacy. Although they contain well-researched cost estimates, implementation may not follow if public authorities do not allocate budgets for the proposed measures. The process of EV infrastructure planning should ideally remain in the public domain, even if technical studies are outsourced, since the accountability and legitimacy remain with the ULBs.

Table 4: Comparative Analysis of EVCI Considerations in Non-Statutory City-Level Charging Infrastructure Plans/Guidelines/Studies

Plan/Guidelines	Prepared by	EVCI Considerations	Types of Vehicles Considered	Land earmarked	Actionable Measures	The implementing agency specified	Budgetary Allocation
Lucknow Comprehensive Electric Mobility Plan	State govt., Niti Aayog, ADB	A comprehensive roadmap for Lucknow's EV transition, aligned with the Uttar Pradesh EV Policy, outlines clear stakeholder roles, inter-agency coordination, and a working group for fast-tracking charging infrastructure. It plans charging needs by vehicle type, with tailored solutions, like for municipal fleets, urban freight, two-wheelers, and corporate transit. Measures are organized into short-, medium-, and long-term actions, with budget estimates. Public charging guidelines include annual demand calculation, placement for fleets and highways, and geospatial site planning with feasibility checks. The plan integrates EVSE into planning instruments such as parking policies, town planning schemes, and land pooling, and advises on enabling private-space charging for both old and new buildings. It also suggests business models, grid management, safety protocols, and renewable energy integration.	Municipal fleet, corporate transit, MaaS Vehicles, Urban Freight, 2w & 4w used by city officials	Yes	Yes	Yes	No
Varanasi city-wide EV Demand Planning and EVCI Network Plan 2025-35	Convergence Energy Services Limited (CESL) and	1. Chapter 11 of the document is about 'EV charging infrastructure and location assessment. It includes: a. Parking space requirements for EVs. b. Approach for location assessment for setting up EVCI - Outlines steps that start from mapping key points of interest, creating a heatmap that informs the locations, which are further finalized via site	All (PCS)	No	No	Yes	No

	Ernst & Young LLP	assessments. 2. Chapter 12 focuses on potential business models for implementation, while the following chapter talks about integrating Renewable energy. The report is concluded by a chapter on making charging infrastructure friendly for EWCD (elderly, women, children, and the disabled)					
Bhubaneswar E-Mobility Plan	Bhubaneswar- Puri Transport Services	The document focuses on specific projects and not a city guidance document. Some of the contents related to EVSE include: 1. Specifies the E-rickshaws introduced in the smart city initiative and the charging infra reqd. for the same, along with the specifications, quantities, and budgets for chargers. 2. Specification, Quantity, and Budget of chargers at depots and terminals for the proposed e-bus network. 3. Specification, Quantity, and Budget of chargers for electric auto rickshaws. Although the rickshaw feeder routes are mapped, the Charging stations are not. 4. A public bike-sharing network is proposed with some electric-assisted bikes and the planning of the docks for the same. 5. Specification, Quantity, and Budget of chargers for 4-wheelers passenger cars for officers in city agencies like BMC, BDA, etc. 6. Includes Undertaking by different public and private agencies like BMC, BPSCL, Ola, and Lithium (fleet management service)	E-rickshaws, buses, and Public bike sharing	Yes	Yes	Yes	Yes

Charging up Mumbai's Electric Vehicle Transition	BMC, WRI	1. Drafts a need for Demand Mapping Analysis, and mentions potential parameters to be considered. 2. Presents a spatial analysis of Mumbai that marks key parameters like population count, public amenities, points of interest, local businesses, transit stations, workplace locations, and maps the spatial energy demand projected for 2025 and 2030.	All (PCS)	No	No	No	No
Pune City Electric Vehicle Readiness Plan	PMC, RMI	Along with a city-level assessment of the current status of Electric Vehicle Charging Infrastructure (EVCI), the document outlines key solutions to make the city EV-ready. These include measures such as establishing a single-window clearance system for private and captive charging, as well as battery-swapping stations; preparing a detailed deployment plan for charging and swapping facilities; upgrading upstream infrastructure; and creating low-emission zones. It also proposes setting dedicated parking regulations for EVs and developing a city-wide EV dashboard to track progress. In total, nine such solutions are identified, each accompanied by specific implementation steps, the stakeholders involved, and a timeline for execution.	All (PCS)	No	Yes	Yes	No
Bengaluru 2030: EV Charging Demand and Infrastructure	Center for Study of Science, Technology and Policy (CSTEP)	The third chapter discusses EV charging needs in Bengaluru in 2030. It drafts a methodology for assessing the impact of EV charging on the grid and various kinds of demand analysis (type, time, load, etc.) for 2030. The spatial analysis of projected charger demand is based on RTO zones, using parameters such as demographics, land use, energy capacity tariffs, etc.,	All (PCS)	Yes	No	No	No

		and is combined with site suitability studies that include factors such as existing parking lots, bus depots, transit stations, and fuel stations. This culminated in a map of 400 prospective sites for EV charging stations, along with 2,500 bus stops that could be modified to house charging infrastructure.					
Ready to Charge: Siting Electric Vehicle Charging Stations in Hyderabad	TSREDCO, ASCI, NRDC	1. Outlines the parameters for selecting optimal EV charging sites, like land, accessibility, traffic, power connection, etc. 2. The study then converts this broad framework into a detailed roadmap that is divided into steps and considerations to be made in all the corresponding steps. The study concluded with 35 potential charging-station sites in the city. The potential sites were assessed for feasibility, including cost and equity considerations. 3. The annexure of the study includes details of all sites with information like cost structure, legal owner, parking capacity, distance from pole/transformer, traffic density, potential for future growth, etc.	All (PCS)	Yes	Yes	Yes	No

6. Learnings from London's Approach

London offers a valuable example of how city-level EV planning can evolve into a coherent, statutory, and accountable process. Its approach demonstrates how successive documents (each building on the previous one) can collectively create an institutional framework that is both adaptable and rooted in public accountability.

For this study, we have studied 4 major documents:

Table 5: London's EV Planning Framework

Document	Prepared by	Remarks
London EV Infrastructure Delivery Plan 2019	The Mayor's Electric Vehicle Infrastructure Taskforce	1. Mapped existing charging points across the city, categorized by type. 2. Analyses utilization patterns: number of chargers, plug-in times, usage intensity. 3. Assessed user experience and pain points. 4. Identified user needs: charger type, frequency of use, preferred locations. 5. Produced maps on vehicle ownership and usage (taxis, PHVs, private cars). 6. Developed demand modelling for 2025. 7. Presented proposals and recommendations for scaling infrastructure. Highlighted enablers to support delivery (policy, governance, funding).
London EV Charge Point Installation Guidance 2019	TfL	Prepared in response to the findings of the Mayor's Electric Vehicle Infrastructure Taskforce and the associated "London EV Infrastructure Delivery Plan 2019". It: 1. Specifies charger types according to vehicle category and use case. Outlines public funding options and procurement frameworks for EV infrastructure. 2. Provides location guidance, referencing the EV Infrastructure Delivery Plan. 3. Includes product design considerations and overarching design principles. 4. Details planning permissions required for installation. 5. Covers implementation standards, including electrical guidance and compliance. 6. Addresses operations: interoperability, design life, safety, and parking integration. 7. Sets maintenance requirements, including security protocols and data management.
London (The London Plan) 2021	GLA	The requirements for charging points in parking for new developments are divided by building use: residential, offices, retail, hotels, leisure, freight, etc. For example, in residential buildings, 20 percent of charging points should be active and 80 percent passive, while in office spaces, all parking spaces should have charging infrastructure, including active charging points for all taxi spaces.
London's 2030 electric vehicle infrastructure strategy 2021	TfL	The 2019 Electric Vehicle Infrastructure Delivery Plan laid the foundation for collaboration between the public and private sectors to meet London's EV charging needs up to 2025. This current strategy builds on that plan by reflecting lessons learned from user feedback, evolving policies, and industry developments, and extends the vision to 2030. It updates London's

		understanding of user requirements beyond early adopters and outlines new commitments and partnerships needed to ensure adequate EV infrastructure and support the city's wider zero-carbon transition. Some of the features include: 1. Due to a lack of off-street parking, investments are made in on-street, predominantly lamp post charge points (near-home charging). 2. Contains temporal data for making decisions for charging infra, e.g.: a. Data on people with off-street parking in London b. Heatmap of major trips made by taxis c. Car ownership, driveway access d. Rapid charge points most used by Car clubs e. Number of LGVs per borough f. Spatial distribution of Licensed PHV drivers g. A common dashboard of all charging points along with usage data 3. Funding and support to Boroughs from TfL, Council, GLA to Boroughs through various schemes and guidance documents 4. Demand-led approach to slow-to-fast chargers through residents submitting a request for on-street chargers near their residence. 5. Flagship rapid charging hubs at various locations 6. Modeling for charging infrastructure projection for 2030 with assumption criteria like sales, tech, behavior, existing infra, traffic, energy capacity, etc. 7. Role of TfL and the public sector drawn out, and a Financing section for recommending various funding streams.

Note: *The London EV Charge Point Installation Guidance (2019) and London's 2030 Electric Vehicle Infrastructure Strategy (2021) were updated after this study. The revised versions are not included in this analysis. London EV Charge Point Installation Guidance and the EV infrastructure strategy (2021)- is now replaced by 'Guide to Electric Vehicle Charging Infrastructure for Local Authorities', and London's 2030 Electric Vehicle Infrastructure Strategy – 2025 Update, respectively*.

The London Electric Vehicle Infrastructure Delivery Plan (The Mayor's Electric Vehicle Infrastructure Taskforce, 2019), was developed by the Mayor's Electric Vehicle Infrastructure Taskforce, which was established in 2018. This plan established the foundation for collaboration between the public and private sectors, setting out evidence-based targets, delivery mechanisms, and user-centered priorities. The task force mapped existing charging points, analyzed usage data, and identified policy and governance enablers for scaling infrastructure.

Building on that foundation, the Electric Vehicle Charge Point Installation Guidance (Transport for London, 2019) translated strategic intent into operational direction. It detailed charger typologies by vehicle category, defined procurement frameworks, addressed planning permissions and compliance requirements, and established maintenance and data-management standards. By doing so, it attempted to transform the targets into technical and regulatory practice.

The London Plan (Mayor of London, 2021) a statutory spatial plan, embedded EV infrastructure within the city's formal planning system. It mandated specific charging requirements across building typologies: for instance, residential developments must provide 20 percent active and 80 percent passive charging points, while all office parking spaces must be EV-ready. Integrating these norms into a legally binding document made EV-readiness an enforceable part of development control.

London's 2030 Electric Vehicle Infrastructure Strategy (2021) (Mayor of London, 2021) extended this trajectory by explicitly reflecting on earlier lessons from the London Electric Vehicle Infrastructure

Delivery Plan (2019). It also listed out the challenges identified in the implementation of the 2019 plan and how they have been addressed in the updated plan. It incorporates user feedback and aligns itself with the broader goals, like the Mayor's Transport Strategy and the London Environment Strategy. It used temporal and spatial data such as trip patterns, driveway access, taxi movements, and local energy capacity to model charging demand up to 2030. It also operationalized a demand-led approach through resident requests for on-street charging, supported by funding mechanisms from Transport for London (TfL) and the Greater London Authority (GLA).

Importantly, the city's governance and accountability framework anchors these plans. The Mayor of London holds statutory responsibility for transport and environmental outcomes, ensuring that each EV-related document aligns with citywide strategies and measurable targets. Moreover, each successive plan explicitly references its predecessors, addressing identified gaps and updating priorities. This iterative and transparent approach ensures that London's EV strategy remains consistent, evidence-based, and publicly accountable.

Finally, London's documents also exemplify collaboration with external knowledge networks. References to research and data from Bloomberg NEF, Castrol, IEA, KPMG, and ICCT in the London EV infrastructure strategy indicate active engagement with industry and academic insights while maintaining a strong public-sector lead. This balance between expert collaboration and public accountability is central to London's ability to institutionalize EV planning as a continuous, learning-oriented process.

7. Cross-Cutting Insights

Statutory translation is decisive: London shows how strategic guidance (Delivery Plan → Installation Guidance) becomes durable only when embedded with authority (via the mayor, TfL, and GLA). In India, many strong technical studies remain detached from the statutory authorities. Without translation into enforceable instruments, there is a persistent implementation gap.

Iterative, referenced planning builds institutional memory: Effective practice documents explicitly reference predecessors and close identified gaps. London's sequence is a textbook case. In India, several city plans do cross-reference older plans, but there is a less systematic "audit trail" showing how one plan corrected or operationalized the prior one. Institutional continuity accelerates delivery and reduces duplication.

Named accountability and empowered coordinating bodies speed delivery: In London, mayoral accountability and TfL/GLA roles concentrate responsibility. Indian experiments like UMTA set-ups in cities like Chennai and Hyderabad point to potential, but these bodies need statutory powers, budget, and operational capacity to resolve cross-agency friction (power utilities, ULBs, planning authorities). Fragmented responsibilities can cause the projects to stall.

From symbolic grids to context-sensitive siting: Grid targets are useful directional tools, but demand-led siting based on temporal and spatial data (trip heatmaps, driveway access, vehicle types, usage patterns) produces more equitable and efficient networks. London's use of temporal data, such as trip and vehicle-ownership datasets, contrasts with many Indian grid targets that lack local contextualization. City-level studies done by research organizations and think tanks provide the

methodological ingredients for demand-led siting; these must be mainstreamed into statutory siting guidance.

Public ownership of analysis and public custody of decisions: City feasibility studies conducted by consultants and technical partners provide rich local analysis, but their impact is muted unless public agencies formally adopt and budget for their recommendations. Public agencies must own the process (publishing data, integrating local research into statutory documents, and allocating budgets).

Financing, delivery pathways, and monitoring must be explicit: Most Indian plans enumerate costs and responsibilities but stop short of binding financing mechanisms.

Retrofitting and equity design are operational priorities: Current DCR practice mandates new developments (parking norms for new buildings). Without retrofit standards, the risk of existing development being excluded is high. Plans should include retrofit pathways (incentives, standard RWA kits, etc.) and explicit equity targets for geographic coverage.

8. Conclusion

India's electric-vehicle transition will be decided in its cities, where mobility demand, land use pressures, and governance responsibilities intersect. The nation already possesses a strong toolkit with national incentive programs, technical guidelines, and numerous high-quality city studies; yet the prevailing pattern is one of technical depth without equivalent statutory or institutional traction. In many Indian cities, robust feasibility work, demand mapping, and carefully crafted recommendations sit alongside master plans and bylaws that either do not integrate those findings or lack the legal and budgetary backing to make them binding. The result is a fragmented landscape in which good analysis does not automatically become deliverable infrastructure.

The comparative evidence in this chapter suggests that what matters most is not any single policy instrument, but the way instruments are linked: technical studies must feed public decision-making; statutory plans must translate strategy into enforceable rules; and accountable institutions must be empowered to convene agencies, secure funding, and monitor delivery. The "London sequence," from delivery plan to technical guidance to statutory plan to a longer-term strategy, illustrates how iterative, referenced planning can create institutional memory and public accountability; Indian cities can adapt those structural features to their own specific requirements.

Equally important are the operational details: siting must move beyond symbolic grid targets to demand-sensitive locations informed by temporal and spatial data; retrofit pathways and explicit equity safeguards must accompany any emphasis on new construction so that residents of existing development, on-street parkers, and peripheral neighborhoods are not excluded. If cities combine statutory translation, designated accountability, and data-led, publicly owned delivery, then the technical promise of EVs can be realized as an accessible, equitable, and resilient urban mobility system rather than a series of disconnected pilots.

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Note: The documents reviewed (including draft master plans, CMPs, etc.) are based on information available online as of August 2025. There may have been subsequent updates, revisions, or discontinuation of some of these documents that may not be captured in this analysis.

Credits:

Sandip Chakrabarti: Conceptualization, Methodology, Resources, Supervision, Project administration, Funding acquisition. **Anish Sugathan**: Conceptualization, Methodology, Resources, Supervision, Project administration, Funding acquisition. **Shreya Sinha**: Formal analysis, Investigation, Data Curation, Writing - Original Draft. **Satya Andani**: Writing - Review & Editing.

Chapter 12

Insights from Stakeholder Consultation & External Engagements

Chapter Summary

Content:

1. Consolidates overall stakeholder perspectives from policymakers, OEMs, battery and charging developers, city agencies, and civil-society actors on EV ecosystem readiness and scale-up challenges.
2. Examines governance, charging infrastructure, battery R&D and safety, procurement models, spatial differentiation, freight electrification, micromobility, and consumer perception.

Findings:

1. Fragmented institutional ownership and weak policy–industry coordination slow coherent implementation and infrastructure readiness.
2. Charging deployment, battery certification, financing models, and heavy-duty electrification face persistent technical, operational, and trust-related constraints.

Takeaways:

1. Strengthen inter-ministerial coordination, statutory embedding, and structured industry dialogue to align targets with delivery capacity.
2. Prioritize demand-led siting, resilient infrastructure design, aggregated procurement, and transparent battery standards to support sustainable scale-up.
3. Non-metro contexts face distinct grid, land, financing, and institutional constraints that cannot be addressed through metro-centric models.

1. Introduction

This chapter consolidates ecosystem-level intelligence gathered through structured stakeholder interviews and external academic-policy engagements conducted during this study. While earlier chapters examined India's EV transition through segmented lenses of consumer behavior, OEM strategy, value chains, e-buses, logistics, planning instruments, and sentiment analysis, this chapter serves a distinct integrative purpose. It captures how stakeholders within the system interpret constraints, assess risks, and envision pathways to scale EV adoption in India.

The chapter brings together three complementary evidence streams. First, structured interviews with senior bureaucrats, OEM leaders, battery manufacturers, charging infrastructure developers, public procurement authorities, smart city administrators, and civil society representatives provided grounded insights into institutional friction, industrial hesitation, infrastructure bottlenecks, and perception barriers. These interviews were conducted in an open-ended format, with question frameworks based on the literature review presented in Chapter 2 and tailored to each stakeholder's professional profile, domain expertise, and institutional role. This approach enabled the discussions to move beyond standardized questionnaires and instead reveal context-specific constraints, strategic priorities, and implementation realities unique to each segment of the EV ecosystem.

Second, insights from the 8th Conference of the Transportation Research Group of India (CTRG-2025) at IIT Guwahati added a research-oriented perspective on network resilience, life-cycle economics, charging optimization, freight electrification, and behavioral dynamics. Third, discussions at the 1st World Symposium on Sustainable Transport and Livability (WSSTL-2025) at IISc Bengaluru introduced a normative, systems-level framing that emphasized accessibility, equity, resilience, and user experience in electrification strategies.

Together, these engagements move the analysis beyond static policy review. They reveal how EV adoption is shaped not merely by subsidy structures or technology readiness, but by coordination capacity, sequencing logic, spatial differentiation, industrial risk perception, and public trust. A recurring insight across consultations is that India's EV transition is structurally viable but unevenly synchronized. Progress is visible across manufacturing, public procurement, infrastructure experimentation, and R&D ambition; however, alignment across these domains remains partial.

This chapter, therefore, performs two critical functions. First, it documents ecosystem realities as articulated by actors directly shaping India's EV trajectory. Second, it synthesizes cross-cutting themes emerging from interviews and conferences to identify structural enablers and systemic bottlenecks. These insights provide an empirical and conceptual bridge for a systems-level perspective on barriers and enablers, which develops an assessment of the conditions under which a sustained EV tipping point may emerge.

1.1. Stakeholder Individual Interviews

The stakeholder consultations conducted for this study included senior bureaucrats, OEM strategists, battery technology leaders, public procurement authorities, smart city administrators, charging infrastructure developers, and civil society representatives. Unlike conference deliberations, these structured interviews enabled detailed reflections on operational constraints, institutional friction,

industrial risk exposure, and ecosystem misalignments that are often understated in formal policy discourse. Across discussions, a consistent pattern emerged: India's EV transition is not fundamentally constrained by technological feasibility, but by policy coordination and complexity, sequencing challenges, asymmetries in risk distribution, and perception differences. The insights below synthesize these consultations thematically.

Table 1: Stakeholders' Profile

Code	Role / Designation	Organization Type	Region
P11.1	Senior Official	Ministry of Electronics and Information Technology of India	National
P11.2	Senior Fellow / Former Automotive Engineering Leader	Energy & Sustainability Think Tank	National
P11.3	Executive Director	Electric Mobility Energy Infrastructure Company	National
P11.4	State-Level Program Executive	Government Energy Services Organization	State
P11.5	Senior Administrative Officer	Urban Special Purpose Vehicle	City
P11.6	Senior Industry Leader	Automotive Industry Association	National
P11.7	Senior Executive –Lithium Technology	Electric Mobility Technology Company	National
P11.8	Head of Product Planning	Major Indian Automobile Manufacturer	National
P11.9	Director – Corporate & Government Affairs	Major Indian Automobile Manufacturing Company	National
P11.10	Program Director	Environmental and Sustainable Transport NGO	City

1.1.1. Ministerial Coordination and the Limits of Policy Alignment

The question of inter-ministerial coordination surfaced repeatedly, particularly in discussions with P11.1. They emphasized that expanding charging infrastructure requires sustained collaboration across MoRTH, MoHUA, the Ministry of Power, and MHI, yet such collaboration remains administratively difficult to institutionalize. While policy intent is strong at the ministerial level, implementation authority is fragmented across departments with differing operational mandates.

As P11.1 observed, scaling charging infrastructure is "not a technological challenge but a coordination challenge." The absence of a unified ownership structure for land approvals, tariff rationalization, grid readiness, and standards-setting slows deployment despite headline policy commitments. The suggestion of formal inter-ministerial MOUs facilitated through academic institutions was proposed as one possible structural mechanism to convert political intent into institutional coherence.

Industry stakeholders echoed similar concerns from a different perspective. P11.2 noted that policy targets, such as 30% EV penetration by 2030, were articulated ahead of broader alignment on production economics and supply chain readiness. They also noted the financial implications of the BS4-to-BS6 transition, observing that the industry remains cautious about aggressively reallocating capital in the absence of parallel ecosystem readiness.

In P11.2's assessment, long-term government commitment is essential, but so is clarity on return pathways. As they noted, "industry is asked to commit long-term, but certainty of return on investment is not promised." This asymmetry creates friction between political ambition and industrial risk tolerance. These consultations suggest that India's EV transition remains administratively ambitious but institutionally diffused. Without structured policy-industry dialogue before target-setting, tipping point pathways risk remaining aspirational rather than executable.

1.1.2. Charging Infrastructure: Visibility, Analytics, and Institutional Ownership

Charging infrastructure was the most extensively discussed ecosystem component across interviews.

P11.3 strongly advocated an infrastructure-first strategy, arguing that visible charging infrastructure reduces behavioral uncertainty and catalyzes vehicle adoption. GLIDA's pre-emptive deployment model of placing chargers in high-density public areas such as malls, office complexes, and residential hubs aims to integrate charging into daily routines, thereby reducing psychological resistance. According to them, infrastructure must "stay ahead of demand" to prevent bottlenecks that discourage potential buyers.

However, public procurement authorities offered a more calibrated perspective. P11.4 emphasized that charging infrastructure should be guided by usage analytics rather than headline targets. Drawing from Gujarat's large-scale e-bus rollout, they argued that infrastructure optimization based on route-level data and fleet operations is more important than blind expansion. In their view, trust among OEMs, utilities, and financiers emerges when infrastructure deployment is demand-linked rather than politically symbolic.

Urban administrators introduced additional layers of complexity. P11.5 highlighted operational disruptions caused by non-resilient charging depots. In smaller cities, charging infrastructure is rarely designed for flood resilience or prolonged grid instability. During monsoon seasons, even minor service interruptions can immobilize entire fleets. They stressed that electrification strategies must embed disaster-proofing standards at the design stage.

Standardization was another recurring concern. P11.6 emphasized the need for a "right to charge anywhere" framework to prevent ecosystem fragmentation. Without interoperability mandates and standardized charging access, industry expansion risks becoming network-segmented, thereby undermining consumer confidence.

Collectively, interviews reveal that charging infrastructure must satisfy four simultaneous conditions: visibility, analytical placement, interoperability, and climate resilience. Infrastructure quantity alone does not guarantee ecosystem acceleration.

1.1.3. Battery Technology, R&D Depth, and the Safety Narrative

Battery manufacturing and technology development emerged as structural determinants of long-term EV competitiveness.

P11.7 emphasized that India's transition must prioritize deep R&D investment in cell manufacturing, thermal management systems, and Battery Management Systems (BMS). In their assessment, large-scale EV adoption will remain cost-constrained until domestic cell manufacturing significantly reduces

battery prices. They argued that “if battery costs are halved through indigenous R&D, the rest of the ecosystem will adjust automatically.”

Battery degradation anxiety has increasingly replaced range anxiety in consumer discourse. Both industry and public stakeholders identified insecurity about resale value and uncertainty about end-of-life battery management as significant psychological barriers. P11.4 advocated for a National Battery Certification Authority and an Extended Producer Responsibility (EPR) framework to address transparency in degradation and accountability for recycling.

Safety perceptions were also discussed extensively. P11.6 observed that safety incidents in low-cost two-wheelers, often linked to poor-quality cells, have shaped broader consumer skepticism, even though passenger car batteries (often LFP chemistry) have significantly stronger safety profiles. They stressed that battery location design and thermal safeguards in modern EVs are “safer than conventional ICE configurations,” yet public awareness of this fact remains limited.

These discussions highlight a dual imperative: regulatory standardization to ensure safety and communication clarity to correct misinformation. Without technical transparency and certification benchmarks, perception gaps may continue to hinder adoption even as technology improves.

1.1.4. OEM Strategy, Profitability Constraints, and Transitional Pathways

OEM strategy discussions revealed a cautious but structured transition approach.

P11.8 outlined their company’s phased portfolio expansion strategy and upcoming premium models, which were designed to democratize adoption across income segments. They emphasized that affordability below the ₹10 lakh threshold was central to widening India’s EV consumer base.

At the same time, profitability pressures remain significant. Both P11.8 and P11.9 representatives acknowledged that EV programs currently operate under constrained margins. P11.9 noted that while PLI schemes support manufacturing, tangible consumer-side benefits remain limited. According to him, policy must move beyond industrial orientation to create visible consumer gains.

Battery-as-a-Service (BaaS) models were discussed as one mechanism to address upfront cost barriers. JSW MG’s BaaS approach reportedly reduces initial purchase cost by up to 30%, aligning better with EMI-driven consumer preferences. However, P11.9 emphasized that regulatory clarity is necessary to govern battery ownership, maintenance responsibility, and resale norms under such models.

Hybrid transition strategies also surfaced in interviews. P11.2 suggested that hybrid pathways may offer a pragmatic intermediate step until charging infrastructure reaches maturity. Others cautioned that hybrid expansion could dilute the momentum of full electrification. This debate reflects broader industry uncertainty regarding the pace of infrastructure readiness.

Overall, OEM interviews reveal a strategic commitment to EV expansion, but only under conditions of policy stability, parallel infrastructure, and risk-sharing mechanisms. Industrial willingness exists—but it remains conditional rather than unconditional.

1.1.1. Public Procurement, Demand Aggregation, and the Role of the State as Market Stabilizer

A dominant insight emerging from consultations was that large-scale public procurement has played a more decisive role in India's EV acceleration than retail subsidies alone.

P11.4 described India's EV trajectory as evolving from "subsidy-driven pilots" (2017–2019) toward institutionalized fleet procurement through aggregated tenders. Drawing from Gujarat's rollout of over 1,700 electric buses under structured public–private models, they argued that economies of scale and standardized contracting frameworks created predictable demand pipelines that stabilized OEM confidence.

In their assessment, the turning point in India's EV ecosystem was not incremental subsidy expansion, but the normalization of institutional demand. Public-sector tenders, particularly under Gross Cost Contracting (GCC) models, transferred demand risk away from operators and provided long-term payment security. This, in turn, improved financial confidence and encouraged discussions about domestic manufacturing.

P11.4 drew a parallel with India's LED lighting transformation, where centralized bulk procurement dramatically reduced prices and normalized adoption. The implication is that EVs may require a similarly decisive, large-scale procurement signal to transition from fragmented pilots to systemic mainstreaming.

However, this model's success appears uneven across segments. While e-bus adoption has scaled under municipal payment guarantees, private fleet electrification remains hesitant. Multiple stakeholders noted that trucks and long-haul logistics vehicles face severe cost asymmetries. As highlighted in P11.7, replacing a ₹45 lakh ICE truck with a ₹1.2 crore electric equivalent shifts operating costs from approximately ₹10 per km to nearly ₹45 per km under current conditions, rendering electrification economically unattractive without targeted incentives.

The broader implication is that public procurement can de-risk adoption in segments where institutional demand exists, but heavy-duty and private commercial fleets require differentiated financial instruments, including viability gap funding, tax incentives, or operational subsidies.

1.1.5. Tier-2/3 Cities, Urban Form Mismatch, and Infrastructure Resilience

Consultations with city-level administrators introduced a crucial geographical dimension often underrepresented in national EV discourse.

P11.5 emphasized that most EV bus designs currently available in India are typically 9 to 12 meters long and are structurally mismatched with the road geometries of Tier-2 and Tier-3 cities. Narrow streets, dense residential clusters, and informal settlements make maneuverability difficult. As a result, electrification efforts may inadvertently bypass precisely those neighborhoods most dependent on public transport. They argued for India-specific compact electric buses in the 6–8-meter range, tailored to smaller urban ecosystems. Without such adaptation, electrification risks reinforcing existing accessibility inequities.

Operational vulnerabilities were also highlighted. Battery replacement delays, spare-part shortages, and limited local service partnerships frequently immobilize vehicles for extended periods. In smaller cities, the lack of local battery warehousing increases the risk of downtime. Climate resilience emerged as an under-addressed vulnerability. Charging depots and bus terminals are rarely designed to

withstand flooding or prolonged grid disruptions. During monsoon events, EV-based public transport systems face systemic reliability risks precisely when mobility continuity is most critical. P11.5 recommended integrating disaster-proofing standards into depot design and creating dedicated "green corridors" between urban centers to reduce range anxiety for intercity travel.

These insights suggest that EV transition strategies must be spatially differentiated. Metro-centric infrastructure assumptions cannot be uniformly applied across India's diverse urban forms.

1.1.6. Consumer Trust, Communication Deficits, and Perception Management

While structural and institutional constraints dominate policy discussions, stakeholders repeatedly returned to the question of consumer perception.

P11.9 identified perception barriers such as range anxiety, battery safety concerns, and resale insecurity as the "biggest barrier in adoption." They emphasized that misinformation, amplified through isolated incidents or fragmented media narratives, shapes consumer hesitation more powerfully than technical specifications.

Similarly, P11.6 stressed that safety perceptions in two-wheelers, where regulatory enforcement has occasionally been inconsistent, spill over into four-wheeler markets. They argued that government and industry must jointly market functional safety standards, including battery placement design, thermal safeguards, and compliance with AIS norms, to counteract negative narratives.

Transparency mechanisms were repeatedly proposed. These included battery health reports integrated into vehicle fitness tests, standardized degradation certificates, and public dashboards to communicate safety benchmarks. The absence of visible regulatory communication allows myths to persist.

Consumer financing also remains a structural concern. While Battery-as-a-Service models reduce upfront costs, several stakeholders observed that consumer awareness of such mechanisms remains limited. Greater institutional endorsement, potentially through government-backed information platforms, could enhance legitimacy.

Ultimately, the consultations indicate that EV adoption is not only an engineering transition but also a communication transition. Trust must be actively cultivated through transparency, standardization, and coordinated public messaging.

1.1.7. Civil Society Perspectives: Mobility as a Social Service

The interviews also incorporated a civil-society lens, notably through discussions with P11.10. He challenged the prevailing vehicle-centric framing of EV policy, arguing that urban mobility should be understood as a public service rather than a vehicle-ownership challenge.

They highlighted the disproportionate allocation of public funds toward metro rail relative to city bus systems, despite buses serving a broader demographic, particularly women and low-income commuters. In his view, electrification must prioritize strengthening bus systems and integrating them with Non-Motorized Transport (NMT) and Transit-Oriented Development (TOD) frameworks.

They further emphasized the absence of standardized carbon accounting and urban energy audits within municipal planning processes. Without such metrics, EV deployment risks becoming symbolic rather than systematically decarbonizing.

This perspective broadens the EV discourse beyond technological substitution toward equity, accessibility, and governance reform.

1.1.8. Expanding the EV Narrative Beyond Passenger Cars

A significant insight emerging from multiple stakeholder interviews was the narrow framing of India's electric vehicle transition around private passenger cars. While four-wheeler adoption dominates public discourse, media narratives, and even policy signaling, several stakeholders argued that such a focus risks underleveraging segments that may offer greater potential for decarbonization and social impact.

P11.1 emphasized that India's EV ecosystem must expand its conceptual scope beyond urban private mobility. They pointed to emerging use cases such as e-ambulances and emergency response fleets, arguing that these segments combine high visibility, high utilization, and strong public-good justification. Electrifying such fleets could generate disproportionate symbolic and operational impact, particularly in demonstrating reliability under mission-critical conditions. In their view, "EVs cannot remain confined to private consumption narratives if they are to become structurally embedded in public systems."

Similarly, P11.7 highlighted the relative neglect of heavy-duty freight vehicles within current policy emphasis. Despite long-haul trucks and agricultural tractors contributing significantly to transport-related emissions, electrification incentives and policy discourse remain concentrated in the passenger segment. They noted that without targeted support mechanisms for heavy-duty vehicles where cost differentials remain substantial, India risks achieving visibility in urban passenger markets while leaving high-emission segments structurally untouched.

Two-wheelers also surfaced as an under-discussed regulatory concern. Stakeholders such as P11.6 argued that safety standard enforcement in the two-wheeler segment must be strengthened to prevent perception spillovers into the broader EV market. Given that two-wheelers constitute a large share of India's vehicle stock, ensuring quality assurance in this segment is central not only to emissions reduction but also to long-term consumer trust.

Finally, several interviewees underscored the importance of electrifying government fleets beyond buses, extending to administrative vehicles, municipal service fleets, and state-owned enterprises. Institutional adoption, they argued, serves as both a market stabilizer and a behavioral signal.

Taken together, these perspectives suggest that India's EV strategy must evolve from a car-centric transition model to a multi-sectoral electrification framework. By focusing disproportionately on private passenger vehicles, policy risks overlooking segments where electrification may yield higher emissions reductions, stronger demand aggregation, and greater public confidence.

1.1.2. Concluding Synthesis: Call for a Self-Reinforcing Transition

Across interviews with policymakers, OEM leaders, infrastructure providers, battery manufacturers, urban administrators, and civil society representatives, a coherent structural pattern emerges. India's EV ecosystem is neither technologically immature nor institutionally inactive. Rather, it is characterized by uneven synchronization across its constituent domains.

Stakeholders consistently acknowledged strong political ambition and visible policy commitment. OEMs have articulated structured product roadmaps spanning multiple price segments, signaling industrial willingness to participate in the transition. Battery manufacturers are investing in domestic cell development and thermal management innovation, reflecting long-term strategic intent. Public procurement mechanisms—particularly in the e-bus segment—have demonstrated that aggregated demand can stabilize markets and build ecosystem confidence. Charging infrastructure developers are experimenting with new deployment models and business innovations.

Yet, despite these parallel efforts, convergence across domains remains incomplete. Institutional coordination between ministries continues to lag behind policy articulation. Charging infrastructure expansion does not uniformly align with usage analytics or climate resilience standards. Battery safety communication remains insufficiently institutionalized. Financing mechanisms are innovative but unevenly regulated. Consumer perception continues to be shaped by fragmented narratives rather than coordinated information strategies.

The interviews collectively indicate that reaching a genuine tipping point will require simultaneous progress across interacting dimensions rather than incremental improvements within isolated silos. Institutional coordination must be formalized rather than informal. Charging infrastructure must be visible, standardized, analytically placed, and resilient to climatic stress. Battery R&D must be paired with transparent certification and degradation reporting frameworks. Demand aggregation through public procurement and fleet electrification must extend beyond buses into additional high-impact segments. Finally, communication strategies must address perception gaps proactively rather than reactively.

In this sense, India's EV transition cannot be described as either stalled or inevitable. It is conditional. Its trajectory depends on whether alignment across technical, institutional, financial, and behavioral subsystems can be achieved in a synchronized manner. The stakeholder interviews presented in this section, therefore, provide more than anecdotal insight. They offer ecosystem-level signals regarding where coordination is strengthening, where friction persists, and where strategic recalibration may be necessary.

1.2. Insights from the 8th Conference of the Transportation Research Group of India (CTRG-2025) at IIT Guwahati, 17–20 December 2025, for Electric Vehicle Research and Policy in India

1.2.1. Context

The 8th CTRG conference at IIT Guwahati brought together researchers, policymakers, and industry experts to discuss emerging trends in transport. The conference offered valuable insights on electric

vehicle adoption, infrastructure planning, and policy frameworks critical for advancing sustainable mobility in India. The insights gained from EV-related sessions are summarized below.

1.2.2. Electrification of Public Transport Systems: Network Structure, Operations, and Economic Viability

A prominent theme across the CTRG-2025 sessions was the electrification of public transport, particularly buses, with a strong emphasis on network performance, charging strategies, and long-term cost implications. Rather than treating electric buses merely as cleaner substitutes for diesel vehicles, these studies conceptualized electrification as a system-level transformation requiring new planning, operational, and governance approaches.

The study titled "Topology Analysis of Circular Electric Bus Networks: Connectivity, Efficiency, and Network Robustness" examined the circular electric bus network using graph-theoretic methods. The study showed that only a few bus stops are critical to keeping the electric bus network connected. These stops carry a large share of passenger movement. If such stops are disrupted or removed, overall accessibility can drop by up to 40%, and travel across the network becomes much longer. This indicates that electric bus planning should not depend only on simple, linear route design. Instead, policymakers need to plan for network resilience by strengthening services at these critical stops, creating alternative routes, and ensuring the system can continue to operate during disruptions.

Operational feasibility was further examined in "A Comparative Analysis of Operational Feasibility and Life Cycle Costs of Electric vs. Diesel Buses in Guwahati City." Using real-world GPS-based operational data, the study compared electric and diesel buses across routes with varying traffic congestion. The findings demonstrated that electric buses perform better in stop-and-go traffic due to smoother acceleration. Importantly, a 15-year life-cycle cost analysis showed that electric buses, despite higher upfront costs, resulted in substantially lower operating expenses and a 30% reduction in total lifecycle costs. This provides strong empirical support for shifting public procurement frameworks away from capital-cost dominance toward life-cycle cost–based decision-making, particularly in congested urban environments.

Charging infrastructure design emerged as another critical dimension. The paper "Optimal Allocation of Stationary Wireless Charging Facilities for Battery Electric Buses" explored the potential of stationary wireless power transfer systems through a mixed-integer linear programming framework. The study examined how wireless charging systems for electric buses should be placed and operated to minimize costs and improve efficiency, and it found that starting buses with a higher battery charge can significantly reduce the need for intermediate charging infrastructure and lower overall system costs, especially for buses making multiple trips. For policymakers, this suggests that charging infrastructure investment should be coordinated with battery management strategies and operational scheduling, rather than being treated as a standalone hardware problem.

Similarly, "Charging Station Allocation and Infrastructure Design for E-Buses: A Machine Learning Approach" applied clustering algorithms and optimization techniques to determine charging station locations and fleet allocation in Delhi. The study examined how cities can plan for charging stations for electric buses when transitioning from diesel or CNG fleets. Using machine learning, it identified the best locations and number of chargers needed for a given fleet. The Delhi case showed that this

approach can reduce inefficiencies. For policymakers, the study suggests that charging infrastructure should be planned systematically alongside bus routes and fleet size, rather than being added randomly. This reinforces the need for transport authorities to build analytical capacity and adopt computational tools when planning large-scale electrification.

In conclusion, the above studies highlight that electric bus adoption represents a systemic transformation, necessitating resilient network design, life-cycle cost–oriented procurement, and strategically integrated charging infrastructure. Policymakers must move beyond simple vehicle substitution and employ data-driven planning, operational strategies, and network optimization to achieve efficient, accessible, and cost-effective public transport electrification.

1.2.3. Electrification of Freight and Logistics: Routing, Range, and Depot-Centric Charging

Another major theme focused on electric vehicles in freight and logistics operations, an area of growing importance given freight's disproportionate contribution to transport-related emissions. These studies moved beyond static feasibility analysis to examine dynamic operational reliability under real-world constraints.

The study "Novel Routing Strategy for Operationally Efficient Deployment of Electric Vehicles in Day-to-Day Logistics Distributions" formulated a comprehensive Electric Vehicle Routing Problem (EVRP) that integrated congestion, delivery time windows, fleet heterogeneity, partial recharging, battery degradation, and capacity constraints. The study tested various battery use and charging scenarios and found that how efficiently electric vehicles operate depends heavily on route planning and battery reserve levels. For policymakers, this means that electrifying delivery fleets requires careful, logistics-focused planning, and general EV incentives alone may not be sufficient without supporting smart routing and operational strategies.

Complementing this, "Evaluating Range Sufficiency and Charging Infrastructure for Electric Light Commercial Vehicles in Delhi" assessed the long-term viability of battery electric Light Commercial Vehicles (LCVs) using a Markov Chain trip simulation model. The study examined whether LCVs can complete their daily trips within their available battery ranges and with available depot charging options. It found that small batteries often fail over several days, and slow chargers cannot fully recharge larger batteries. Semi-fast and fast chargers work much better. For policymakers, this means supporting LCV electrification requires installing faster chargers, considering en-route charging, and setting minimum battery standards to ensure reliable operation. Policymakers are thus also advised to move beyond one-day feasibility metrics and incorporate multi-day operational resilience into standards for freight EV deployment.

These studies show that electrifying freight and logistics requires more than incentives—it demands route-optimized operations, battery-aware planning, and strategically placed fast chargers. Policymakers should prioritize multi-day operational reliability, fleet heterogeneity, and smart charging infrastructure to ensure electric delivery vehicles can meet real-world demand efficiently, sustainably, and consistently.

1.2.4. Planning Charging Infrastructure: Spatial Optimization and Context Sensitivity

Charging infrastructure planning emerged as one of the most extensively examined themes, with multiple studies proposing optimization frameworks tailored to different urban contexts. Collectively, these papers emphasized that charging infrastructure effectiveness depends not only on quantity, but also on location, accessibility, and alignment with travel behavior.

The study "Optimizing Electric Vehicle Charging Station Locations Using MCLP Model: A Case Study of Bharatpur, India" applied a Maximum Coverage Location Problem framework using household survey data and origin–destination matrices. The results demonstrated that optimal service radii vary significantly by vehicle type, underscoring the inadequacy of one-size-fits-all planning norms. For policymakers, this study argues for vehicle-segment-specific infrastructure standards, especially in smaller cities.

In the study "Strategic Spatial Allocation of Electric Vehicle Charging Stations Using a Voronoi-Based Model," the authors examined how to place EV charging stations while accounting for existing chargers and local demand. Tested in Hyderabad, the approach reduced service gaps and avoided the need for unnecessary new stations. For policymakers, this means charging stations can be planned efficiently, saving money and improving access in areas that need them most.

The paper "Optimal Planning for Electric Vehicle Charging Stations: Balancing Produced and Attracted Demand" extended this logic by distinguishing between EVs owned within a ward and EVs traveling into it. Using a mixed-integer programming model, it optimized station locations to minimize travel distance and efficiently meet charging demand. For policymakers, this means planning charging infrastructure should account for movement patterns, not just local ownership, and should follow realistic service ranges and local guidelines to ensure effective, practical coverage. For urban policymakers, this suggests that charging demand should be modeled as a mobility phenomenon rather than a residential attribute.

Finally, "Strategic Placement of EV Charging Stations in Developing Urban Environments: Lessons from Tier 1 and Tier 2 Indian Cities" compared Mumbai and Warangal using a multi-criteria utility framework. The study examined how to place EV charging stations in two Indian cities: Mumbai (a Tier 1 metro) and Warangal (a Tier 2 city). Using a model that accounted for factors such as land use, points of interest, population coverage, grid connectivity, highway access, and property costs, it found that in Warangal, existing stations were well aligned with land use and high-demand locations, whereas in Mumbai, cost considerations were more important. This shows that EV charging station planning should be tailored to local urban conditions and city characteristics, rather than applying the same strategy to all cities. This reinforces the argument that national EV infrastructure policies must allow substantial local flexibility.

Thus, charging infrastructure planning must move beyond sheer numbers to consider location, accessibility, travel patterns, and city-specific contexts. Studies show that optimized placement—tailored to vehicle type, demand flows, and urban characteristics—enhances efficiency, equity, and cost-effectiveness. Policymakers should adopt flexible, data-driven frameworks that reflect mobility realities rather than uniform national norms.

1.2.5. Consumer Adoption, Behavior, and Sociopsychological Barriers

A large body of work at CTRG-2025 focused on understanding why EV adoption remains uneven despite policy support. These studies collectively reveal that perceptions, social influence, and trust deficits are as important as infrastructure availability.

The study "Understanding Electric Vehicle Pessimism: How Sociopsychological Factors Affect Prospective Buyers" used survey data from Hyderabad to examine how social influence and media exposure shape EV-related concerns. The findings showed that social narratives can amplify risk perceptions, highlighting the need for strategic public communication alongside financial incentives.

The study "A Comparative Study of Adoption Inclination Towards Electric Vehicles in Metro and Non-Metro Indian Cities" examined factors affecting EV adoption in metropolitan and non-metropolitan cities. Using a decision tree model, it found that low perceived utility, limited charging infrastructure, and driving range are major barriers in both city types. Pro-environmental attitudes mattered more in metro cities than in non-metro cities. The study suggests that policymakers and manufacturers should focus on improving EV reliability, range, and charging speed to encourage adoption across all cities.

In "Examining Factors Influencing Electric Vehicle Adoption: A Hybrid SEM–FsQCA Approach," the authors demonstrated that while incentives and regulatory frameworks promote adoption, concerns related to range and charging infrastructure continue to exert a strong negative influence. The fsQCA analysis revealed multiple causal pathways, implying that no single policy lever is sufficient.

The macro-level implications were explored in "Accelerating Electric Vehicle Adoption in India: A System Dynamics Approach." This study showed that purchase subsidies accelerate early adoption, while charging infrastructure subsidies are more cost-effective over the long term. Crucially, a combined approach yielded the highest adoption rates, offering actionable guidance for fiscal prioritization.

The study "Estimating User Behavior & Attitudes of Personal Electric Vehicle (EV) Owners in a Tier-II City of India: A Case of Lucknow" explored how EV owners in smaller Indian cities use and perceive their vehicles. Using surveys and interviews, it found that electric two-wheelers are most popular because they are affordable and good for short trips. However, adoption is limited by factors like poor charging infrastructure, range anxiety, high upfront costs, and battery concerns. Negative word-of-mouth also discourages potential buyers. For policymakers, the study suggests designing EV policies that focus on user needs—improving charging facilities, addressing range and battery concerns, and providing consumer support—to boost adoption in Tier-II cities. Another study from a Tier-II city, "Modeling Electric Vehicle Adoption Intention in a Tier-2 Indian City: Role of Technology Knowledge and Infrastructure Concerns," examined factors influencing EV adoption in Jodhpur. Using surveys and structural equation modeling, it found that concerns about technology and charging infrastructure strongly discourage adoption. For policymakers, the study highlights that promoting EV adoption in smaller cities requires addressing local barriers by improving charging infrastructure, increasing awareness, and educating users about EV technology.

The above studies reveal that EV adoption is shaped as much by sociopsychological factors—perceptions, trust, and social influence—as by infrastructure. Policymakers must therefore integrate targeted incentives with strategic communication, greater awareness of technology, and improved

charging and battery support, particularly in non-metro and Tier-II cities, to overcome adoption barriers and accelerate uptake.

1.2.6. Micromobility and Informal Electrification Pathways

Several studies highlighted the importance of micromobility and informal electric modes in India's EV transition. The study "Who Will Adopt Electric Bicycles in Urban India and Why? Insights from psychographic segmentation of potential adopters in the greater Hyderabad region" explored the characteristics of potential e-bike users in the greater Hyderabad region. Using psychographic segmentation, it identified three groups: Skeptics, Optimists, and Enthusiasts. The study found that Enthusiasts and Optimists, especially those making trips of 5 km or less, are most likely to adopt e-bikes, influenced by attitudes such as environmental awareness, social influence, and personal norms. Skeptics were less likely to adopt, and their adoption intentions were shaped by education and personal norms. For policymakers and urban planners, these findings suggest that targeted, group-specific strategies are needed to close gaps in attitudes and adoption intentions and to encourage wider e-bike adoption.

The study "Emergence of Micromobility and User Perception in Delhi, India: Insights for Policy Planning" examined e-scooter and e-bike adoption in Delhi, comparing global policies and surveying local users. It found that adoption depends on infrastructure, licensing, parking, and technical standards, while regulations vary widely across countries. For policymakers, the study highlights the need for a context-specific regulatory framework to enable safe and efficient growth of micromobility in India.

The study "Exploring the Key Factors Influencing the Choice of Electric Rickshaw Usage: A Case Study of Silchar City, India" examined why people use e-rickshaws in Silchar, a Tier-3 city. It found that affordability, door-to-door service, safety, comfort, and short waiting times are the main reasons, with younger male students traveling short distances being the most frequent users. For policymakers, the study emphasizes the need to provide safe, reliable, and affordable e-rickshaw services to promote sustainable mobility in smaller cities.

Together, these studies suggest that supporting micromobility could deliver rapid equity and emission benefits, particularly where formal public transport is weak.

1.2.7. Traffic Integration and System Performance

The study "Empirical Analysis of Electric Vehicle Behavior in Mixed Traffic Conditions" analyzed how human-driven Electric Vehicles (EVs) behave in real-world traffic alongside conventional vehicles. Using a new high-resolution trajectory-level dataset, it found that EVs tend to maintain shorter, more stable distances than internal combustion engine vehicles. These findings can help policymakers and traffic planners design more effective lane management, adaptive traffic models, and strategies to integrate EVs safely and efficiently into mixed traffic environments.

The study "Energy-Efficient Traffic Assignment Framework Incorporating Electric Vehicle Characteristics" focused on designing shared auto networks in non-metro Indian cities, where public transport is limited. Using a framework similar to bus network design, the study mapped shared auto stands, accounted for overlapping routes, and evaluated route efficiency based on directness and path

length. This approach helps planners identify efficient travel routes and assign traffic to reduce unnecessary travel distance, improve connectivity, and support energy-efficient transport planning in cities with emerging electric vehicle networks.

The study "Studying the Impact of Plug-in Hybrid Electric Vehicle (PHEV) Penetration on CO_2 Emission: Evidence from Delhi, India" examined the effects of adopting PHEVs in Delhi. It found that purchase subsidies can significantly reduce gasoline consumption and CO_2 emissions. For policymakers, the study highlights that subsidies are an effective tool for promoting PHEVs and improving urban air quality.

These studies show that effective EV integration requires traffic systems to adapt to distinct vehicle behaviors and energy characteristics. Policymakers should incorporate EV-specific dynamics into traffic modeling, network design, and subsidy frameworks to improve safety, efficiency, and emissions outcomes, particularly in mixed-traffic and non-metro urban contexts.

1.2.8. Conclusion

Across themes, the CTRG-2025 studies collectively demonstrate that India's EV transition is not primarily constrained by technology, but by planning paradigms, institutional coordination, and behavioral dynamics. Effective policy must therefore integrate infrastructure planning, operational intelligence, consumer engagement, and context-sensitive governance to achieve a sustainable and inclusive transition to electric mobility.

1.3. Insights from the 1st World Symposium on Sustainable Transport and Livability (WSSTL-2025) at IISc Bengaluru (25–27 June 2025) for Electric Vehicle Research and Policy in India

1.3.1. Context

The 1st World Symposium on Sustainable Transport and Livability (WSSTL-2025) at IISc Bengaluru (25-27th June, 2025) focused on how transport systems can evolve to support inclusive, healthy, and sustainable urban living. It served as a platform to discuss mobility not just as infrastructure, but as a cornerstone of social cohesion and economic vitality. The key message is that sustainable transport is a moral and social imperative, not just a technical goal. This underscores the need for a citizen-centered transportation system, emphasizing governance reforms and design guidelines that prioritize human needs, accessibility, and quality of life rather than merely facilitating vehicle movement.

Although the symposium mainly focused on transportation and liability, some sessions and presentations also addressed EVs. The insights gained from those sessions are summarized below.

1.3.2. Electrifying Public Transport in India: Accessibility, Equity, and Systemic Challenges

The Session: “Advancing Public Transport and Well-being through Zero-emission Buses” discussed the evolving role of electric and zero-emission buses in India’s transport transition, with a strong emphasis on accessibility, sustainability, and governance.

A key insight from the session was the persistent accessibility deficit in Indian cities. Despite investments in metro rail and modern bus contracting models, nearly one-third of urban residents still live beyond a comfortable walking distance from a bus stop. This gap disproportionately affects low-income and mobility-dependent populations, revealing a planning approach that prioritizes large, capital-intensive projects over local, everyday mobility needs. The session argued that without addressing neighborhood-level accessibility, electrification efforts risk benefiting only a limited segment of the population. To illustrate alternative approaches, the presentation shared evidence from the Delhi Electric Vehicle Initiative (DEVI) pilot, which demonstrated the potential of small electric buses operating at the neighborhood level. These services showed promise in improving last-mile connectivity and expanding public transport access, particularly in underserved areas.

The discussion also touched on aspects of intercity electric buses, revealing slower adoption, especially among private operators. While national-level subsidies and highway charging networks are expanding, operators continue to face challenges within cities, including the lack of formal terminals, depots, and charging facilities. The absence of integrated planning between urban and intercity systems was identified as a major risk to achieving India’s long-term fleet electrification goals.

One key insight from discussions on electric buses was the negligible adoption of EV buses by the private sector. Unlike public transport undertakings, which are often supported by government subsidies and policy mandates, private operators face high capital costs, operational uncertainties, and risks associated with battery availability and performance. This has resulted in limited private participation, slowing the overall electrification of bus fleets.

A critical conceptual insight gained from the session was to electrify routes, not buses. This implies that electrification should be approached at the corridor or route level— integrating charging infrastructure, grid preparedness, and operational planning—rather than being limited to vehicle procurement. If routes are made EV-ready, the transition to electric buses is likely to follow organically, reducing uncertainty for operators.

The discourse around EV anxiety was also discussed. While early concerns centered on range anxiety, the current challenge is increasingly one of battery degradation anxiety. Operators and agencies are worried about long-term battery performance, replacement costs, and downtime, particularly given India’s climatic conditions and intensive usage patterns.

Several operational constraints were also highlighted. The absence of dedicated or prioritized lanes for electric buses, especially on highways and major corridors, limits their efficiency and attractiveness. Furthermore, small and medium towns face a mismatch between urban form and vehicle design. Most EV buses currently available in India are large and unsuitable for narrow streets common in smaller cities. There is a clear need for smaller EV buses designed specifically for small-town geographies, local travel demand, and road conditions.

Another major concern relates to battery supply delays and availability. In periods of uncertainty—such as supply chain disruptions or delayed battery replacements—entire public bus fleets risk being grounded, severely affecting urban mobility and equity. This highlights the vulnerability of centralized battery systems and the need for contingency planning and diversified supply chains.

The subsequent panel discussion broadened the focus to systemic issues in transport planning. Panelists emphasized the need to move away from isolated investments toward multi-level mobility planning that simultaneously addresses citywide, regional, zonal, and neighborhood scales. They argued that many existing transport networks lack a systems perspective and fail to respond to actual travel behavior. Embedding accessibility indicators into planning and decision-making was identified as essential to improving public transport use and inclusivity.

Another major theme was the formalization of informal transport, particularly in intercity corridors. The discussion noted that informal operators often function without adequate infrastructure or regulatory recognition, despite playing a critical role in mobility provision. Integrating these operators into the formal system—through access to terminals, depots, digital ticketing, and regulatory reform—was seen as essential for improving service quality and enabling electrification.

It was concluded that, in the absence of coordinated planning across intercity and intracity transport, India risks falling short of its fleet electrification goals for 2030 and 2047.

1.3.3. Inclusive EV Buses: Designing Public Transport for Women, Children, and the Elderly

The Session on 'Bridging Gaps for Inclusive Urban Transport Systems' provided a crucial intersectional perspective, linking electrification with gender equity and inclusive design. The transition to electric buses was identified as a strategic opportunity to redesign public transport vehicles to be more user-friendly for women, the elderly, and children. It was discussed that the Bengaluru Metropolitan Transport Corporation (BMTC) has incorporated low footboards and lowered handrails in its new electric bus fleet—design choices intended to facilitate easier boarding and alighting for women who often travel with children or carry heavy loads. Beyond the vehicle design itself, the session called for national policy frameworks, such as the FAME scheme, to incorporate specific gender clauses. This would ensure that public funds directed toward electrification also mandate safety and inclusivity standards. Furthermore, the discussion highlighted the economic potential of the EV ecosystem for women, advocating for targeted training programs that would enable women to enter the workforce as drivers and conductors of these new electric vehicles, as well as owners of electric rickshaws, thereby challenging traditional gender roles in the transport sector.

1.3.4. Towards Organized IPT: Integrating E-Rickshaws into Metro Networks

The role of Intermediate Public Transport (IPT) in the electrification landscape was another major theme. Research paper titled “Feasibility Assessment of Last Mile Connectivity Options for Metro Stations Accessibility in Dwarka Sub-city, New Delhi” presented in Technical Session 4 discussed the oversupply of e-rickshaws at metro stations in Dwarka, New Delhi. While this saturation indicates robust demand and market penetration, it also highlights regulatory fragmentation that leads to congestion and chaotic operations. Despite these challenges, e-rickshaws were recognized as a vital,

affordable, and preferred mode of transport for short distances. Thus, better infrastructure integration and fare harmonization could formalize this sector, transforming e-rickshaws from a chaotic, informal service into a robust, organized feeder system for Metro networks.

1.3.5. Enabling E-Bike-Taxi Adoption

In the Session on "Towards a Livable Bengaluru: Addressing Congestion through Connectivity and Care-driven Urban Planning," a key insight was the role of bike taxis in improving last-mile connectivity and promoting electric variants. The underlying idea is that, given the deep integration of two-wheelers into Indian mobility culture, electrifying this segment through commercial bike taxis provides a practical pathway to affordable, rapid connectivity without increasing the emissions burden. It was also discussed how fragmented state policies and union resistance limit bike-taxi adoption. The discussion concluded with policy recommendations calling for a balanced approach, including short-duration commercial authorizations and safety training, to encourage the adoption of electric bike-taxis.

1.3.6. Resilience and Usability in the Face of Climate Risks

Concerns around climate resilience emerged strongly during the session titled "Shift/Transport – From congested and vulnerable to connected and resilient." A key insight from this session concerned the usability of electric buses during urban flooding and disaster events. Indian cities are increasingly vulnerable to extreme weather, particularly flooding. Electric buses, charging depots, and electrical infrastructure are at risk of water damage, service disruptions, and safety hazards. Thus, electrification strategies must explicitly incorporate disaster preparedness, flood-resilient design, and emergency operational protocols. Without addressing these concerns, EV-based public transport systems may become unreliable precisely when resilient mobility is most critical.

1.3.7. Design, Aesthetics, and User Experience Beyond Functionality

While not directly focused on electric vehicles, two paper presentations: "Functional to Emotional: Exploring the Role of Art in Enhancing Well-Being in Singapore's MRT Stations" and "The Nexus of Urban Street Design and Human Well-Being: A Bibliometric Perspective", offered important conceptual insights relevant to EV infrastructure.

These presentations argued that transport infrastructure should move beyond purely functional considerations to incorporate emotional, aesthetic, and experiential dimensions. This perspective is highly relevant to EV charging infrastructure, particularly out-of-home charging, where users often spend significant time waiting.

The discussions prompted an important question: Can EV charging stations be designed as engaging, aesthetically pleasing, and socially meaningful spaces? Integrating art, greenery, seating, lighting, digital interfaces, or small commercial and community activities could transform charging stations from passive waiting points into positive urban spaces. Such design interventions could reduce boredom, improve perceived charging time, and enhance overall EV user satisfaction which is an aspect often overlooked in technology-centric EV policies.

By framing charging infrastructure as part of the public realm rather than mere utility hardware, cities can simultaneously improve EV adoption experiences and contribute to broader urban wellbeing goals.

1.3.8. Conclusion

Overall, the symposium emphasized that India's EV transition requires route-based planning, accessibility-focused approaches, context-sensitive vehicle design, resilient infrastructure, and a rethinking of user experience. Integrating operational efficiency with aesthetics, emotional well-being, and climate resilience will be essential to ensure that electric mobility in India is not only cleaner but also more inclusive, reliable, and human-centric.

1.4. Key Insights and Conclusions from Thematic Analysis of Consultations and External Engagements

Thematic analysis across stakeholder interviews and external engagements reveals several cross-cutting structural insights that extend beyond individual segments or institutions. While the specific discussions ranged from charging infrastructure optimization and battery chemistry to urban form and public procurement design, a coherent pattern emerges when viewed through a systems lens.

First, the EV transition in India is fundamentally a coordination challenge rather than a technology challenge. Interviews highlighted fragmented ownership across ministries, uneven sequencing between vehicle targets and infrastructure readiness, and limited structured dialogue between policymakers and industry before setting penetration goals. Similarly, research presented at CTRG-2025 demonstrated that electrification outcomes depend heavily on network design, operational planning, and charging optimization, underscoring that technical feasibility alone does not guarantee systemic efficiency. The implication is that institutional synchronization is as critical as technological advancement.

Second, charging infrastructure must be conceptualized as both a technical and a behavioral instrument. Stakeholder consultations emphasized the importance of visibility, interoperability, and right-to-charge provisions in building consumer confidence. Academic studies presented at IIT Guwahati reinforced the need for data-driven spatial optimization, vehicle-segment-specific planning norms, and integration of charging within route-level operational strategies. Discussions at IISc further expanded this framing by highlighting the role of design, aesthetics, and public-realm integration in improving user experience. Collectively, these engagements suggest that charging infrastructure is not merely a utility asset but a trust-building mechanism embedded within urban space.

Third, battery technology and certification frameworks constitute the structural backbone of long-term competitiveness. Stakeholders repeatedly stressed that domestic R&D in cell manufacturing, thermal management, and battery management systems is central to reducing costs and ensuring safety. Concerns around degradation, resale value, and end-of-life management were identified as major psychological barriers. Academic discussions reinforced the need for integrating technical performance metrics into broader system dynamics models. Without transparent certification regimes and strong quality assurance standards, perception gaps may persist even as technology improves.

Fourth, public procurement and institutional fleet electrification have emerged as decisive market stabilizers. Evidence from state-level e-bus rollouts demonstrates that aggregated demand and standardized contracting can build ecosystem confidence more effectively than fragmented retail subsidies. However, freight electrification and heavy-duty segments remain structurally under-supported, despite their high emissions intensity. This reveals a mismatch between visibility-driven passenger narratives and high-impact decarbonization opportunities.

Fifth, spatial and social differentiation is essential. Insights from smart city administrators and IISc discussions indicate that Tier-2 and Tier-3 cities face mismatches in vehicle design, limited service ecosystems, and climate resilience vulnerabilities. Electrification strategies must therefore be adapted to diverse urban morphologies rather than extrapolated from metropolitan assumptions. Similarly, civil-society perspectives emphasize that EV policy must integrate gender-responsive mobility, Non-Motorized Transport (NMT), and accessibility metrics to avoid reinforcing inequities.

Sixth, consumer perception remains a decisive tipping variable. Research presented at CTRG-2025 demonstrated that sociopsychological factors, such as risk amplification, social influence, and technological knowledge, strongly shape adoption intention. Stakeholder interviews echoed this finding, identifying safety narratives, resale insecurity, and misinformation as persistent barriers. This convergence across empirical research and practitioner insight suggests that communication strategy is not peripheral but central to scaling adoption.

Beyond descriptive documentation, the insights gathered through interviews and external engagements carry immediate policy relevance. The consultations indicate that incremental adjustments within isolated policy instruments, whether subsidy recalibration, charging targets, or manufacturing incentives, will be insufficient to trigger sustained acceleration. Instead, the transition demands coordinated policy sequencing, clearer institutional ownership, differentiated segment-level strategies, and structured mechanisms for industry–government dialogue. The evidence suggests that policy effectiveness will depend less on the magnitude of individual schemes and more on the coherence across ministries, the predictability of regulatory signals, and the alignment between infrastructure rollout and market readiness. In this sense, the consultations point toward governance recalibration rather than a technology recalibration.

These findings also directly reinforce the Theory of Change framework articulated in Chapter 1. The interviews and conference insights reveal that EV adoption does not scale linearly with single interventions; rather, it responds to reinforcing feedback loops across demand confidence, infrastructure visibility, industrial investment, and institutional credibility. Institutional coordination strengthens infrastructure deployment; visible infrastructure reduces consumers' risk perception; improved demand signals justify OEM investment; aggregated procurement stabilizes manufacturing; battery certification enhances trust; and trust feeds back into accelerating adoption. Conversely, misalignment in any one domain can weaken the entire chain. The consultations, therefore, empirically validate the central premise of this study: that India’s EV tipping point will emerge only when technical, financial, institutional, and behavioral subsystems are synchronized through deliberate, sequenced policy design.

Taken together, these thematic insights indicate that India’s EV transition is neither stalled nor guaranteed. The ecosystem exhibits strong ambition, structured OEM participation, emerging depth in R&D, and institutional procurement momentum. However, tipping dynamics will depend on the

alignment of technical, institutional, financial, spatial, and behavioral subsystems. Fragmented progress within isolated domains will not suffice.

Credits

Sandip Chakrabarti: Conceptualization, Methodology, Resources, Supervision, Project administration, Funding acquisition. **Anish Sugathan**: Conceptualization, Methodology, Resources, Supervision, Project administration, Funding acquisition. **Shreya Sinha**: Writing - Review & Editing. **Shriyash Puranik**: Formal analysis, Investigation, Writing - Original Draft, Writing - Review & Editing. **Jayanth Kumar Narsim**: Formal analysis, Investigation, Writing - Original Draft. **Sagar Verma**: Formal analysis, Investigation, Writing - Original Draft. **Satya Andani**: Writing - Review & Editing.

Chapter 13

Takeaways from the Stakeholder Workshops

Chapter Summary

Content:

1. Two multi-stakeholder workshops (September 2025 and May 2026) brought together policymakers, OEMs, fleet operators, and researchers to bridge the gap between research and implementation.
2. Discussions covered infrastructure, manufacturing, financing, charging ecosystems, and sector-specific EV adoption pathways.

Findings:

1. Execution and coordination gaps remain the primary barriers to EV scale-up.
2. Consumer concerns are shifting from range anxiety to battery health, resale value, and long-term ownership confidence.

Takeaways:

1. Accelerating adoption requires stronger execution architecture, improved institutional coordination, demand aggregation, and scalable business models such as leasing and Battery-as-a-Service (BaaS).
2. Long-term transition will depend on supply-side reforms, including domestic manufacturing capabilities, lifecycle management, workforce development, Right to Repair provisions, and stronger regulatory signals such as ZEV mandates and tighter CAFE standards.

1. Introduction

This chapter bridges the study's analytical findings with the practical realities of India's automotive ecosystem by synthesizing insights from two high-level, multi-stakeholder workshops. Designed to move the discussion beyond the technological feasibility of electric mobility toward questions of implementation, these forums brought together policymakers, industry leaders, researchers, mobility operators, and other ecosystem stakeholders. Their perspectives enabled the research team to test emerging findings against real-world operational, institutional, and market conditions.

The first workshop, *Accelerating Electric Vehicle Adoption in India* (September 12, 2025), served as an exploratory foundation for the study. Discussions focused on identifying barriers to EV adoption across production, consumption, infrastructure, and policy domains. Participants emphasized that electrification represents a broader systems transition requiring institutional coordination, financial innovation, and behavioral change. Key challenges highlighted included the interdependence of charging infrastructure and vehicle demand, as well as adoption barriers faced by fleet operators and commercial users.

The second workshop, *Driving India's EV Tipping Point: Strategies to Accelerate Transition* (May 18, 2026), served as the study's validation and synthesis stage. Participants from government, industry, and research institutions engaged with the study's findings and examined pathways for accelerating the transition from policy-driven adoption to a self-sustaining, market-led EV ecosystem. Discussions focused on the institutional, technological, financial, and behavioral interventions required to reach a durable tipping point.

The following sections summarize key takeaways from both workshops

2. First Workshop: Stakeholder Consultation

On September 12, 2025, the Centre for Transportation and Logistics (CTL), IIMA, and the Centre for Sustainability and Corporate Governance (CSCG), IIMA, jointly organized a workshop on "Accelerating Electric Vehicle Adoption in India." The event brought together experts from diverse domains, including academia, government organizations, fleet operators, e-commerce, and industry, to discuss the challenges and prospects of India's e-mobility transition. The program featured welcome addresses by the organizers, followed by a keynote lecture, two invited talks, and a panel discussion. The workshop was moderated by Prof. Sandip Chakrabarti, JSW Chair in Innovation and Public Policy at IIMA, and Prof. Anish Sugathan, Chair of the Centre for Sustainability and Corporate Governance Research at IIMA. Participants included students, researchers, and faculty members from both within and outside IIMA. Each session concluded with interactive Q&A, giving participants the opportunity to engage directly with the speakers.

In his welcome address, Prof. Sandip Chakrabarti emphasized that the workshop should serve as a platform for insightful conversations, encouraging diverse perspectives on the barriers and opportunities to faster EV adoption in the Indian automobile market. He highlighted that the workshop's key objective is not only to facilitate academic research but also to inform policymaking. The broader aim is to produce impactful academic publications, practitioner briefs, policy insights, and

other outputs that can be disseminated more widely across public and private sectors, both in India and globally. He further noted that discussions on India's e-mobility transition are no longer limited to isolated elements of the EV ecosystem, such as vehicle manufacturing or charging infrastructure. Instead, they are concerned about the whole ecosystem. For this reason, the workshop convened experts from both the public and private sectors - spanning production, consumption, and policymaking - to establish a dialogue among key actors on challenges, opportunities, and new ideas, with the potential to inform both academic research and policy debates.

Prof. Anish Sugathan opened the workshop by outlining its objective: a focused discussion to generate ideas, critiques, and insights on India's EV transition. The transition to EVs, he noted, is inevitable. Drawing on historical parallels, he explained that just as Model T rendered animal-powered transport obsolete, the efficiency gains of electric vehicles make the shift unavoidable. He stressed the role of policy direction, investments, and consumer choices in shaping the speed of change. While the "why" of the EV transition is clear, the "how, where, and when" require collective exploration.

In his closing remarks, Prof. Sugathan framed the workshop as an opportunity to bring together diverse perspectives to move India from its current equilibrium towards a more sustainable one, remarking that while the future cannot be predicted, it can be shaped through collective effort.

2.1. Keynote Speech

2.1.1. Mr. J. P. Gupta, IAS (Retd.), Former Additional Chief Secretary (Finance), Government of Gujarat

In his keynote speech, Mr. J. P. Gupta addressed several important themes related to India's transition from Internal Combustion Engine (ICE) vehicles to EVs, as well as the broader dynamics of this shift. He began by underscoring mobility's critical role in enabling development, noting that key aspects of human progress, such as health and education, depend heavily on it. Against the backdrop of increasing demand for mobility infrastructure in both rural and urban settings, on the one hand, and mounting environmental challenges, on the other, the policy paradigm has shifted toward e-mobility solutions. This transition is evident not only in the four-wheeler market but also across other modes of urban transport, including two-wheelers, three-wheelers, and public buses.

Mr. Gupta also highlighted the familiar chicken-and-egg dilemma of sequencing in the EV transition: should policymakers prioritize investments in charging infrastructure to encourage adoption, or should adoption be accelerated first through subsidies and innovative marketing strategies, thereby generating natural demand for infrastructure?

He also emphasized the parallel energy transition in the power sector, especially the growth of solar energy. Gujarat's renewable capacity already exceeds peak demand, but variability and lack of storage remain constraints. He posed a paradigm-shifting question: "Can electric vehicles be equipped to store solar energy during peak generation hours, thereby acting as virtual energy storage devices?"

His speech also yielded several policy recommendations. These included: scaling up solar power generation, creating adequate transmission systems, adopting time-of-use pricing policies for solar energy use, improving battery technologies to enhance storage capacity, and integrating solar power

generation with both battery-swapping services and (public and private) charging infrastructure. He reiterated that since the battery is the defining feature of an EV, continuous technological improvements in battery capacity and performance are critical. Furthermore, given that solar power generation peaks during daylight hours, it is impractical to expect all vehicles to charge during that period. In this context, battery-swapping, if standardized, could simultaneously align the needs of consumers, the grid, solar integration, and charging infrastructure, offering a comprehensive solution.

2.2. Invited Talks

2.2.1. Mr. Anil Kumar Choudhary, Chief General Manager & Head – Operations, Energy Efficiency Services Ltd. (EESL), Government of India

In his talk, Mr. Anil Kumar Choudhary highlighted the role of government agencies in accelerating EV adoption through innovative business models. He began by highlighting the role of Energy Efficiency Services Limited (EESL). This nodal government agency has played a pivotal role in India's transition toward sustainable energy alternatives, spanning street lighting initiatives to e-mobility. After briefly outlining EESL's historical contributions to sustainable energy transitions in the country, Mr. Choudhary emphasized the importance of demand aggregation as a foundation for sustainable business strategies to promote EV adoption. Drawing on examples from the adoption of EVs across government departments, he explained how EESL invests in EVs and charging infrastructure, much like its earlier LED lighting initiatives: by creating demonstration projects that catalyze wider adoption.

Since one of the central strategies of both the Union and State Governments has been to integrate more EVs into government departments, EESL has played a strategic role in managing the demand–supply mechanism across India. Mr. Choudhary identified three key functions that EESL performs in this regard: (i) procuring EVs from manufacturers, (ii) signing contracts with central and state government organizations and their associated bodies, and (iii) identifying suitable locations for charging infrastructure. In this way, EESL effectively bridges the gap between vehicle manufacturers and government clients. He further noted that EESL facilitates connections between service providers (for maintenance and repair) and client organizations.

A major insight from his talk was the potential of innovative business models to make EV procurement more financially viable for government organizations and other clients. He argued that, instead of procuring EVs directly from Original Equipment Manufacturers (OEMs) through traditional tendering, vehicles could be leased through agencies under an open tendering system. Such a model would offer multiple benefits across the demand–supply chain, including minimizing the need for recurring tender processes, reducing or eliminating upfront investment, and addressing management and maintenance concerns through leasing agencies.

2.2.2. Mr. Suveer Sahdev, Lead, EV & Strategic Supply, Uber India

In this talk, Mr. Suveer Sahdev shared substantial insights into the real-world business models of fleet-operating companies on incorporating EVs into fleet operations, focusing primarily on Uber in India.

The central theme of his talk was the major challenges fleet operators face in adopting EVs and potential solutions to them. To begin with, he highlighted three key challenges that fleet operators (in

this case, Uber) face in integrating EVs into their business model: vehicle access, asset financing, and charging infrastructure.

The challenge of vehicle access is directly linked to the limited availability of car models in the base-category EV segment. Most OEMs currently offer EVs only in premium categories, and even the base models are priced higher than ICE vehicles. In the commercial fleet sector, as Mr. Sahdev emphasized, vehicles are typically low-cost, base models. Individual drivers whose livelihoods depend on fleet operations cannot afford premium vehicles. Consequently, the absence of affordable EV models poses a major constraint to commercial fleet electrification.

The second challenge, as underscored by Mr. Sahdev, concerns asset financing, stemming from a lack of appropriate loan structures for commercial buyers. On the one hand, higher upfront costs and, on the other, lower resale values make it imperative that buyers have access to suitable financing, such as low-interest loans. However, the absence of such mechanisms creates significant barriers to EV adoption.

The third and final challenge pertains to charging infrastructure and charging time. Mr. Sahdev pointed out a highly relevant and practical issue: every additional hour a commercial fleet driver spends charging the vehicle translates into an hour of lost earnings. Moreover, he noted that charging infrastructure continues to face significant challenges, particularly in coordinating among multiple agencies. He highlighted that securing suitable land at viable prices is a major bottleneck, and without optimal location and adequate demand volumes, the economics of charging stations cannot be sustained.

These challenges do not act in isolation; they cumulatively impact decision-making. Against this backdrop, however, Mr. Sahdev outlined several potential and ongoing solutions - several already piloted by Uber - to facilitate EV adoption in commercial fleets. For instance, Uber is developing robust tech systems that can continuously inform EV drivers about battery status and nearby charging stations. Additionally, these systems filter trip notifications so that if a vehicle's battery level falls below a certain threshold, the driver receives only trip requests that end near a charging facility. This mechanism will help alleviate range anxiety among drivers.

He also highlighted Uber's development of an Electric Vehicle Infrastructure Estimator Tool, which uses global demand data to predict charging needs. The tool can estimate charging load, the number of required chargers, their capacities, locations, timing, and hourly utilization. He noted that improving utilization is one of the biggest challenges for Charging Point Operators, and the organization is working with both CPOs and state governments to address this.

2.3. Panel Discussion on "Future Landscape of Electric Vehicles in India towards achieving Net-Zero Emission."

The final event of the workshop was a panel discussion featuring four experts from diverse fields who shared insights into the future landscape of EV adoption in India, including the associated challenges and opportunities.

2.3.1. Dr. Ranga Srinivas Gunti

General Manager, Capacity Building at Tata Motors

The panel discussion began with a talk by Dr. Ranga Srinivas Gunti, who shared his expertise and experience in capacity building and EV manufacturing. He began by emphasizing that achieving e-mobility is a collective task to be addressed jointly by governments, OEMs, and customers, with each required to play their respective roles.

On the government side, Dr. Gunti highlighted that the new central GST tax rates will help lower the overall cost of vehicles.

From the perspective of OEMs and governments together, he underscored the importance of research and development, particularly in areas such as Cell Chemistry, which can enhance battery capacity, reduce battery weight, and, most importantly, lower costs. Since batteries are the most critical component of EVs, reducing their cost would significantly lower overall vehicle cost.

From the user side, he stressed the importance of optimizing driver behavior. He noted that their research has demonstrated that the driving range at the urban scale can vary by 50-60 km among different drivers of the same electric vehicle. He explained ongoing research to optimize performance by analyzing telematics data and developing algorithms that provide customized recommendations to individual drivers over time. Such systems could eventually adapt control settings to improve both range and driving experience. He further emphasized that the indigenization of batteries and the scaling up of domestic manufacturing in India are critical for the EV transition and noted that next-generation EVs demand new expertise, making it necessary to strengthen skilling not only in service and maintenance but also within dealership networks.

During the Q&A session, Dr. Gunti was asked about the possible role of OEMs (in this case, Tata Motors) in promoting driver behavior optimization. He stated that OEMs are working to integrate both instruction-based and constraint-based algorithms into vehicle systems. While instruction-based algorithms may provide drivers with softer guidance regarding optimal vehicle use, constraint-based algorithms can directly assist drivers by regulating vehicle speed and other driving parameters in accordance with prevailing conditions (e.g., traffic congestion, slopes, or freeways).

2.3.2. Mr. Awadhesh Kumar Jha

Executive Director, GLIDA India

Mr. Awadhesh Kumar Jha highlighted three key themes: the shortage of skilled human resources in automobile dealerships, particularly in sales; the disconnect between elite-level discourse on EVs and the actual transition unfolding on the ground; and the limitations of battery-swapping services for four-wheelers, especially for private vehicles.

The first theme drew on Mr. Jha's personal experience of purchasing an EV and visiting several dealerships across Indian cities. He noted that, since the EV sales process takes place in dealerships, sales professionals must be adequately trained to build customer confidence, particularly as electric cars are still relatively new to the market. Sales teams need to possess deeper technical knowledge - not just of battery range and charging time, but also of vehicle components and driving-related technicalities. He observed that much remains to be done in this regard.

The second theme concerned the prevailing disconnect between discussions among the elite sphere - academics, policymakers, sections of industry, and corporate bodies - and the ground-level reality of EV transition. Mr. Jha emphasized that, for the average Indian, EVs are most closely associated with two- and three-wheelers. This is not incidental, as the largest EV penetration has occurred in these two segments.

The third theme concerned the growing advocacy for battery swapping as a feasible pathway to accelerate EV adoption. Mr. Jha underlined that while battery-swapping is indeed viable and efficient for two- and three-wheelers and public buses, its applicability to four-wheelers is challenging. In the Indian context, where cars carry high social value and involve substantial financial investment, frequent battery replacement without adequate quality assurance may cause consumer hesitation. Additionally, the lack of battery standardization across OEMs poses further complications. As such, a uniform, one-size-fits-all approach may not be effective in this domain.

During the Q&A, Mr. Jha was asked why India finds it challenging to adopt the battery-swapping mechanism for four-wheelers, even as several other developing countries are moving in this direction, and whether the difficulty is due to the high cost of such ventures. He prudently noted that cost is a secondary issue and that the principal obstacle lies with OEMs regarding battery standardization. At present, numerous OEMs are producing electric four-wheelers, each with its own battery standards. While standardization is not impossible, aligning their interests and persuading them to adopt common standards could limit their ability to offer differentiated options based on speed and range.

2.3.3. Mr. Dippy Vankani

Director - Government Affairs (South & West Region), M/s. Flipkart Internet Pvt. Ltd.

Mr. Dippy Vankani, drawing on his extensive experience in corporate bodies and the e-commerce sector, shared with the audience the trajectory of EV adoption at Flipkart and the business model behind it. He underlined that in e-commerce, there is substantial potential for faster EV adoption, as the entire business depends on automobiles, predominantly two- and three-wheelers. In this context, he noted that Flipkart has incorporated nearly 13,300 EVs (two- and three-wheelers combined) into its product-delivery operations. This, in turn, reduces the financial burden on delivery partners, as EVs' operational costs are lower than those of ICE vehicles.

At the same time, Mr. Vankani pointed out several challenges. The foremost concern relates to charging infrastructure and battery-swapping services. Given the high daily vehicle usage of delivery partners, even in urban areas, the lack of adequate charging infrastructure, long charging times, and limited availability of battery-swapping facilities may pose significant barriers. A further issue is the high upfront cost of EVs and the lack of adequate financial support. He emphasized that insufficient financing from banks and other institutions often discourages delivery partners from purchasing EVs.

During the Q&A session, when asked about the challenges Flipkart faced in adopting EVs, Mr. Vankani remarked that the company does not view the e-mobility transition as a burden, but rather as a civic responsibility that every corporate body should recognize.

2.3.4. Mr. Saurabh Gupta

Partner, KPMG in India, Energy and Infrastructure Practice

Mr. Saurabh Gupta began his talk by emphasizing the importance of transition, particularly in cities with worsening air pollution. While valid concerns remain about emissions from an unclean grid, he argued that centralized emissions from power plants are far easier to capture and manage than dispersed vehicular pollution in cities.

He also drew attention to areas that have been relatively neglected or under-studied, namely freight trucks and vehicles used in agricultural production, such as (e-)tractors. Turning to freight, he noted that trucks make up only around 2–3% of vehicles but account for nearly 45% of emissions. On the agricultural side, he noted that the tractor market is predominantly rental-driven, with many farmers accessing vehicles through custom-hiring centers established to promote mechanization. He suggested that incentivizing this model could help integrate electric tractors into the mainstream. He also highlighted municipalities as another potential demand cluster for electric tractors.

In a structured manner, he divided the EV adoption process across the passenger vehicle, agricultural, and road-based freight transportation sectors into five interrelated components: adoption, deployment, infrastructure, finance, and innovation.

On adoption, he offered a different perspective by pointing to mandates - legislative measures through which governments can require manufacturers to produce EVs as a fixed proportion of their overall vehicle production. Similar requirements, he noted, can be extended to franchised dealerships regarding sales.

During deployment, Mr. Gupta emphasized the importance of demand aggregation and recommended focusing on sectors where it is feasible, such as agriculture and freight transportation. He also highlighted the significance of the Battery-as-a-Service model and the potential of start-up companies to advance it.

On infrastructure, he drew attention to two challenges: the limited or inadequate availability of charging stations at suitable locations, which contributes to “range anxiety,” and the nonfunctional state of many existing stations, which, as he termed, translates into “charge anxiety.”

On finance, he discussed the role of constructive taxation (particularly GST) in reducing the upfront cost of EVs and the cost of electricity supplied to public charging stations. At present, taxation makes public charging more expensive than home charging, thereby increasing EVs' operational costs and discouraging users from relying on public charging stations. He emphasized the role of demand aggregation, particularly through large PSUs such as Coal India, mining operations, and ports, which represent ready customers with significant potential.

On the policy front, he highlighted that India’s EV transition has so far leaned heavily on pull strategies. To accelerate adoption, he suggested complementing these with push measures. On the demand side, he cited Delhi’s aggregator policy, which mandates the full electrification of two-, three-, and four-wheelers, as well as small trucks, by 2030, with clear targets and penalties. On the supply side, he called for mandates requiring OEMs to sell a fixed share of EVs, similar to California's model.

Finally, he emphasized the role of innovation in battery technology, business models, and related domains - to make EVs more efficient, user-friendly, and widely accessible. He argued that beyond passenger vehicles, if EVs are to be successfully adopted in the agricultural and freight transport sectors, innovation in both vehicle technology and business models will be decisive.

Concluding his remarks, he stressed that success cannot come from just one stakeholder in the room; a whole-systems approach is needed.

2.4. Conclusion

The day-long workshop on “Accelerating Electric Vehicle Adoption in India” yielded several valuable insights on multiple fronts. Firstly, it highlighted that the electrification of India's mobility system is essentially a collective endeavor that requires not only goodwill and strategic government intervention (on the policy side) but also sustained support from OEMs, dealerships, private organizations, fleet operators, and individual vehicle buyers. Second, the workshop opened avenues for fresh discussions and research on integrating sustainable energy sources -particularly solar energy (given the tropical nature of the Indian climate) - into the ongoing EV transition. Third, it served as an open forum that enabled multiple actors along the demand–supply chain, such as e-commerce organizations and fleet operators, to freely articulate the challenges they have encountered while pursuing electrification. It appeared that, apart from the commonly cited challenges and barriers to EV adoption faced by individual vehicle buyers for private use, e-commerce companies and fleet operators also face distinct challenges in adopting EVs as a business strategy. Fourth, it underlined that India’s journey towards e-mobility cannot be based solely on the production, marketing, and adoption of four-wheeler EVs, as has been the case in many European nations. India remains predominantly a country of two-wheelers and para-transits (three-wheelers), with relatively low car ownership. Additionally, with more than 60% of the population residing in rural areas, the agricultural sector may hold huge potential. Therefore, research, development, academic discussions, and policymaking on EV transition must take these idiosyncrasies into account. Lastly, it reaffirmed the question raised at the beginning by both professors, who observed that discussions on India’s e-mobility transition now concern the policy-production-supply-adoption ecosystem as a whole, and that it is not a question of if India will adopt EVs, but when and how quickly and effectively the transition will take place.

3. Second Workshop: Presentation of Research Findings

The second multi-stakeholder workshop, “Driving India’s EV Tipping Point: Strategies to Accelerate Transition,” held on 18th May 2026, served as the study’s platform for validation and synthesis. Bringing together policymakers, industry leaders, researchers, and practitioners, the workshop focused on translating research findings into actionable strategies for accelerating India’s transition from policy-driven EV adoption to a self-sustaining, market-led ecosystem.

A central theme emerging from the discussions was that India’s EV transition is no longer constrained by technology readiness but by coordination among institutions, markets, and value chain actors. Participants emphasized that electrification represents a broader systems transformation requiring alignment across policy, industry, finance, infrastructure, and consumer ecosystems.

Policy and Institutional Coordination

Ms. Archana Mittal (NITI Aayog) highlighted the need for stronger institutional coordination across the multiple ministries and agencies involved in the EV ecosystem, describing NITI Aayog as a necessary "silo-buster" capable of aligning fragmented policy efforts. While EV sales continue to grow, she pointed to persistent structural challenges, particularly the low utilization of charging infrastructure. With charger utilization rates remaining below 2%, compared to the 4–6% typically required for commercial viability, she emphasized the need for coordinated interventions that can simultaneously stimulate both vehicle adoption and charging demand.

Industry Transformation and Manufacturing Challenges

Industry participants underscored the scale of disruption underway. Shri SJR Kutty (Tata Motors) characterized EVs as "MacBooks on wheels," arguing that the sector is undergoing a fundamental transformation rather than a simple technological transition. He highlighted the growing importance of software-defined and connected vehicles, which could significantly improve safety by reducing information asymmetries between vehicles and road users. He also emphasized the importance of Extended Producer Responsibility (EPR) frameworks to ensure sustainable battery recycling and end-of-life management.

From the component manufacturing perspective, Shri Rama Shankar Pandey (ACMA) highlighted the challenges faced by Tier-2 and Tier-3 suppliers in accessing capital for research and development investments. He further advocated for stronger "Right to Repair" provisions that would allow independent service providers access to OEM diagnostic systems, thereby preventing excessive concentration of after-sales service capabilities.

Consumer Adoption and Market Readiness

The IIMA research team presented findings from their research, including expert interviews and consumer surveys, revealing a significant gap between consumer awareness and adoption. While familiarity with EVs has increased substantially, participants noted that traditional "range anxiety" is increasingly being replaced by "information anxiety," driven by uncertainty regarding battery degradation, resale value, and long-term ownership costs. The workshop also highlighted a "dealer motivation dilemma," whereby EV sales often require substantially longer customer engagement while generating lower margins for dealerships than conventional internal combustion engine vehicles.

Industry representatives discussed efforts to address these concerns through ecosystem-building initiatives. Ms. Neha Jain (JSW MG Motor India) outlined the company's "6 Es" framework—Ecosystem, Energy, Excitement, Employment, Education, and Equity—as a holistic approach to accelerating adoption. She also highlighted initiatives aimed at reducing consumer uncertainty, including integrated charging platforms and localized battery manufacturing efforts.

Infrastructure, Supply Chains, and Technology Development

Discussions emphasized that infrastructure deployment and supply-chain resilience remain critical enablers of large-scale EV adoption. Shri Rishabh Sethi (Energiva Ventures) highlighted the strategic risks associated with critical mineral supply chains, noting that key battery minerals are often more geographically concentrated than oil resources. He stressed the importance of maintaining adequate

charger-to-vehicle ratios and improving charger uptime and reliability to support consumer confidence.

Shri Suraj Kant (EESL) shared implementation experiences from public-sector EV deployments, noting that visible government adoption can play an important role in increasing consumer confidence. He also identified procedural delays in obtaining high-capacity electricity connections as a major bottleneck for fast-charging infrastructure deployment.

Shri IV Rao (TERI) emphasized the importance of adopting a life-cycle perspective toward EV sustainability. Rather than relying exclusively on imported battery technologies, he advocated for cell designs and battery systems optimized for Indian climatic, operational, and usage conditions.

Financing and Market Acceleration

Participants also examined the policy and financial mechanisms required to move the sector toward a self-sustaining growth trajectory. Shri Amit Bhatt (ICCT) argued that long-term market transformation cannot depend solely on consumer subsidies and instead requires stronger supply-side regulations. Measures such as Zero-Emission Vehicle (ZEV) mandates and progressively stricter Corporate Average Fuel Efficiency (CAFE) standards, he argued, would create predictable market signals and incentivize manufacturers to innovate and scale production.

Shri Dippy Vankani (Flipkart) highlighted the potential of EVs to create new livelihood opportunities through platform-based employment models. Drawing on Flipkart's "Project Sakhi," he described how women have been successfully integrated into hyperlocal delivery networks using EVs. He further emphasized the need for financing frameworks that evaluate borrowers based on income-generating potential rather than relying exclusively on conventional credit metrics.

Collectively, the workshop reinforced the study's conclusion that reaching an EV tipping point will require coordinated interventions across policy, infrastructure, manufacturing, finance, and consumer ecosystems. The discussions demonstrated that the challenge is no longer whether EV adoption will occur, but how effectively stakeholders can align incentives and institutions to accelerate the transition.

3.1. Synthesis of Observations and Expert Experiences

To provide a clear overview of the insights shared during the proceedings, the following tables categorize expert observations by Use Case and Value Chain segment. These summaries highlight the specific "friction points" identified by external experts and their recommendations for systemic reform, focusing strictly on industry and policy feedback.

Table 1: Use-Case Wise Summary of Stakeholder Observations

Use Case	Observations & Expert Experiences
Private Two-Wheelers (e-2W)	Safety risks: Low-speed electric vehicles (under 25 km/hr) are surging in popularity because they require no license or registration, making them "immune" to traffic fines; however, riders often manipulate them to reach 40 km/hr, creating safety risks.

	Motorcycle Gap: Current adoption is limited to scooters (approximately 30% of the market); for mass penetration, the industry must electrify the remaining 70% of the motorcycle segment.
Private Four-Wheelers (e-4W)	Primary vs. Secondary Vehicle: Most owners currently treat EVs as secondary vehicles for local commutes; to become "primary" vehicles, intercity reliability and unified charging apps are essential. Resale Assurance: Industry players are introducing "buy-back" programs (e.g., a 60% resale value after 3 years) to alleviate consumer anxiety about the asset's long-term value.
Commercial & Logistics (Gig Economy)	Lending Reform: Traditional CIBIL scores do not work for gig workers; lenders should instead evaluate "potential income generation" based on the EV's low operational costs. Project Sakhi (Flipkart): Delivery pilots are successfully engaging housewives for hyperlocal delivery during afternoon "gap" hours (2 PM–5 PM), as e-2Ws offer better ease of driving for women.
Buses & Public Transport	Interoperability Choke-points: In current Gross Cost Contract (GCC) models, different operators cannot share charging infrastructure even within the same depot, leading to massive inefficiencies. Private Fleet Neglect: While government buses are subsidized, they account for only 5–6% of the fleet; the remaining 94% of private buses currently lack a viable financing ecosystem.
Freight	The 3% Paradox: Trucks account for only 3% of the vehicle population but nearly 50% of transport emissions. Operating Cost Asymmetry: Transitioning a diesel truck to electric can shift operating costs from ₹10/km to nearly ₹45/km, making "Battery-as-a-Service" (BaaS) essential to shift CAPEX to OPEX.

Table 2: Value-Chain Wise Summary of Stakeholder Observations

Value Chain Segment	Observations & Expert Experiences
R&D & Mineral Sourcing	TRL Gaps: current battery research projects (such as sodium-ion and solid-state) are largely stalled at TRL 3-5 and require a roadmap for time-bound commercialization. Critical Mineral Concentration: Minerals are more geographically concentrated than oil, making India's transition to a net-zero economy highly sensitive to geopolitical disruptions.

Manufacturing & Assembly	Tier-2 & Tier-3 Struggles: Small suppliers are technically "locked" into ICE parts and lack the capital or talent to invest in long-term EV R&D. Inclusivity in Production: Modern EV assembly lines at MG Motors are managed by 100% women workforces through ergonomic design changes that reduce the need for traditional "male-dominated," power-oriented tasks.
Charging Infrastructure	Low Utilization Paradox: While the US sees 12–18% utilization, Indian chargers are at less than 2%, suggesting that deployment is driven more by symbolic numeric targets than by actual demand-led siting. Procedural Delays: High-power grid connections (>100kW) face severe delays and heavy security deposits that lock up operator capital.
After-Sales & Skilling	The 5-Million Gap: India will require 5 million EV technicians by 2030, but there is currently a massive gap between academic output and industry-ready skills. Right to Repair: Independent garages (around 3 lakh nationwide) must be granted access to OEM diagnostic data to prevent a service monopoly and ensure affordable maintenance for consumers.
Ownership & Lifecycle	Information Anxiety: Consumers are less worried about physical range and more about "information anxiety"—specifically battery health after 5 years and the lack of a standardized resale market. Visible Adoption: Public confidence increases significantly when the government leads by example, such as the visible deployment of EVs in state department fleets.
Recycling & End-of-Life	Black Mass Processing: India currently lacks the advanced industrial processing required to extract valuable minerals from "black mass" (recycled battery powder). EPR Mandate: Extended Producer Responsibility (EPR) is the right approach to hold large OEMs accountable for the full lifecycle and safe disposal of batteries.

4. Conclusion

The multi-stakeholder consultations confirmed that India’s EV transition has moved beyond questions of feasibility and into the challenge of execution. Achieving a self-sustaining tipping point will require shifting from a policy-driven push to a market-led pull built on ecosystem trust.

A key consensus was that institutional coordination remains a major constraint. Stakeholders highlighted fragmented governance, low charger utilization, and procedural barriers to infrastructure deployment, underscoring the need for stronger cross-sector coordination and streamlined implementation mechanisms.

Participants also emphasized the importance of addressing the diverse needs of different vehicle segments. Priorities include closing the motorcycle adoption gap, improving transparency into battery health and resale confidence for private vehicle owners, expanding financing options for bus operators, and supporting Tier-2 and Tier-3 suppliers as they transition from ICE-dependent business models. The discussions also reinforced the study's finding that consumer concerns are shifting from range anxiety to information anxiety, particularly around battery life, resale value, and long-term ownership risks. Addressing these concerns through greater transparency, financial de-risking, and supportive supply-side policies will be critical to accelerating adoption.

Ultimately, stakeholders agreed that India's EV tipping point will depend on coordinated action across government, industry, and finance to create the confidence, infrastructure, and market conditions necessary for a durable transition.

Credits:

Sandip Chakrabarti: Conceptualization, Methodology, Resources, Supervision, Project administration, Funding acquisition. **Anish Sugathan**: Conceptualization, Methodology, Resources, Supervision, Project administration, Funding acquisition. **Shreya Sinha**: Data Curation, Writing - Original Draft, Writing - Review & Editing. **Shriyash Puranik**: Writing - Review & Editing, Project administration. **Aditya Saxena**: Data Curation, Writing - Original Draft. **Medhaa Priya:** Data Curation, Writing - Original Draft. **Manuchandran Nair**: Data Curation, Writing - Original Draft. **Sagar Verma:** Data Curation, Writing - Original Draft. **Iman Banerjee**: Data Curation, Writing - Original Draft. **Subodh Patrikar**: Resources, Project administration. **Satya Andani**: Writing - Review & Editing.

Chapter 14

Summarizing Policy Pathways and Strategic Interventions

Chapter Summary

Content:

1. Synthesizes evidence across the EV value chain, linking battery R&D, manufacturing, charging infrastructure, dealership dynamics, consumer behavior, and recycling into a unified policy narrative.
2. Compares adoption barriers across segments, including private vehicles, shared mobility, commercial fleets, and buses, to highlight variation in constraints and use-case dynamics.

Findings:

1. The transition is constrained by interconnected gaps in domestic manufacturing, infrastructure reliability, financing, and institutional coordination, limiting large-scale adoption.
2. Across segments, key barriers include high upfront costs, charging and information gaps, battery and resale uncertainty, and weak service and financing ecosystems.

Takeaways:

1. Policy must shift toward lifecycle support through R&D investment, realistic localization norms, financing innovation, and secure revenue mechanisms for fleets and public transport.
2. Scalable adoption requires demand-led infrastructure planning, transparent battery standards, decentralized service networks, and stronger institutional coordination.

1. Introduction

Based on the 2025 McKinsey Mobility Consumer Pulse Survey, covering ~19,500 respondents across six major markets, the transition to electric mobility has entered a global "market twist," where early rapid growth is giving way to divergent regional adoption and shifting consumer sentiment. While markets like China have shifted from a regulatory push to a consumer-driven pull, with over 80% of buyers intending their next vehicle to be electric, Western and emerging markets face a more uncertain path. As this report highlights, the resulting "crisis of confidence" is not unique to India but reflects a broader global challenge: aligning regulation, infrastructure maturity, and technology evolution with evolving consumer expectations.

Consumer hesitation remains anchored in three persistent concerns: range, price, and charging infrastructure. Non-owners tend to focus on infrequent "edge cases," such as long-distance travel, rather than everyday usage, which pushes the perceived acceptable range to around 500 km. At the same time, nearly 35% of consumers are unwilling to switch until EVs reach upfront price parity with internal combustion engine (ICE) vehicles, prioritizing purchase cost over long-term total cost of ownership (TCO) benefits. This reinforces our earlier findings that for the next phase of adoption to succeed, stakeholders must move beyond abstract financial incentives and toward transparent, lifecycle-based value propositions.

Despite these entry barriers, strong "stickiness" emerges post-adoption. Fewer than 10% of battery electric vehicle (BEV) owners indicate a desire to return to ICE vehicles. This highlights a divide between continuers, who value driving performance and digital features, and non-adopters, who remain constrained by information gaps around charging access and battery life. Addressing this requires an omnichannel approach that combines digital transparency with experiential confidence-building measures, such as extended test drives and home-charging support, to ensure adoption is both initiated and sustained.[*] (McKinsey & Company, 2025)

2. Synthesis of the Report

2.1. Systemic Bottlenecks and Strategic Shifts in the EV Value Chain

This section synthesizes the structural bottlenecks across the electric vehicle (EV) value chain in India, spanning upstream R&D to end-of-life systems. Rather than treating these as isolated inefficiencies, the table frames them as interdependent constraints that collectively slow ecosystem maturation. For each value chain stage, we identify the core problem, outline the required strategic shift, and map the institutional actors responsible for execution. This systems-level view highlights that EV adoption is not

[*] McKinsey & Company. (2025). *New twists in the electric-vehicle transition: A consumer perspective.* Retrieved from https://www.mckinsey.com/features/mckinsey-center-for-future-mobility/our-insights/new-twists-in-the-electric-vehicle-transition-a-consumer-perspective#/

constrained by a single “missing piece,” but by coordination failures across technology development, manufacturing economics, infrastructure deployment, and lifecycle management.

Value Chain Category	What is the Problem?	What Must Change?	Who Needs to Act?
Battery Manufacture & R&D	High import dependence (~70%) for cells and precursors. A gap exists for TRL 4-6 technologies (e.g., Sodium-ion, Zinc-air) due to a lack of pre-commercial grant funding.	Shift from unit-sale subsidies to R&D grants for lab-to-pilot scale-up. Establish a "Final System Integrator" to own interfaces across materials and cells.	Central Govt (MHI/DST), Academic Consortia.
Vehicle Manufacturing & Assembly	EVs are priced ₹4–5 lakh (cars) to ₹80 lakh (buses) higher than their ICE equivalents. Rigid 50% Domestic Value Addition (DVA) norms under PLI schemes are currently unrealistic for high-value technologies such as magnets and cells.	Recalibrate DVA norms pragmatically to exclude high-tech components until local alternatives mature. Focus on "de-over-designing" to reduce the bill of materials.	OEMs, Ministry of Heavy Industries.
Charging Infra & Energy Supply	Top-down PSU-led models have resulted in high non-functionality (60-80%) and low utilization. Grid connection delays and an 18% GST on swapping/charging services create financial bottlenecks.	Transition to a PPP-led model guided by usage data rather than grid targets. Rationalize GST to 5% for all charging and swapping services.	ULBs, State DISCOMs, Ministry of Power.
Distribution & Sales (Dealer Level)	A "motivation dilemma" exists: it takes three times as long to sell an EV, yet margins are lower, and back-end service profits are nonexistent.	Establish ‘EV dealer training’ for technical certification and provide manufacturer-led direct incentives for EV sales staff.	OEMs, Auto Dealerships.
Consumer Ownership & Lifecycle	A "crisis of confidence" regarding long-term ownership, specifically "information anxiety" over battery health and resale value.	Standardize "Battery Passports" and Health Certificates; decentralize the repair ecosystem by upskilling local mechanics.	MoRTH, Insurance Providers, QCI.
End-of-Life & Recycling	Lack of a circular economy for battery minerals and high uncertainty over post-warranty replacement costs.	Implement mandatory recycling targets (EPR) and standardized "State-of-Health" (SoH) metrics for second-life markets.	MoEFCC, Battery Manufacturers.

2.2. Adoption Barriers Across Key EV Use Cases

While value chain challenges are structural, their manifestation varies significantly across end-use segments. This section reframes the EV transition through a demand-side lens, analyzing how different user categories experience adoption-related friction. The table below evaluates key use cases based on their specific operational constraints, behavioral barriers, and economic realities. By pairing each problem with targeted interventions and responsible stakeholders, and further scoring them on importance, urgency, and effectiveness, this framework prioritizes actionable pathways for accelerating adoption where it matters most.

Use Case Segment	What is the Problem?	What Must Change?	Who Needs to Act?
Private Two-Wheelers (e-2W)	Mid-range rider anxiety (100–200 km/week) and a massive gender gap (57% male vs 39% female interest) due to seasonal safety fears (rain/heat).	Pivot marketing from "green" to "system reliability"; provide transparent safety testing data and extended warranties for extreme weather.	OEMs
Private Four-Wheelers (e-4W)	A systemic "Crisis of Confidence" regarding the full ownership lifecycle, driven by anxiety over charging, resale value, and repair-cost complexity.	Pivot from purchase subsidies to "Lifecycle Security" by standardizing Battery Passports and health certifications, and mandating residential "right to charge" access	OEMs, MHI, MoP, ULBs
Shared/Logistics Fleets (2W/3W)	Every hour of charging is an hour of lost earnings; gig workers face high-interest rates due to perceived lender risk.	Aggressively scale Battery-as-a-Service (BaaS) and leasing; formally include commercial EV financing under Priority Sector Lending (PSL).	RBI, Banks, Logistics Platforms
Commercial (Buses/Trucks/Tractors)	Massive ₹80-lakh price gap over diesel; 12m bus designs are a mismatch for narrow Tier-2/3 streets.	Scale Payment Security Mechanisms (PSM); adopt "Electrify Routes, Not Buses" models and introduce 6-8m compact e-bus designs.	State Transport Authority, OEMs, Ministry of Power.

2.3. Use Case–Wise Value Chain Breakdown

To complement the value chain analysis, this section examines EV adoption through a segmented, use-case-driven lens. Each segment—ranging from private two-wheelers to commercial buses—operates under distinct technical, economic, and behavioral constraints that shape both the nature and the intensity of adoption barriers.

The tables below disaggregate these differences across value chain stages, showing how similar systemic issues—such as cost premiums, infrastructure gaps, and ownership uncertainty—manifest differently depending on usage patterns, asset utilization, and user priorities. While private segments are more sensitive to trust, convenience, and affordability, high-utilization commercial segments are constrained by downtime, financing structures, and operational reliability. This segmentation highlights that a uniform policy or market approach is insufficient; instead, targeted, segment-specific interventions are required to unlock scale across the ecosystem.

Segment 1: Private 2W			
The primary driver of Indian EV volumes, focused on urban commutes.			
Value Chain Stage	**What is the Problem?**	**What Must Change?**	**Who Needs to Act?**
Battery R&D	Safety incidents in low-cost 2Ws have cratered broader consumer trust.	Shift from high-density NMC to abuse-tolerant LFP or Sodium-ion for hot climates.	OEMs, DST
Vehicle Mfg	EVs remain more expensive; high-performance models lack price parity without subsidies.	Iterative "de-over-design" to reduce bill-of-materials by up to 40% for sub-₹1 lakh price points.	OEMs
Charging Infra	95% of charging happens at home/work, but apartment dwellers face hurdles with RWA permission.	Mandate EV-ready wiring in building bylaws and provide "RWA kits" for retrofitting.	ULBs, State Govts
Sales & Distribution	Dealers lack the tech literacy to explain battery life or thermal safety.	Establish an "EV Dealer Academy" to train sales staff as tech educators.	OEMs, Dealerships
Ownership	Pronounced gender gap in purchase intent (57% male vs 39% female) due to safety fears.	Provide transparent safety testing data and extended warranties for extreme weather (rain/heat).	OEMs

End-of-Life	Paper-compliant recycling with low actual reverse-logistics throughput.	Implement traceable reverse logistics through the CPCB's EPR portal.	MoEFCC, Recyclers
Segment 2: Private 4W			
An aspirational but slow-moving segment defined by "information anxiety."			
Value Chain Stage	**What is the Problem?**	**What Must Change?**	**Who Needs to Act?**
Battery R&D	70–100% import dependency for cells and high-value precursors.	Institutionalize TRL 4–6 grants to bridge the "lab-to-pilot" gap for next-gen chemistries.	DST, MHI
Vehicle Mfg	Lack of affordable "base models"; most EVs are positioned as premium/luxury.	"De-over-design" vehicles to reach the sub-₹10 lakh threshold without quality regression.	OEMs
	Price gap of ₹4–5 lakh vs ICE; 50% Domestic Value Addition (DVA) norms are unrealistic.	Pragmatically recalibrate DVA norms to allow high-tech imports until local ecosystems mature.	MHI, OEMs
Charging Infra	Public charging visibility is low, and consumers fear getting stranded on intercity trips.	Site chargers at high-visibility malls/hubs and integrate real-time "heartbeat" data into apps.	CPOs, MHI
	60–80% of PSU-installed chargers are non-functional; low visibility of inter-city fast charging.	Pivot to PPP models and "demand-led" siting based on temporal trip patterns.	MoP, CPOs, ULBs, MoRTH
Sales & Distribution	"Motivation dilemma": Dealers make lower profits on EV services and prefer selling ICE vehicles.	Implement performance-linked financial incentives for dealers to neutralize the EV/ICE margin gap.	OEMs, Dealers
Ownership Lifecycle	67-75% of owners are "upset" by uncertainty about resale value and the complexity of repair costs.	Implement "Battery Passports" and standardized State-of-Health (SoH) certificates for the secondary market.	MoRTH, Insurance companies

End-of-Life	High uncertainty over post-warranty replacement costs (40-50% of car price).	Mandate 2nd-life stationary reuse for degraded traction packs to shore up residual values.	MoEFCC, OEMs
Segment 3: Shared & Commercial Fleets (Logistics/Gig)			
High-utilization users where "every hour of charging is an hour of lost earnings".			
Value Chain Stage	**What is the Problem?**	**What Must Change?**	**Who Needs to Act?**
Battery R&D	Cold-chain LCVs lose 40-50% of range to refrigeration systems.	Prioritize R&D in thermal efficiency and modular refrigeration for LCVs.	DST, OEMs, Startups
Vehicle Mfg	Lenders perceive high risk for commercial EV assets.	Scale leasing and Battery-as-a-Service (BaaS) to shift capital costs to operating costs.	NBFCs, Banks
Charging Infra	Charging downtime disrupts tight delivery windows.	Aggressively scale standardized battery swapping and depot-centric fast charging.	Logistics Platforms, CPOs
Distribution	3PLs lack clear ROI benchmarks for LCV fleet conversion.	Use aggregated public procurement (EESL model) to stabilize fleet demand.	EESL/CESL, State Agencies, 3PLs & OEMs
Ownership Lifecycle	Gig workers face high-risk loan classifications and 18% GST on swapping services.	Formally include EV financing under Priority Sector Lending (PSL) and rationalize GST to 5%.	RBI, Ministry of Finance
End-of-Life	Fragmented digital tracking of high-use batteries.	Create an "ONDC-like" digital platform for battery health and reverse logistics.	MHI, MeitY
Segment 4: Commercial (Buses)			
The segment with the highest decarbonization potential but the largest financial gap.			
Value Chain Stage	**What is the Problem?**	**What Must Change?**	**Who Needs to Act?**
Battery R&D	High anxiety over battery degradation in intensive urban duty cycles.	Invest in Lithium Titanium Oxide (LTO) batteries for higher cycle life and ultra-fast charging.	DST, OEMs

Vehicle Mfg	Massive ₹80 lakh price gap over diesel; 12m buses are too big for Tier-2 city streets.	Incentivize 6–8m compact designs and scale Payment Security Mechanisms (PSM).	MHI, OEMs
Charging Infra	Depot grid load requires up to 4000kW, often mired in DISCOM approval delays.	"Electrify Routes, Not Buses": Embed high-power grid access into statutory city masterplans.	ULBs, DISCOMs
Energy Supply	Electricity demand charges and security deposits tie up capital for SRTUs.	Reform electricity tariffs for public transport and exempt STUs from heavy security deposits.	State Electricity Regulatory Commissions
Distribution	Fragmented contracting (separate vehicle/infra/ops) increases delivery risk.	Move toward holistic Build-Operate-Transfer (BOT) models for bundled fleet delivery.	STU, Private Ops
Ownership Lifecycle	Financial instability of STUs leads to payment defaults to private operators.	Pivot to Public-Private Fleet Entities (BOT models) to decouple ownership from operations.	State Govts, CESL
End-of-Life	Inefficient recovery of high-value minerals from heavy-duty packs.	Establish "anchor-tenant" recycling hubs linked to large SRTU depots.	MoEFCC, SRTUs

2.4. Stakeholder Action Framework for EV Ecosystem Transformation

The EV transition in India is fundamentally a coordination challenge across multiple institutional stakeholders, each controlling critical levers within the ecosystem. From central policy design and state-level implementation to capital provision and product development, progress is contingent on aligned action rather than isolated interventions.

The following tables map key bottlenecks to the stakeholders best positioned to address them, highlighting gaps in policy design, regulatory execution, financing frameworks, and industry strategy. A recurring theme across these actors is the need to move beyond fragmented, reactive measures toward integrated, system-level solutions—whether through institutional coordination, standardization, or risk-sharing mechanisms. This stakeholder-oriented view underscores that accelerating EV adoption is not only a technological or market challenge, but equally an issue of governance, incentives, and execution capacity.

Central Govt./Ministries		
Factor	**What is the Problem?**	**What Must Change?**
Industrial Strategy	TRL 4–6: Promising technologies such as sodium-ion or zinc-air stall in laboratories because incentives like PLI and FAME primarily reward post-commercial production volumes and not R&D.	Shift to Pre-Commercial Grants: Institutionalize TRL 4–6 grants for pilot tooling, metrology, and yield mastery rather than focusing only on unit sales.
Governance	Ministerial Fragmentation: Responsibilities for land, power, and transport are dispersed across agencies, making coordinated institutional action difficult.	Establish a Nodal Authority: Can create a National Urban Freight and Electrification Mission to provide unified oversight for standards and data protocols.
Supply-Side Push	Import Dependence: India remains 70–100% dependent on imported cells and precursors, leaving the industry vulnerable to geopolitical supply shocks.	Pragmatic PLI Reform: Consider recalibrating domestic value addition (DVA) norms to exclude high-tech components such as magnets until domestic ecosystems mature.
Fuel-Efficiency Regulation	Current CAFE norms still allow manufacturers to achieve compliance through incremental ICE efficiency gains and mass-based target adjustments, limiting the framework's direct push toward EV adoption.	Future CAFE phases should progressively strengthen the role of zero-emission vehicles within compliance pathways while revisiting mass-based target structures that may unintentionally favor heavier vehicles.
Taxation	GST Anomaly: EVs are taxed at 5%, but standalone batteries and charging or swapping services are taxed at 18%, creating a working capital blockage.	Consider GST Rationalization: Flatten GST to 5% across the entire EV value chain, including batteries and energy services, to unlock sector growth.
State Govt/ULBs		
Factor	**What is the Problem?**	**What Must Change?**
Statutory EVSE Planning	Implementation Gaps: High-quality technical studies exist, but they lack statutory backing in city masterplans, leading to uneven deployment.	Embed charging in Masterplans: Mandate land reservation for charging hubs and depot siting as a foundational urban service.

Residential Access	The Apartment Hurdle: Densely populated older apartment blocks often prohibit installing home chargers due to grid constraints or RWA restrictions.	Mandate EV-Ready Bylaws: Update building bylaws to require a share of EV-ready parking in existing buildings and fast-track retrofit permissions.
Infrastructure Siting	Symbolic Grid Targets: Current charging targets use 1 × 1 km grids, which often leave 60–80% of chargers non-functional or underutilized.	Pivot to Demand-Led Siting: Use temporal trip heatmaps and charging demand data to locate chargers.
Grid Reliability	Connection Friction: Charge Point Operators face bureaucratic delays and high security deposits when seeking high-tension connections from DISCOMs.	Single-Window Clearance: Implement time-bound approval systems and exempt STUs and CPOs from heavy security deposits for grid upgrades.
Financial Institutions		
Factor	**What is the Problem?**	**What Must Change?**
Credit Risk	Asset Uncertainty: Lenders perceive EVs as high risk due to rapid technological obsolescence and limited residual-value data.	Include EVs in PSL: Formally include EV financing under Priority Sector Lending (PSL) or create a Partial Risk Sharing Facility (PRSF).
Operational Cash-Flow	High Upfront Burden: The ₹80-lakh price gap for buses and LCVs makes ownership prohibitive for small fleet operators.	Scale OpEx Models: Fund Battery-as-a-Service (BaaS) and leasing models to shift capital costs into manageable operating expenses.
Payment Security	STU Defaults: Financial instability of State Transport Undertakings discourages private bus operators from bidding.	Secure the PSM: Fully operationalize the ₹3,435 crore Payment Security Mechanism (PSM) to guarantee timely payments to private e-bus fleets.
Valuation Standards	Residual Value Gap: The lack of benchmarks prevents banks from determining the "Fair Market Value" of used EVs.	Adopt Residual Value Guarantees (RVG): Use standardized Battery Health data to build predictive models of EV resale value.

OEMs		
Factor	**What is the Problem?**	**What Must Change?**
Product Portfolio	The Premium Gap: Most 4W EVs are positioned as luxury items, leaving a lack of affordable base models for middle-class and fleet users.	Battery indigenization to bring down costs, alongside simplifying vehicle design and trimming the bill of materials to reach sub-₹10 lakh price thresholds.
Trust Deficit	Battery Anxiety: Consumer concern has shifted from range to battery health and resale value, affecting 67% of current users.	Standardize Lifecycle Transparency: Launch battery passports and provide in-app battery health certificates to de-risk the secondary market.
Supply Risk	Rare-Earth Exposure: Heavy reliance on imported NdFeB magnets for motors creates a strategic supply bottleneck.	Re-architect Powertrains: Consider shifting towards magnet-lean motor topologies (e.g., synchronous reluctance motors) combined with in-house gearbox design.
Operational Control	Software Vulnerability: Reliance on third-party packs prevents OEMs from managing deep diagnostics or safety.	Internalize the Control Stack: Own the BMS and VCU software authority, even when cells are sourced externally, to ensure India-specific safeguards.

2.5. Lifecycle-Secured Transition Model for EV Adoption in India

India's EV transition is no longer constrained by awareness or early demand, but by the system's ability to deliver a reliable and scalable ownership experience. The evidence across this report shows that isolated interventions—whether subsidies, infrastructure targets, or manufacturing incentives—have limited impact when underlying coordination and lifecycle risks remain unresolved.

The transition is therefore best understood as a systems problem. Adoption depends on simultaneous progress in domestic capability, institutional execution, financing structures, and consumer trust. Gaps in any one of these areas create friction across the ecosystem, slowing the conversion from intent to sustained use.

At scale, the market evolves through a reinforcing dynamic: improved execution reduces uncertainty, stronger demand signals unlock private investment, and increased supply depth lowers costs and expands access. The implication is clear: policy must move from signaling intent to enabling coordinated execution across the full lifecycle of EV ownership.

This shifts the focus from new policy announcements to the quality of implementation. Ensuring infrastructure uptime rather than just installation, enabling data transparency rather than fragmented platforms, and reducing financing risk through standardized lifecycle metrics will be critical. Without these shifts, adoption will remain uneven; with them, the ecosystem can transition to a self-sustaining growth trajectory driven by reliability, cost competitiveness, and user confidence.

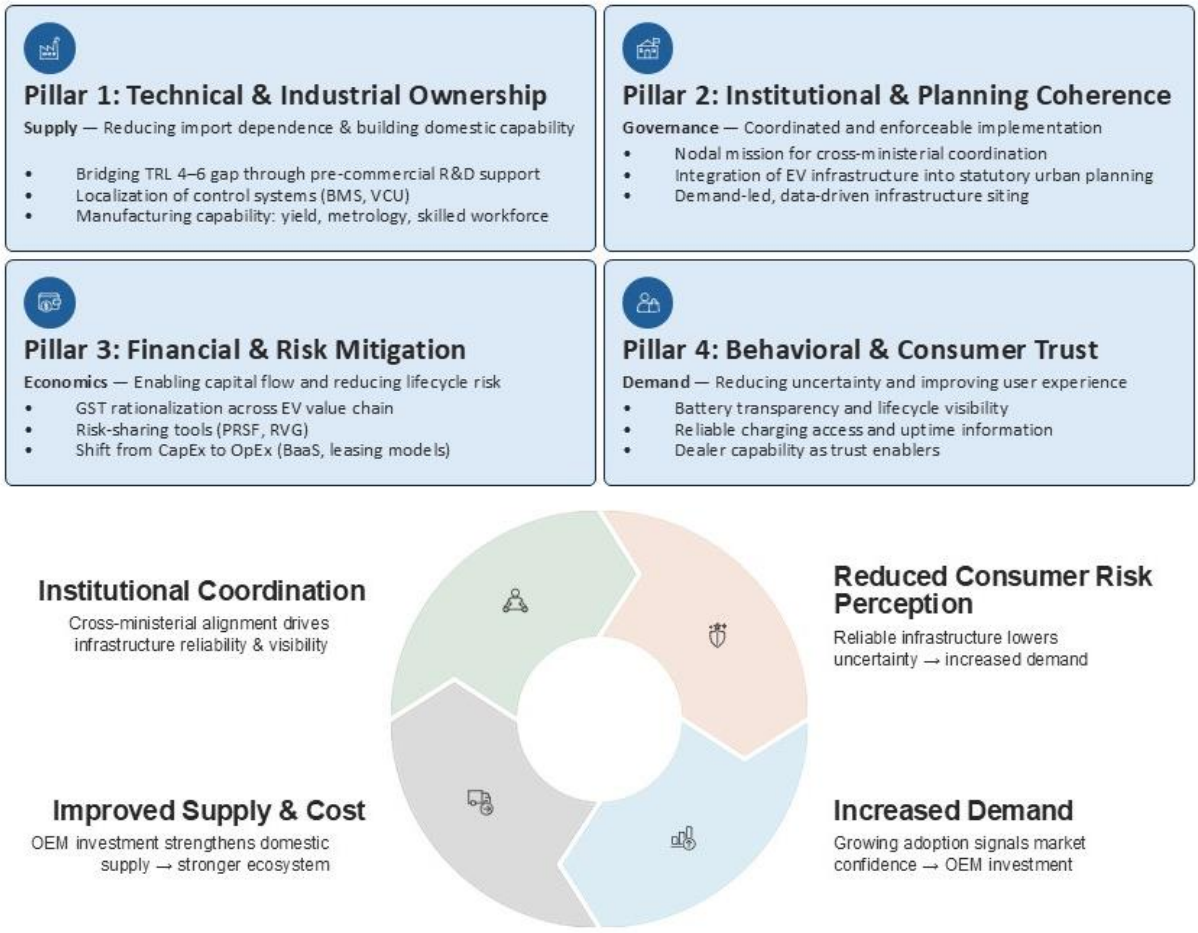


Figure 1: Four-Pillar Framework for India's EV Transition

3. Conclusion

India's EV transition is constrained less by demand and more by execution gaps across the ecosystem. Three issues cut across all segments: high upfront costs, unreliable and underutilized charging infrastructure, and a lack of standardized battery health and resale frameworks. These are not

independent problems—together, they suppress consumer confidence, distort financing risk, and slow down adoption despite underlying interest.

The analysis shows that each segment requires a different policy focus:

1. Private two-wheelers need residential charging access and safety standardization to rebuild trust at scale.

2. Private four-wheelers require cost reduction through pragmatic DVA norms and clear battery health disclosure frameworks to address price and resale concerns.

3. Commercial fleets will only scale with the help of battery-as-a-service models, priority sector lending inclusion, and GST rationalization on energy services to improve unit economics.

4. Electric buses require payment security mechanisms, route-level electrification planning, and tariff reforms to address viability gaps.

At the system level, four reforms are critical:

1. First, shift incentives upstream - from subsidizing end-products to funding TRL 4–6 scale-up for cells and next-generation chemistries.

2. Second, fix the GST inversion by aligning batteries and charging services with EV tax rates to remove working capital inefficiencies.

3. Third, move from target-based to demand-led infrastructure planning, using real usage data to guide charger deployment and ensure up-time.

4. Fourth, standardize battery passports and state-of-health metrics to unlock resale markets and reduce lender risk.

Finally, institutional coordination is the binding constraint. Responsibilities today are fragmented across ministries, regulators, and local bodies, leading to delays in land allocation, grid access, and financing approvals. A nodal mechanism with authority over standards, data protocols, and cross-sector coordination is necessary to move from pilot-led growth to system-wide scale.

Without these corrections, EV adoption will continue in pockets, driven by subsidies and early adopters. With them, the market can transition to self-sustaining growth anchored in cost competitiveness, infrastructure reliability, and consumer trust.

Ultimately, India's transition toward a net-zero mobility future is no longer a question of "if," but of how quickly and effectively it can be achieved. By aligning technical, financial, and institutional efforts, the country can move beyond fragmented pilots toward a self-reinforcing adoption cycle. Reaching this stage would not only reduce transport emissions but also strengthen India's position in the global battery economy, contributing to significant oil import savings in the future. The roadmap presented across these fourteen chapters underscores that the next phase of the transition will depend less on policy ambition alone and more on coordinated, ecosystem-wide execution.

Credits

Sandip Chakrabarti: Conceptualization, Methodology, Resources, Supervision, Project administration, Funding acquisition, Writing - Review & Editing. **Anish Sugathan**: Conceptualization, Methodology, Resources, Supervision, Project administration, Funding acquisition. **Shreya Sinha**: Formal analysis, Investigation, Writing - Original Draft.



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