

ELECTRIC MOBILITY INFRASTRUCTURE IN MEDIUM-SIZED CITIES

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Abstract

Electric mobility is increasingly relevant to medium-sized cities, where short and medium-distance trips, growing two-wheeler and three-wheeler use, expanding commercial activity, and improving electricity networks create both opportunities and constraints for low-emission transport. This paper presents an evidence-based assessment of the infrastructure required to support electric mobility in medium-sized cities. It examines charging access, electricity-distribution readiness, land-use integration, parking conditions, public and shared transport applications, digital information systems, safety standards, financing arrangements, and municipal governance. The analysis treats infrastructure as more than a count of charging points: an effective system must match vehicle types, trip purposes, dwell times, grid capacity, site ownership, affordability, and the ability of users to locate and pay for reliable services. The study compares residential, workplace, destination, fleet, corridor, and public charging contexts and identifies their different operational roles. It finds that medium-sized cities should avoid copying infrastructure models designed for large metropolitan areas. Instead, they require phased deployment built around high-use activity centres, electric two- and three-wheelers, municipal and commercial fleets, public parking, bus depots, freight and delivery clusters, and well-coordinated upgrades to local distribution networks. The paper does not claim a new survey or provide fabricated utilization figures. Its recommendations are based on published policy guidance, planning literature, and documented implementation considerations. The study concludes that inclusive and reliable electric mobility infrastructure depends on coordinated action by urban local bodies, electricity-distribution companies, transport agencies, site owners, charging-service providers, financial institutions, and users. Planning should prioritize safe access, transparent pricing, interoperable systems, equitable coverage, and measurable service quality.

Keywords: Electric Mobility, Medium-Sized Cities, EV Charging Infrastructure, Urban Transport, Distribution Grid, Public Charging, E-Rickshaws, Electric Buses, Sustainable Mobility

1. INTRODUCTION

Electric mobility is no longer limited to large metropolitan regions. Medium-sized cities are becoming important locations for the transition because they often combine compact travel patterns, expanding urban populations, growing delivery activity, high dependence on two- and three-wheelers, and a need to improve local air quality and transport affordability. These cities can make rapid progress when charging and energy systems are planned around daily travel behaviour rather than around a uniform national template. At the same time, the transition can be slowed by limited public parking, uneven distribution-network capacity, fragmented land ownership, small municipal budgets, uncertainty about charging demand, and weak

coordination between transport and electricity agencies.

Electric mobility infrastructure includes charging equipment, grid connections, transformers, distribution upgrades, parking arrangements, signage, digital platforms, payment systems, maintenance practices, safety procedures, and data systems that allow operators and cities to monitor service quality. A public charging station that is difficult to locate, frequently unavailable, poorly maintained, unsafe at night, or connected to an unreliable supply does not provide meaningful mobility confidence. Infrastructure planning must therefore consider reliability, accessibility, utilization, user safety, operating cost, and the practical needs of different vehicle segments.

The needs of a medium-sized city differ from those of a megacity. Many trips are shorter, land values may be lower, and travel demand may be more concentrated around markets, hospitals, educational institutions, railway stations, industrial areas, municipal offices, and neighbourhood commercial streets. These features can make strategically located charging more feasible, but they also require detailed local assessment. A city that has abundant on-street parking but limited transformer capacity faces a different challenge from a city with strong electricity supply but scarce public land. A successful approach must identify these local conditions before equipment is procured.

Electric two-wheelers, three-wheelers, buses, taxis, municipal fleets, delivery vehicles, and private cars do not require identical infrastructure. Two- and three-wheelers may depend on low-cost, distributed charging or battery swapping; buses need depot-based charging and route scheduling; commercial fleets require predictable turnaround; and private vehicles benefit from residential, workplace, or destination charging. A balanced city strategy combines these use cases rather than allocating resources only to highly visible fast-charging locations.

This study evaluates electric mobility infrastructure in medium-sized cities through a comparative planning framework. It identifies the main infrastructure components, examines location and governance priorities, and outlines measures for urban local bodies, distribution companies, transport authorities, businesses, and charging providers. The purpose is to support practical, inclusive, and scalable deployment rather than an

infrastructure plan based solely on charger numbers.

2. LITERATURE REVIEW

Research on electric mobility consistently shows that charging infrastructure affects user confidence, vehicle adoption, fleet operations, and the overall practicality of an electric transport transition. Earlier studies emphasised charging availability and range confidence, while more recent work has examined charger reliability, interoperability, pricing transparency, grid integration, charging behaviour, and the relationship between private, public, and fleet-based charging. A recurring finding is that a public network cannot be assessed only by the number of installed connectors; location quality, uptime, payment simplicity, power availability, and user access are equally important.

The literature also indicates that infrastructure planning should reflect local travel and land-use conditions. Medium-sized cities may not require dense high-power charging networks in every neighbourhood at the outset, but they need dependable coverage at activity centres and fleet locations. Studies on urban charging highlight the value of combining residential and workplace charging with destination and public options, especially for users without private parking. Policy guidance further stresses coordinated grid planning, common standards, open information, safety compliance, and institutional clarity. These principles are particularly significant in cities where transport, parking, electricity distribution, and municipal land are managed by separate organizations.

LITERATURE REVIEW SUMMARY TABLE

S. No.	Author / Year	Study Focus	Key Contribution	Limitations Identified
1	Hall & Lutsey (2017)	Charging deployment strategy	Explained how charging needs vary by vehicle market and urban context	Focused largely on policy design and early market development
2	Hardman et al. (2018)	User interaction with charging	Showed that convenience, reliability, and payment experience shape charging acceptance	Evidence differed across regions and user groups
3	Funke et al. (2019)	Public charging demand	Highlighted that charging infrastructure should be linked to travel behaviour and parking duration	Model assumptions may not fit all city forms

4	NITI Aayog et al. (2022)	Indian charging implementation	Provided practical guidance on siting, power supply, business models, and stakeholder roles	Requires city-level adaptation for local conditions
5	Ministry of Power (2024)	Charging-infrastructure guidelines	Clarified the enabling framework for installation and operation in India	Guidelines do not replace detailed municipal planning
6	IEA (2025)	Global EV and charging trends	Documented the continued expansion of public charging and electric mobility markets	Global data cannot substitute for city-specific demand assessment

3. OBJECT OF STUDY

The primary focus of this research is to assess the infrastructure conditions required for practical and equitable electric mobility in medium-sized cities. The study considers charging access, energy supply, urban-space availability, site selection, user needs, operational reliability, safety, financing, and coordination between institutions. The main objects of study are outlined below:

3.1 ELECTRIC MOBILITY SEGMENTS UNDER CONSIDERATION

- Electric two-wheelers used for personal travel, campus movement, local delivery, and commercial activity
- Electric three-wheelers, including passenger e-rickshaws and last-mile freight vehicles
- Electric buses, municipal service vehicles, and institutional fleets
- Electric taxis, delivery vans, and other commercial vehicles with predictable daily routes
- Private electric cars, shared mobility vehicles, and vehicles requiring public or destination charging

3.2 INFRASTRUCTURE CONTEXTS

- Residential, workplace, institutional, destination, public-parking, and highway or corridor charging
- Bus depots, municipal yards, logistics clusters, market areas, hospitals, railway stations, and commercial centres
- Electricity-distribution capacity, transformer loading, service connections, metering, and demand management
- Parking layout, lighting, universal accessibility, signage, safety equipment, and user information

- Digital discovery, booking, payment, usage monitoring, grievance channels, and service-maintenance systems

3.3 EVALUATION PARAMETERS

- Accessibility for users with and without private parking or dedicated home charging
- Reliability of electricity supply, charging equipment uptime, and fault-response arrangements
- Suitability of charging power and dwell time for the relevant vehicle and trip purpose
- Affordability, pricing transparency, payment options, and user confidence in service availability
- Safety, security, environmental suitability, local permitting, and long-term maintenance feasibility

3.4 COMPARATIVE ANALYSIS FOCUS

- Private, shared, fleet, public-transport, and commercial charging requirements
- Slow, medium-power, and fast-charging roles within a citywide infrastructure mix
- Central activity nodes, neighbourhood-level access, depot needs, and intercity corridor connections
- Municipal responsibilities, distribution-company responsibilities, private operator roles, and user protections
- Short-term deployment priorities versus long-term grid and land-use planning

3.5 RESEARCH OBJECTIVE SCOPE

- To identify key infrastructure requirements for electric mobility in medium-sized cities
- To explain why charging location, reliability, and grid readiness matter as much as charger counts
- To compare the needs of major electric vehicle segments and charging contexts

- To identify planning gaps related to land, parking, power supply, data, finance, and governance
- To recommend phased and locally appropriate infrastructure measures

4. RESEARCH METHODOLOGY

The present study adopts a comparative and evidence-based research methodology. It synthesises published research, official charging-infrastructure guidance, urban-planning practice, and documented implementation considerations. The research does not present a new field survey, a city-specific engineering audit, or a fabricated count of vehicles, charging points, or electricity demand. This approach is suitable because the infrastructure needs of medium-sized cities vary according to population distribution, travel patterns, vehicle ownership, parking availability, commercial activity, climate, local electricity networks, and institutional capacity.

The analysis follows the infrastructure pathway through which a user seeks to charge a vehicle: locating a suitable site, reaching it safely, verifying availability, connecting to reliable power, completing payment, receiving support if a fault occurs, and continuing the journey. Each infrastructure context is assessed under common dimensions: demand fit, location quality, dwell time, electrical readiness, user access, operational reliability, safety, affordability, and coordination requirements. The methodology also recognises that women, persons with disabilities, low-income users, commercial drivers, renters, and residents of dense neighbourhoods can experience charging access differently.

The study distinguishes between immediate deployment measures and long-term system planning. Immediate measures include mapping feasible sites, improving permitting, installing signage, setting service standards, and supporting priority fleets. Long-term measures include distribution-network upgrades, land reservation, parking policy, building-code integration, interoperable data systems, procurement capability, and performance monitoring. Recommendations are framed as planning and governance priorities rather than as a universal numerical formula.

METHODOLOGY FRAMEWORK

1. The study uses a comparative urban-infrastructure framework for medium-sized cities.
2. Published research, official guidelines, and implementation reports support a qualitative synthesis.
3. Charging location, electricity supply, parking, user access, safety, and digital service quality are evaluated together.
4. Vehicle segments are compared according to trip distance, charging duration, route predictability, and fleet characteristics.
5. Infrastructure is assessed across residential, workplace, destination, public, depot, commercial, and corridor contexts.
6. Grid capacity, transformer loading, service connections, metering, and demand management are treated as core planning factors.
7. The analysis considers municipal land, private sites, public parking, institutional properties, and commercial partnerships.
8. Reliability, maintenance, payment systems, emergency support, and grievance pathways are included in service evaluation.
9. No fabricated utilization rates, fleet counts, electricity-demand figures, or city rankings are presented.
10. Recommendations focus on phased deployment, inclusive access, transparent governance, and measurable service quality.

5. DATA ANALYSIS

The data analysis section presents a qualitative comparison of electric mobility infrastructure requirements in medium-sized cities. It examines how different charging environments serve different users and how planning decisions affect reliability, affordability, and access. The analysis does not treat charging stations as interchangeable assets. A charger at a bus depot, for example, serves a different operational purpose from a public charger near a market or a workplace charger at an institutional campus.

Six infrastructure settings are considered: residential charging, workplace and institutional charging, destination charging, public parking charging, depot and fleet charging, and corridor or intercity charging. The comparison is qualitative because the

appropriate mix depends on local travel demand, parking conditions, city form, electricity-distribution capacity, land control,

climate, commercial activity, user income, and the maturity of local electric vehicle markets.

5.1 COMPARATIVE INFRASTRUCTURE ANALYSIS

S. No.	Infrastructure Setting	Primary Users	Operational Requirement	Planning Priority	Risk if Neglected
1	Residential and neighbourhood charging	Private two-wheelers, three-wheelers, cars, renters	Safe low-cost access, electrical safety, building or community arrangements	High	Unequal access for users without private parking
2	Workplace and institutional charging	Employees, students, visitors, service fleets	Daytime dwell time, managed access, predictable billing	High	Missed opportunity for low-cost routine charging
3	Destination charging	Shoppers, hospital visitors, rail users, tourists	Visible, dependable service at activity centres	High	Range anxiety and weak user confidence
4	Public parking and civic sites	Users without home charging, shared and commercial vehicles	Fair access, safety, lighting, transparent pricing	Very High	Infrastructure benefits only higher-income or property-owning users
5	Depot and fleet charging	Buses, municipal fleets, taxis, delivery and logistics vehicles	Load management, route scheduling, maintenance, backup plans	Very High	Fleet disruption and poor service reliability
6	Corridor and intercity charging	Private cars, taxis, freight and intercity travellers	Reliable fast charging, amenities, wayfinding, grid capacity	Moderate-High	Limited regional travel confidence

5.2 EXTENDED INFRASTRUCTURE EVALUATION

Residential and neighbourhood charging:

Home and neighbourhood charging can provide the most convenient option for many users, but access is unequal. Residents of apartments, rented homes, informal neighbourhoods, or dense mixed-use areas may lack dedicated parking or authority to install equipment. Cities should examine shared parking, community charging, retrofitting guidance, electrical-safety procedures, and building-permit processes. The aim should be to prevent electric mobility from becoming practical only for households with private garages or controlled parking space.

Workplace and institutional charging:

Workplaces, educational campuses, hospitals, government offices, and commercial complexes can support predictable daytime charging. These sites may reduce pressure on public networks because users have longer dwell times. Their usefulness depends on access rules, parking management, metering, payment systems, and the ability of site owners to maintain equipment. Municipal policies can encourage suitable sites to include charging readiness during new construction and renovation.

Destination and public-parking charging:

Destination charging is valuable at locations where users already spend time, including markets, railway stations, shopping areas, hospitals, civic centres, and cultural sites.

Public parking can also provide access for residents without home charging. However, these locations require careful attention to safety, lighting, disability access, vehicle circulation, signage, vandalism prevention, and service reliability. A station that occupies parking space but is persistently inoperative can create public dissatisfaction and reduce trust in electric mobility.

Depot and fleet charging: Electric buses, municipal vehicles, shared fleets, delivery vehicles, and commercial three-wheelers can create predictable demand and early utilization. Depot charging requires detailed operational planning because fleet schedules, charging windows, route distances, electricity tariffs, transformer capacity, maintenance, and contingency arrangements are linked. In medium-sized cities, prioritising one or two well-managed fleet applications may provide a stronger initial foundation than dispersing fast chargers across sites with uncertain demand.

Grid integration and demand management: Charging infrastructure must be planned with the distribution network rather than added after site selection. Distribution companies need visibility into expected loads, connection requirements, transformer capacity, time-of-use patterns, and potential clustering of chargers. Smart charging, scheduled fleet charging, appropriate tariff design, and local energy management can reduce avoidable stress on the network. Grid readiness should be assessed before installation commitments are made, especially at depots, commercial clusters, and transport terminals.

Digital service and user support: Users need clear information about station location, connector availability, pricing, operating hours, payment methods, and support channels. Interoperability and transparent data reduce the need for users to navigate multiple incompatible platforms. A practical system also requires fault reporting, timely repairs, customer support, usage monitoring, and data safeguards. Digital convenience should supplement, not replace, physical accessibility and reliable operation.

5.3 OBSERVATIONS FROM DATA ANALYSIS

- Infrastructure suitability is context-specific: residential, public, fleet, and corridor charging perform different

functions and should not be evaluated using a single metric.

- Medium-sized cities should match charging power to dwell time and vehicle use; fast charging is useful in some locations but is not the default solution for every site.
- Public charging is important for equity because many potential users do not have access to private parking or a dedicated electrical connection.
- Fleet and depot applications can create early demand, but they require closer coordination with electricity-distribution companies and service operators.
- Charger reliability, safety, visible information, payment options, and maintenance response are essential elements of user confidence.
- Land-use planning and parking policy can either enable or restrict charging access, particularly in dense markets and mixed-use neighbourhoods.
- Digital systems are valuable when they provide accurate information, simple payment, interoperable access, and responsive complaint handling.
- Municipal monitoring should track uptime, user feedback, repair time, access equity, and operational performance, not only the number of installations.

6. DISCUSSION

The comparative analysis shows that electric mobility infrastructure is an urban systems issue rather than a stand-alone equipment procurement exercise. Charging stations are dependent on electrical capacity, parking availability, local permissions, maintenance capability, user behaviour, digital services, and institutional cooperation. A medium-sized city that installs equipment without addressing these conditions may create visible assets with limited practical value. Conversely, a city that begins with a clear site map, priority vehicle segments, grid coordination, and service standards can build a network that grows in response to real demand.

Equity should be a central consideration. Users who live in single-family homes with dedicated parking may find it easier to adopt electric vehicles than apartment residents, renters, informal-sector workers, or drivers who depend on public space. Municipal

strategies should therefore include public and community-accessible charging, secure lighting, transparent pricing, accessible payment options, and locations connected to everyday activity centres. This approach is especially important for electric two- and three-wheelers, which can support affordable mobility and local livelihoods but may not have access to private charging arrangements. Institutional coordination is equally important. Urban local bodies influence public land, parking, permits, road design, street lighting, signage, and local planning. Distribution companies manage service connections, transformer capacity, metering, and grid reliability. Transport agencies and fleet operators understand route operations and vehicle dwell times. Private operators contribute equipment, software, maintenance, and customer service. A practical governance model should define roles, share planning data, establish safety and service standards, and create a reliable mechanism for resolving operational issues.

Financing and business models should be phased. Medium-sized cities may not initially provide enough public charging demand to justify high-cost installations at every location. Public investment or concession arrangements can focus on strategic sites, municipal fleets, bus depots, parking assets, and underserved areas. Private participation can expand as usage becomes more predictable. Procurement should prioritize equipment quality, warranties, maintenance commitments, interoperable payment, and verified uptime rather than selecting only on the basis of the lowest initial price.

A resilient strategy also requires future readiness. New buildings, public parking projects, market redevelopments, bus depots, and institutional campuses should assess electrical and space provisions before

construction is complete. Reserving conduits, transformer space, parking bays, and metering arrangements is usually easier than retrofitting later. Medium-sized cities should use this transition to improve broader mobility management, including parking discipline, safe walking access, shared transport integration, and local air-quality planning.

7. CONCLUSION

This study examined the infrastructure requirements for electric mobility in medium-sized cities. The findings show that charging infrastructure must be understood as a coordinated service system involving sites, power supply, parking, user access, safety, digital information, maintenance, and governance. The appropriate infrastructure mix depends on vehicle segments, travel patterns, dwell times, land availability, distribution-network capacity, and the needs of users who do not have private charging access. Residential, workplace, destination, public-parking, fleet, depot, and corridor charging each have distinct roles within a citywide strategy.

Medium-sized cities should adopt phased implementation. Early action should focus on mapping demand and feasible sites, coordinating with distribution companies, enabling public and institutional access, supporting priority fleets, improving safety and service standards, and establishing transparent performance monitoring. Longer-term planning should reserve space and grid capacity in new development, strengthen data systems, support interoperable services, and ensure that charging access is inclusive. The transition to electric mobility will be more durable when infrastructure is reliable, locally appropriate, affordable, and designed around the everyday travel needs of residents and commercial users.

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