European Economic Letters
ISSN 2323-5233
Vol 15, Issue 3 (2025)
http://eelet.org.uk

Economics of Home-Based EV Charging in India: Challenges and Policy Implications

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Abstract

The electric vehicles (EVs) have become a key part of a sustainable means of transport with India determined to attain net-zero emissions and lessen oil imports. The most convenient and preferred EV charging mode used by the owners of the private vehicle, the home-based charging occupies the central role in the evolution of the adoption process. The current paper outlines economics residential EV charging in India, chief challenges, consisting of a high prevalence of front-end infrastructure, uneven access on parking rights to the private, and regulatory holes. It also provides policy suggestions based on the socioeconomic situation in India, which is meant to facilitate the adoption of home-based EV chargers on a large and equal scale.

Keywords: Home-Based EV Charging, Electric Vehicles (EV), Charging Infrastructure, EV Policy in India

1. Introduction

The electric vehicle (EV) market in India is growing at a significant rate and this is fueled by the fact that the country is keen on decreasing the level of greenhouse gas emissions, reducing the reliance on fossil fuel as well as fighting air pollutants in cities. At the national level, the Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME-II) and other state-specific policies on EVs A case in point is Delhi, Maharashtra, Tamil Nadu, and Gujarat, among others are providing immense financial aid, tax exemption, and subsidies to consumers and manufacturers alike [1]. Such initiatives look to catapult the EV adaption at both the personal and commercial segments of vehicle markets, especially the two wheelers, three wheelers, and electric-car one to avail urban commuting. With this shift picking up steam, it is imperative to have easy access to validated, convenient, affordable charging equipment. Although rolling out of public charging networks across highways, malls, metro stations and office complexes are gradually being deployed, they are also not deployed at par especially in Tier II and Tier III cities. Home-based EV charging has become the mainstream and an easier way of charging EV by the users of the electrically powered vehicles in this landscape particularly the two-wheelers and the passenger cars [2]. Home charging gives a user the convenience of charging overnight, avoids the waiting at a pubic charger and vastly decreases the cost per-kilometre energy consumption. Nevertheless, economic viability of home charging in India is determined by a variety of interrelated factors. These involve regional electricity charges which are really wide between states, initial cost of hardware and installation that might not be affordable to all homes, physical space limitation, particularly when living in apartment complex or highly crowded cities and the stability and capacity of the local electricity grids, which is normal in urban and rural regions [3-4].

In India with a variety of residential patterns, wide income gaps across cities and uneven power infrastructure, there is an opportunity-challenge paired dynamic in the economics of charging EVs at home [5]. The transition towards home EV charging to these urban high-income households with residential parking access and reliable electricity is a rather smooth transition and one that is economically advantageous. Conversely, in the case of low-income and median users or residents of rental units, infrastructure unavailability and upfront cost might become a problem. This paper seeks to explore such economic dynamics through charging costs structures, infrastructural constraints, and charge station users in the Indian context. It also presents the interventions that it recommends at the policy level in order to resolve the existing impediments, support burgeoning egalitarian access, and make home-based EV charging a cost-effective, modular, and sustainable solution to all socio-economic fabric levels in India [6-7].

2. Cost Structure of Home-Based EV Charging in India

Economics of home-based EV charging can be largely divided into two broad segments, the first one is Capital Expenditure (CAPEX) and the second is Operational Expenditure (OPEX). The two have a crucial part to play in defining whether the use of electric vehicles in the Indian homes is affordable and long-term economical. Policymakers, consumers, and infrastructure planners should have a clear understanding of these cost components to plan powerful support mechanisms and strategies [8-9].

2.1 Capital Expenditure (CAPEX)

The **initial investment** required to set up a home EV charging facility varies depending on the type of vehicle, the charging speed required, and the existing electrical infrastructure of the residence. In India, the common components contributing to capital costs include:

- **Level 1 Charger (Slow Charging)**:
  This typically involves using a standard **15-ampere (15A)** household socket, which is already present in most Indian homes. While this setup is economical, with costs ranging from ₹5,000 to ₹10,000 (for socket enhancement and safety integration), charging time is long—often exceeding 8–10 hours for electric cars. This method is more suited for **two-wheelers** and **users with low daily commute**.
- **Level 2 AC Charger (Moderate to Fast Charging)**:
  Level 2 chargers require dedicated equipment and wiring to deliver higher power (generally 3.3–7.2 kW). These chargers **reduce charging time significantly**, making them ideal for four-wheelers. In India, branded Level 2 AC chargers cost between **₹25,000 and ₹60,000**, depending on features like weatherproofing, smart connectivity, and integration with mobile apps.
- **Electrical Panel Upgrades and Wiring Costs**:
  Many Indian homes, especially older constructions, may lack the required electrical load capacity or separate circuit protection. In such cases, **upgrading the distribution board**, adding a dedicated power line, and installing circuit breakers or residual current devices (RCDs) can add **₹10,000 to ₹50,000** to the setup cost. This is especially common in urban apartments and Tier II city homes.
- **Optional Smart Infrastructure**:
  Advanced users may opt for **smart meters**, surge protectors, Wi-Fi-enabled control units, and solar inverter integration for optimal energy usage. While not mandatory, these add-on components can improve charging efficiency and provide real-time energy tracking. Such smart accessories can cost an additional ₹5,000 to ₹25,000.

While these expenditures may be manageable for upper-income households, they pose a significant **financial barrier** for middle-class and economically weaker segments. The absence of bundled financing options or targeted subsidies for home charging infrastructure further compounds this issue, making initial investment a **critical challenge** in the EV adoption curve.

2.2 Operational Expenditure (OPEX)

Once the charger is installed, the recurring cost of **electricity consumption** becomes the main operational consideration for EV users. These costs depend primarily on **state-wise residential electricity tariffs**, **vehicle battery capacity**, and **usage frequency**.

- **Electric Cars**:
  Consider a typical electric car with a **30 kWh battery**. If charged at an average residential tariff of **₹6/kWh**, the total cost for a full charge is approximately **₹180**. This charge typically provides a range of 200–250 km, depending on the vehicle and driving conditions. On a per-kilometre basis, the cost comes down to **₹0.7 to ₹0.9/km**, compared to **₹6 to ₹8/km** for petrol or diesel cars, resulting in **up to 80% savings** in fuel costs.

- **Electric Two-Wheelers**: With smaller battery sizes (typically 1.5 to 3 kWh), electric scooters and bikes incur **minimal charging costs**, often under **₹10 per charge**. This translates to less than **₹0.25 per km**, making electric two-wheelers highly economical for daily commutes and deliveries.
- **Impact of Tariff Variation**: Electricity prices vary widely across Indian states. For instance, **Delhi** offers lower residential tariffs (~₹4.5/kWh), while in **Maharashtra** or **Karnataka**, prices can exceed **₹7–₹8/kWh** during peak hours. Additionally, few states have implemented **Time-of-Day (ToD) tariffs**, which could allow users to charge during low-demand hours at reduced rates, thereby lowering operational costs further.
- **Additional Costs**: Users with smart chargers may incur minimal **network or software subscription fees** for app-based monitoring or cloud integration. Maintenance is usually low, although occasional servicing of connectors, circuit checks, or software updates may be needed annually.

Despite the significant **lifetime savings in fuel costs**, these benefits can only be realized if the home charging setup is used consistently, electricity rates remain stable, and infrastructure remains reliable. The operational cost advantage is most prominent for high-usage individuals such as office commuters, taxi aggregators, or logistics operators.

Summary:
While the **operational costs of EV charging at home in India are significantly lower** than conventional fuel expenses, the **upfront capital expenditure** remains a major bottleneck. Without supportive financial tools or policy incentives, home charging may remain accessible only to higher-income groups, undermining the broader national goal of inclusive electric mobility. Hence, **both CAPEX and OPEX considerations must be addressed** simultaneously to ensure widespread adoption of home-based EV charging.

3. Challenges in the Indian Context

Although the idea of electric vehicles rapidly gains popularity in India and the awareness regarding their environmental and economic positivity, a number of structural and socioeconomic obstacles are on the way to the wide implementation of home-based EV charging. The Indian situation is characterized by these issues more than the others because of special urban planning requirements, income gaps, housing status, and unsteady generation of electrical facilities. These obstacles are important to address to facilitate an inclusive, dependable, and affordable EV charging point at the domestic level.

3.1 Lack of Dedicated Parking in Urban Areas

Shortage of dedicated parking spaces in urban centres in India is one of the most burning issues of EV adoption in specific electrification of homes. Majority of the population, especially in Tier I cities such as Mumbai, Delhi, Bengaluru and Kolkata are residing within multi-storey apartment blocks, shared house accommodation or slum colonies that are unauthorized. There is no personal garage and parking space or personal spot. The electrical panels are common, and individual meters of electricity meters in parking facilities are not readily accessible. • Physical infrastructure, e.g. underneath cabling or the area to mount the chargers, is absent or not practical to install. Under these circumstances, it is logistically and legally cumbersome and even impossible to set up an EV charging point in an individual place with or without the assistance of Resident Welfare Associations (RWAs) and building developers and utility service providers.

3.2 Unregulated Installation Practices

Due to the absence of a **nationally enforced regulatory framework** for residential EV charger installation, many consumers rely on local electricians or untrained service providers to set up charging units. This leads to several risks:

- **Improper wiring** or lack of surge protection may result in fire hazards or equipment damage.

- **Lack of grounding or circuit isolation** can endanger user safety, especially in monsoon conditions or damp basements.
- **Non-compliance with DISCOM or Central Electricity Authority (CEA) norms** may lead to penalties or denial of power upgrades in the future.

The **lack of standardized protocols, certifications, or inspection mechanisms** not only compromises safety but also affects charger performance and long-term energy efficiency. Inconsistent installation also makes it difficult to integrate smart charging features or connect to centralized monitoring systems.

3.3 High Upfront Cost and Financing Gaps

Although the government is providing finance to buy an electric vehicle, many banks; the majority of the loan programs do not cover the surrounding mobility costs, e.g. purchase and installation of chargers, the electrical infrastructure upgrades. This leaves a financing gap which the consumer has to fill in totality. To a large number of middle-income families as well as lower-income families this comes as an additional load:

The average Level 2 charging installation would be cost ₹30,000 Like to ₹70,000 relying upon the intricacy of installations.

• This initial investment, in the absence of financing or subsidies, will make adoption

undesirable, even in the case of a subsidized EV. Vehicles and home charging units lack bundled finance, and consequently, their poor affordability will be a barrier among the first-time users of EVs or two-wheeler riders shifting to electric four-wheelers use.

3.4 Grid Reliability and Peak Load Concerns

Another major challenge is the **capacity and reliability of the local power grid**, especially in Tier II cities, semi-urban areas, and rural towns. These issues manifest in the following ways:

- **Frequent voltage fluctuations** can reduce charger life or impact charging speed.
- **Unplanned power cuts and load shedding** disrupt regular charging schedules.
- The **concentrated charging of multiple vehicles in the evening** (when people return home) can create **peak load pressure** on local transformers and distribution lines, leading to overheating or outages.

Unless **grid upgrades, demand response systems, or smart load management** strategies are implemented by DISCOMs, widespread residential charging could compromise grid stability and reduce consumer confidence in EV usability.

3.5 Awareness and Behavioral Barriers

Finally, the success of home-based EV charging also depends on **consumer awareness and behavioral adoption**, which remains low in many parts of India. Key gaps include:

- **Limited understanding of smart charging features**, such as scheduled charging, load balancing, and remote monitoring.
- **Lack of awareness about Time-of-Day (ToD) pricing** models, where electricity can be cheaper during off-peak hours (e.g., midnight to early morning).
- **Ignorance of safety protocols and best practices**, such as not using standard household extension cords or improperly ventilated charging spaces.

Many first-time users prioritize convenience over long-term cost optimization or safety, which can lead to suboptimal outcomes. For example, charging during peak hours can increase electricity bills and strain the grid, while ignoring maintenance can reduce charger lifespan.

Summary:
The challenges to home-based EV charging in India are multidimensional—ranging from **physical infrastructure and regulatory deficiencies** to **financial and behavioral limitations**. Addressing these requires a **holistic policy approach**, including updated building codes, public awareness campaigns, financing support, and active collaboration between housing societies, DISCOMs, and state governments. Only then can home-based EV charging be truly inclusive and scalable across India's urban and rural landscapes.

4. Policy Implications and Recommendations

4.1 Subsidies for Home Charger Installation

- Extend FAME-II or state EV policies to **include subsidies for home chargers**, especially in economically weaker sections.
- Include charger and installation costs in **vehicle loan packages**.

4.2 Regulatory Framework for Residential Charging

- The **Bureau of Indian Standards (BIS)** should establish mandatory safety and installation standards for home EV chargers.
- Make it mandatory for **new residential buildings** to be "EV-ready" with pre-installed charging conduits.

4.3 Support for Apartment and Rented Housing

- Introduce model guidelines for **Resident Welfare Associations (RWAs)** and builders on allowing common-area charging stations.
- Encourage shared charging points with **smart metering and billing systems**.

4.4 Time-of-Day Tariffs and Smart Charging

- State DISCOMs should implement **Time-of-Day (ToD) electricity tariffs** for EV users to incentivize off-peak charging (e.g., 10 PM–6 AM).
- Promote smart chargers that delay or manage charging based on real-time grid load.

4.5 Solar Integration and Rural Feasibility

- Promote bundling of **rooftop solar panels with EV charging** in homes to reduce long-term electricity costs.
- In areas with grid instability, promote **off-grid solar + battery charging stations** for home and community use.

5. Comparative Case Study: Delhi vs. Rural Uttar Pradesh

Factor	**Delhi (Urban Metro)**	**Rural UP**
Charger cost recovery	Faster (due to daily use)	Slower
Power supply reliability	High	Medium–Low
Space for installation	Limited in apartments	More availability

Factor	Delhi (Urban Metro)	Rural UP
Tariff structure	Time-of-day under discussion	Flat-rate prevalent
Awareness level	High	Low

This shows the **need for region-specific policies** rather than a one-size-fits-all approach.

6. Future Directions for India

The complete potential of electric mobility in India will require establishing an inclusive, comprehensive, and future-proof ecosystem in home-based EV charging. It is not only the physical infrastructure and subsidies that are involved but also the technological innovation, digital support systems, financing solutions, or the ability to manufacture domestically. The above strategic directions could play a crucial role in ensuring that EV charging of residential buildings will be economically viable and operationally sustainable anywhere in India.

6.1 Digital Platforms and Consumer Empowerment

The Indian government, along with private technology companies and startups, should promote the development of **centralized digital platforms and mobile applications** that:

- Help consumers **locate certified and affordable EV charger installers** in their local area.
- Allow comparison of **charging costs across regions and providers**.
- Offer **virtual assistance for charger selection** based on vehicle type, daily usage, and budget.
- Enable real-time **monitoring of home energy consumption**, charging status, and billing estimates.

Such platforms can play a pivotal role in **demystifying EV home charging** for first-time users, especially in Tier II and Tier III cities where digital penetration is high but technical literacy is variable.

6.2 AI-Based Energy Management Systems

The government ought to promote the use of Artificial Intelligence (AI)-based energy management systems to residential buildings and homes to promote effective power usage and optimize costs. Such systems are able to: • Charge a EV at off-peak time or when the sun is producing lots of power (households using rooftop solar). • Privileges automatic correction of power allocation to avoid overload. • Give predictive billing forecasts and energy budgeting. With the usage of AI tools it is possible to integrate them with smart meters and chargers and encourage intelligent load management which is also necessary to sustain grid stability with the increase of the EV penetration.

6.3 Green Financing for Chargers and Energy Infrastructure

There is a clear need to expand the **scope of green financing** in India beyond just electric vehicle purchases. **Public sector banks**, **non-banking financial companies (NBFCs)**, and **microfinance institutions** should introduce:

- **Bundled loans** that include both the EV and the cost of home charger installation, wiring upgrades, and optional smart systems.
- **Interest subvention schemes** or **zero-interest EMI options** for low-income EV buyers.
- **Pay-as-you-go (PAYG)** or **subscription-based models** for home charging equipment, where users pay a monthly fee instead of bearing full upfront costs.

These financing mechanisms can democratize access to EV charging infrastructure and accelerate adoption among economically weaker sections.

6.4 Boosting Indigenous Charger Manufacturing under Make in India

At present, a significant proportion of EV charger components are imported from countries like China or sourced from international OEMs. This dependence drives up costs and makes supply chains vulnerable to global market disruptions. To address this:

- The Indian government should include **EV chargers and related components** in the **Production Linked Incentive (PLI) schemes** to incentivize local manufacturing.
- Research and development (R&D) funding should be extended to **academic institutions, MSMEs, and startups** working on affordable, scalable, and modular charging solutions.
- Public procurement through organizations like **Energy Efficiency Services Limited (EESL)** should prioritize Indian-made chargers, creating volume demand and reducing prices through economies of scale.

Promoting domestic production will **lower installation costs**, create local jobs, and ensure **greater customization** of chargers to suit Indian residential conditions.

7. Conclusion

India's dream of becoming a global hub for electric mobility is far-fetched unless home-based EV charging is strongly supported. At least 80 percent of private EV users are likely to consider this method convenient, cost-effective, and scalable, given the availability of charging in multiple parking locations. The financial feasibility of this model lies in reducing infrastructure costs, improving operational efficiency, and reaching various housing categories and income groups.

A multi-stakeholder approach is essential to address the current challenges. The central and state governments must strengthen regulatory frameworks and provide financial incentives to promote residential installations. DISCOMs need to modernize grid infrastructure and facilitate smart load management. Urban developers should be mandated to incorporate EV-readiness into housing projects, while green loans offered by financial institutions should also cover the cost of charging systems.

By coordinating infrastructure development, policy support, financing mechanisms, and consumer education, India can build an inclusive and resilient home charging ecosystem. This will not only accelerate EV adoption but also significantly contribute to making the country energy-secure, climate-conscious, and economically empowered.

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