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Editorial

Roadblocks in India's Electric Vehicle Push

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ABSTRACT

India's tactical spindle toward electric mobility, in line with its condescending commitment to attain net-zero greenhouse gas emissions by 2070, signifies one of the most complex socio-technical transitions endeavoured by an emerging economy. Decarbonizing the transport sector is a dual imperative triggered by the need for domestic economic growth and environmental stewardship, especially among the nations of the Global South. This article provides a comprehensive, multi-dimensional analysis of the fundamental roadblocks currently delaying India's electric vehicle (EV) deployment as envisaged by the policy makers and the industry leaders. It analyses the geopolitical vulnerabilities of the upstream mineral supply chain, the massive grid synchronization issues linked to localized charging spikes, the macroeconomic challenges of capital allocation and high upfront acquisition costs, and the structural design deficits in urban infrastructure. The article also provides a tentative framework of strategic action points designed to bridge the policy-practice gap, accelerate localization, and insulate India's EV ecosystem from global and domestic shocks.

KEYWORDS: Electric Vehicle, Decarbonization, Sustainability, Emerging Economies, India

INTRODUCTION

The scale and structure of India's transport sector demand deep structural changes if the nation is to meet its decarbonization goals by 2070. Globally, investment in energy transitions has fast-tracked dramatically, with cross-sector electrification driving a surge in clean technology

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deployment. Yet, while global leaders like China and the United States command 50% and 25% of the global EV market share respectively, India hangs at a modest 5% currently. This deficiency highlights a massive gap between India's regulatory intent and its industrial output.

The core structure of India's mobility market varies fundamentally from the Western economies. While Western EV adoption has focused on four-wheeled passenger vehicles, India's vehicular density is overwhelmingly dominated by two-wheelers (motorcycles and scooters) and three-wheelers (auto-rickshaws), which account for over 80% of total vehicular movement. Consequently, the supply chain dynamics, consumer price sensitivities, and infrastructural requirements of the Indian market are highly distinct and relatively contextual.

Transitioning this unique fleet away from Internal Combustion Engines (ICE) introduces broad, complex shifts across the automotive supply chain (Jagani et al., 2024). Automotive component suppliers who have historically spent decades optimizing production processes for ICE vehicles must now pivot completely to meet the growing demands of EV production (Jagani et al., 2024). This transition is highly vulnerable to disruption, pigeon-holed by evolving regulations and an infrastructure that remains under stress due to inadequacy (Jagani et al., 2024).

UPSTREAM VALUE CHAIN SUSCEPTIBILITIES

At the core of India's structural roadblocks is its high dependence on imported core components, specifically lithium-ion battery cells. The fundamental differences between traditional ICE and modern EV supply chains illuminate the vulnerabilities India faces as reflected in the table below.

Table 1: Distinctive Features of ICE and EV Supply Chain Ecosystems

Feature	ICE Supply Chain	EV Supply Chain
Primary Raw Materials	Steel, Aluminum, Plastic	Lithium, Cobalt, Nickel, Manganese
Role of Suppliers	Straightforward, modular components	Complex, software-integrated electronics
Supply Chain Resilience	High; diversified global sourcing	Vulnerable; highly concentrated markets

Technology Lifecycle	Mature; slow incremental changes	Evolving; rapid chemical shifts
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(Source: Jagani et al., 2024)

India's current domestic production capacity satisfies only about 20% of its domestic demand for lithium-ion batteries. Extreme reliance on imports drives up overall vehicle production costs and leaves the domestic market highly exposed to supply chain bottlenecks induced by geopolitical developments. About 85% of the world's known lithium ores are controlled by just three nations: Australia, Chile, and China. Because China commands roughly 60% of global battery production capacity, Indian Original Equipment Manufacturers (OEMs) operate in a state of structural disadvantage. Recent global supply chain shocks—from pandemic-induced disruptions to major geopolitical conflicts—highlight the fragility of relying on highly concentrated, non-localized resource channels.

While the Indian government has used the Production Linked Incentive (PLI) scheme for Advanced Chemistry Cell (ACC) battery storage to catalyse domestic manufacturing, translating these fiscal incentives into operating gigafactories takes years. The domestic value chain remains highly vulnerable to raw material price volatility. Without home-grown extraction, refining capabilities, or long-term off-take agreements for unrefined lithium, cobalt, and nickel, India's EV sector remains highly exposed to external geopolitical pressures.

MIDSTREAM INFRASTRUCTURE CONSTRAINTS

The deployment of a reliable public charging network is a primary prerequisite for widespread EV adoption. In India, this midstream segment faces unique challenges tied to urban spatial constraints, financial risks, and grid engineering limitations.

Urban Congestion and Land Acquisition

Deploying public charging infrastructure in high-density large Indian cities like New Delhi, Mumbai, and Bengaluru involves navigating severe spatial and regulatory hurdles. Urban planners must operate within high population densities, limited physical space, and a highly fragmented regulatory environment. The public charging network planning process requires balancing a variety of competing local parameters: The financial realities of urban real estate create severe barriers. Building and maintaining a network of public EV charging stations requires massive upfront capital investments, while the long-term returns on investment remain

highly volatile and difficult to project. Because land acquisition costs in Tier-1 cities are exceptionally high, charge point operators (CPOs) face long, uncertain paths to financial viability. This risk profile frequently deters private developers from entering the market without heavy government subsidies.

High Upfront Costs and Financing Constraints

The Indian automotive market is exceptionally sensitive to initial purchase prices. The upfront cost of an electric vehicle in India remains significantly higher than its ICE counterpart, primarily driven by the cost of the imported battery pack. While the Total Cost of Ownership (TCO) over a five-year lifecycle can favor EVs due to lower per-kilometer fuel costs, the high initial purchase price deters most conventional retail buyers.

This issue is compounded by a cautious, conservative financing environment. Indian banks and Non-Banking Financial Companies (NBFCs) view EVs as high-risk assets. This risk perception stems from three factors:

- The historical lack of a robust secondary or used market for EVs, making residual asset value highly uncertain.
- Concerns regarding the long-term degradation of battery health under extreme tropical climate conditions.
- The evolving regulatory landscape surrounding vehicle registration, battery standards, and subsidies.

As a result, EV buyers face higher interest rates, increased down-payment requirements, and shorter loan tenures compared to buyers of conventional vehicles. This credit friction slows down adoption rates among commercial fleet operators and low-to-middle-income consumers, who rely heavily on affordable financing.

Second-Life and Recycling Bottlenecks

As the initial waves of early-adoption EVs reach the end of their operational lifecycles, India faces an impending surge of spent lithium-ion batteries. Managing these retirement volumes requires a highly coordinated approach to circular economy practices, specifically through Second-Life Battery (SLB) applications and closed-loop material recycling. It has been observed that when an EV battery pack degrades to approximately 70% to 80% of its original

capacity, it is no longer sufficient for the high-power, long-range demands of automotive propulsion. However, substantial serviceable capacity remains, making these packs excellent runners for less demanding, stationary energy storage roles. In an economy like India's—where power outages are common, power demands are high, and renewable energy integration is expanding—second-life batteries can serve as highly cost-effective backup power systems for homes, commercial facilities, and telecom towers, while simultaneously stabilizing the local grid. Despite this clear potential, India's midstream and downstream value chains have been slow to scale SLB strategies due to several key systemic barriers.

MANUFACTURING CAPABILITIES AND WORKFORCE DEFICITS

The domestic industrial ecosystem lacks the technical maturity and specialized workforce required to execute a high-velocity shift to electric mobility. Advanced manufacturing metrics within India's EV sector continue to lag global benchmarks, highlighting an urgent need for targeted capital investments and specialized technical training programs. Further, domestic manufacturing deficit is deeply knotted to a historical dependence on manual or semi-automated legacy assembly lines. While international leaders leverage fully automated, robotic assembly setups to optimize quality control and production speed, much of the Indian manufacturing sector has been slow to implement the emerging technologies. Adopting advanced manufacturing technologies—such as automated precision welding, robotic battery cell assembly, and AI-driven quality inspection systems is essential to reduce production errors, cut manufacturing costs, and eliminate heavy reliance on imported sub-assemblies.

Apart from physical factory infrastructure, India faces a severe workforce skill deficit. The design, assembly, servicing, and maintenance of high-voltage EV architectures require a fundamentally different set of competencies than traditional ICE vehicle production. Modern EV manufacturing demands deep expertise in high-voltage electrical safety and power electronics engineering; advanced chemical composition monitoring and thermal management design; and embedded software engineering for intelligent Battery Management Systems (BMS).

The domestic labor market currently lacks a scaled pipeline of technicians and engineers trained in these specialized disciplines. Without a comprehensive overhaul of technical training curricula and close collaboration between academic institutions and industrial OEMs, the lack of skilled personnel will continue to limit production quality, slow down factory execution, and raise workplace safety risks across the domestic EV ecosystem.

STRATEGIC ACTION POINTS

To resolve interconnected bottlenecks and accelerate the transition toward a stable, self-sustaining electric vehicle ecosystem, India must adopt a series of highly targeted structural, regulatory, and financial interventions as discussed below.

- **Establish a National Sovereign Critical Minerals Fund:** India must aggressively pursue equity ownership in overseas lithium, cobalt, and nickel mining assets through public-private joint ventures. This must be paired with bilateral agreements with resource-rich nations across the "Lithium Triangle" (Argentina, Bolivia, Chile) and Australia to secure long-term, unrefined material supply chains.
- **Accelerate Domestic Refining Infrastructure:** Provide explicit fiscal incentives and fast-tracked environmental clearances for the construction of domestic chemical processing plants capable of refining crude lithium concentrates into battery-grade Lithium Hydroxide and Lithium Carbonate, thereby bypassing third-party refining dependencies.
- **Standardize Battery Dimensions and Communication Protocols:** Formulate strict Bureau of Indian Standards (BIS) mandates for uniform physical form factors, terminal placements, and software communication interfaces for batteries used in the two-wheeler and three-wheeler segments. This step is critical to enable interoperable battery-swapping networks at scale, minimizing localized grid impacts and drastically reducing consumer range anxiety.
- **Introduce Government-Backed Risk-Sharing Facilities:** To lower the cost of capital, the Ministry of Finance, in partnership with multilateral development institutions (such as the World Bank or SIDBI), should launch a first-loss default guarantee fund. This mechanism will cushion commercial banks and NBFCs against defaults, lowering interest rates and expanding credit availability for retail and commercial EV buyers.
- **Enact a Comprehensive Second-Life Battery Framework:** The Ministry of Environment, Forest and Climate Change must expand the Extended Producer Responsibility (EPR) rules to mandate functional state-of-health tracking for automotive batteries. Introduce official technical standards for safe disassembly, diagnostic categorization, and re-certification of spent vehicle batteries for stationary grid storage applications, rendering second-life deployment more economically attractive than early-stage destructive recycling.

- **Drive Industry-Wide Automation via Targeted Tax Incentives:** Offer accelerated depreciation benefits and customized customs duty exemptions for domestic component suppliers upgrading to fully automated, robotic assembly lines. This intervention will bridge the quality gap and lower domestic manufacturing costs relative to global market leaders.
- **Launch National EV Skilling Centers of Excellence:** Establish public-private partnerships between the National Skill Development Corporation (NSDC), premier engineering institutions (IITs/NITs), and automotive OEMs to create certified, standardized training programs focused on high-voltage systems safety, advanced cell diagnostics, and digital power electronics management.

CONCLUSION

India's shift to electric vehicles stands at a critical transition point. While initial consumer interest and introductory policy frameworks have established an early market presence, deep structural roadblocks across the upstream, midstream, and downstream value chains threaten to slow long-term progress. Resolving these challenges requires moving past disjointed, reactive policy measures and embracing a highly coordinated strategy that treats the vehicle, the distribution grid, the upstream mineral supply, and the downstream end-of-life ecosystem as a single, unified system. By quickly localizing advanced manufacturing capabilities, standardizing key technical architectures, securing resilient material supply lines, and creating dedicated financial de-risking mechanisms, India can create a highly robust, economically viable, and wholly self-sustaining electric mobility ecosystem capable of attaining its ambitious net-zero commitments by 2070.

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