Laneshift

THE CLIMATE PLEDGE | C40 CITIES

Electrifying Indian Highways: A Guidance Framework for Zero-Emission Freight

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ACKNOWLEDGEMENT

This report was developed by C40 Cities with the support of The Climate Pledge (co-founded by Amazon) under the Laneshift Programme. The Laneshift Programme is a global initiative by C40 Cities and The Climate Pledge that accelerates the transition to zero-emission freight by scaling electric truck deployment and fostering collaborations across the e-freight ecosystem in India and Latin America. The Climate Pledge provided strategic guidance and programmatic support to advance the zero emission freight agenda in India, including enabling cross-sector collaboration and supporting the Bengaluru-Chennai zero emission truck demonstration project. Their contribution was central to informing the development of this guidance framework.

C40 Cities gratefully acknowledges the peer reviewers for their valuable inputs and constructive feedback, which significantly strengthened the analytical depth and practical relevance of this report. Their detailed reviews, technical insights, and thoughtful recommendations — drawn from expertise across government, development organisations, industry, and academia — helped refine the framework and enhance its applicability for policymakers and industry stakeholders.

This report was developed with KPMG serving as the technical partner, who provided critical support across research design, data analysis, pilot coordination, and synthesis of findings into a comprehensive guidance framework.

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FOREWORD

It is my privilege to extend this foreword for a report that marks an important milestone in India's journey toward freight decarbonisation. Laneshift's vision — to accelerate the adoption of zero-emission medium- and heavy-duty trucking — resonates deeply with our national priorities and with the work being advanced through the National Highways for Electric Vehicles (NHEV) programme.

India's national highways are more than transport arteries. They are the economic backbone of the nation, and increasingly, the foundation of our clean energy transition. With freight demand projected to reach nearly 9.6 trillion tonne-kilometres by 2050, the transition to zero-emission freight is not simply an environmental imperative — it is an economic, industrial, and strategic priority.

Through NHEV, a notable transformation has already begun. Evidence-based pilots, corridor testing, and collaborative frameworks are enabling national highways to evolve into advanced e-highways. The Laneshift demonstration on the Bengaluru–Chennai corridor — where electric trucks collectively covered over 200,000 kilometres across sectors including e-commerce, retail, pharmaceuticals, and auto components — provides clear evidence that electric freight is ready for mainstream deployment.

What this report gets right is its insistence on an end-to-end ecosystem view. Charging infrastructure alone is insufficient without grid readiness. Demand without infrastructure creates hesitation. Infrastructure without a trained workforce creates downtime. Every element must move together. The five-pillar framework emerging from Laneshift provides precisely this — a structured, evidence-based roadmap grounded in real operational data and measurable outcomes.

The designation of 20 priority highways under PM E-DRIVE creates a powerful starting point. This framework builds on that momentum. The continued collaboration with C40 Cities and allied institutions will be instrumental in advancing freight decarbonisation not only within India but also across emerging economies worldwide. I extend my gratitude to C40 Cities and all participating partners for their support in this collective endeavour. The highways we electrify today will define the economy we build tomorrow.

Abhijeet Sinha
National Program Director – Ease of Doing Business (EoDB) &
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FOREWORD

India’s freight sector is entering a decisive decade of transformation. Medium and heavy-duty trucks form the backbone of the country’s logistics economy yet they account for a disproportionate share of transport emissions, fuel consumption, and air pollution. With freight demand projected to grow fivefold by 2050, the transition to zero-emission freight is no longer optional but essential.

India stands at a pivotal moment of transition with long standing climate impacts. Electrifying freight corridors can reduce logistics costs, strengthen energy security, improve air quality, and advance India’s climate commitments. But achieving this at scale requires a coordinated ecosystem approach, one that aligns infrastructure, energy systems, financing, workforce readiness, and public policy, moving beyond electric truck deployment.

This report, developed under the Laneshift Programme by C40 Cities in collaboration with The Climate Pledge, co-founded by Amazon, marks an important step in catalysing the freight ecosystem. Grounded in real-world data from the Bengaluru–Chennai electric truck demonstration project, the report provides practical, evidence-based guidance for developing EV-ready freight highways across India. Spanning across five interconnected pillars: highway profiling, demand enablement, infrastructure creation, operations optimisation, and just transition, the report outlines pathways for electric trucks to achieve operational competitiveness along with environmental benefits.

India is uniquely positioned to lead the global transition to sustainable road transport, and the groundwork is already being laid. Landmark initiatives such as PM E-DRIVE and the designation of priority freight corridors reflect the Government’s unwavering commitment to clean, future-ready infrastructure, placing India at the vanguard of emerging economy nations charting a credible path to net-zero mobility. This framework builds on that momentum, offering a replicable blueprint for an interconnected national network of EV-ready highways.

C40 acknowledges the engagement and support extended by KPMG in developing this framework and whose insights shaped this work. C40 looks forward to further supporting the acceleration of transition toward a future that is cleaner, greener, and more equitable for all.

Naim Keruwala
Regional Director, South and West Asia
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ABBREVIATIONS AND ACRONYMS

3PL	Third-Party Logistics
ADAS	Advanced Driver Assistance System
ADTT	Average Daily Truck Traffic
AI	Artificial Intelligence
ASDC	Automotive Skills Development Council
B2B	Business-to-Business
BaaS	Battery as a Service
BEE	Bureau of Energy Efficiency
BET	Battery Electric Truck
BHEL	Bharat Heavy Electricals Limited
BLR–MAA	Bengaluru–Chennai
CaaS	Capacity-as-a-Service
CCTV	Closed Circuit Television
CESL	Convergence Energy Services Limited
CFS	Container Freight Station
CNG	Compressed Natural Gas
CPO	Charge Point Operator
CPSE	Central Public Sector Enterprises
DFI	Development Finance Institutions
DG	Diesel Generator
DISCOM	Distribution Company
DT	Distribution Transformer
e-2Ws / e-3Ws / e-4Ws	Electric two-wheelers, electric three-wheelers, electric four-wheelers
e-FAST	Electric Freight Accelerator for Sustainable Transport - India
e-LCV	Electric Light Commercial Vehicle
e-MHDT	Electric Medium- and Heavy-Duty Trucks
EV	Electric Vehicle
EV PCS	Electric Vehicle Public Charging Station
EVCI	Electric Vehicle Charging Infrastructure
FLDG	First Loss Default Guarantee
FMCG	Fast-Moving Consumer Goods
GCC	Gross Cost Contract
GDP	Gross Domestic Product
GESI	Gender Equality and Social Inclusion
GHG	Greenhouse Gas
GIS	Geographic Information System
GST	Goods and Services Tax
GVW	Gross Vehicle Weight
HGV	Heavy Goods Vehicle
HT	High tension
IC	Infrastructure Concessionary
ICD	Inland Container Depot
ICE	Internal Combustion Engine
IHMCL	India Highways Management Company Limited
INR	Indian Rupee
IoT	Internet of Things
kWh	Kilowatt-hour

LCV	Light Commercial Vehicle
LED	Light Emitting Diode
LNG	Liquified Natural Gas
LSP	Logistics Service Provider
MCS	Megawatt Charging Station
MHDT	Medium- and Heavy-Duty Trucks
MHI	Ministry of Heavy Industries
MoP	Ministry of Power
MoRTH	Ministry of Road, Transport and Highways
MSDE	Ministry of Skill Development and Entrepreneurship
MW	Megawatt
NBFC	Non-Banking Financial Companies
NDC	Nationally Determined Contribution
NH	National Highway
NHAI	National Highways Authority of India
NHFN	National Highway Freight Network
NHLML	National Highways and Logistics Management Limited
O&M	Operations and Maintenance
O-D	Origin-Destination
OEM	Original Equipment Manufacturer
PM	Particulate Matter
PM E-DRIVE	PM Electric Drive Revolution in Innovative Vehicle Enhancement
PoI	Point of Interest
PPA	Power Purchase Agreement
PPP	Public-Private Partnership
PSM	Payment Security Mechanism
PWD	Public Works Department
RE	Renewable Energy
RO	Retail Outlet
ROI	Return on Investment
RPO	Renewable Purchase Obligations
RSF	Risk Sharing Facility
SEWA	Self Employed Women's Association
SEZ	Special Economic Zone
SIDBI	Small Industries Development Bank of India
SME	Small- and Medium-sized Enterprise
SNA	State Nodal Agency
SOC	State of Charge
SOH	State of Health
TaaS	Truck-as-a-Service
TAT	Turnaround Time
TCO	Total Cost of Ownership
UPEIDA	Uttar Pradesh Expressways Industrial Development Authority

EXECUTIVE SUMMARY

India must electrify its freight highways to avoid a diesel-driven future that threatens both climate goals and economic competitiveness.

India's freight sector is poised for transformation, with freight demand set to grow five times to 9.6 trillion tonne-kilometres and fleet size reaching ~17 million by 2050.[1] This surge is expected to be driven by rapid urbanisation, industrial expansion, growth of e-commerce and gross domestic product (GDP) growth, leading to increased demand for goods and freight. As road transport carries nearly 70% of India's freight[2], the increase in freight demand will lead to an increase in the fleet of medium- and heavy-duty trucks (MHDTs) across India.

Continued reliance on diesel-powered trucking could increase air pollution, global greenhouse gas (GHG) emissions, and India's oil import requirements, while also exposing businesses to fuel price volatility. Timely measures can help mitigate these challenges, strengthen India's energy security, maintain economic competitiveness, and support progress toward the nationally determined contributions (NDCs), which target a 45% reduction in emissions intensity by 2030.

Various technologies, such as liquified natural gas (LNG), hydrogen fuel cells and other low-carbon fuels are emerging as alternatives to the internal combustion engine (ICE) trucks. While most of these technologies are still nascent, battery electric trucks (BETs) have emerged as a suitable alternative, as the technology has matured globally and proven itself across segments such as e-2Ws, e-3Ws, e-4Ws, and e-light commercial vehicles (e-LCVs). Electric trucks are fast approaching total cost of ownership (TCO) parity with diesel counterparts and, more importantly, offer GHG emissions reduction and air quality improvement through zero tailpipe emissions, contributing to substantial reductions in particulate matter (PM), and nitrogen oxides, which can go a long way in supporting India's climate goals.

Thus, BETs offer a strategic pathway to decarbonise freight while supporting economic growth, mitigating emissions, reducing operating costs, and aligning India's logistics sector with global sustainability trends. Yet, despite the broader electric vehicle (EV) momentum, electric commercial vehicles[3] comprised only ~1.10% of India's annual sales until 2024.[2]

India's BET market is emerging, but low adoption in the e-MHDT segment and fragmented pilots highlight the need for ecosystem-level interventions.

Despite strong momentum in India's broader EV market, the uptake of electric medium- and heavy-duty vehicles (e-MHDTs) remains at an early stage of adoption. In 2024, of the 274,407 total MHDTs sold, only 166 were electric.[4] This limited uptake underscores the hurdles in transitioning the freight segment to BETs, including the dominance of diesel vehicles, tight operational margins, high upfront costs, inadequate charging infrastructure, and range and performance concerns.

Recognising the importance of building momentum, NITI Aayog launched the electric freight accelerator for sustainable transport (e-FAST) as India's first platform to facilitate collaboration between government stakeholders and private sector partners. To further catalyse adoption, the Government of India launched the PM E-DRIVE scheme in 2024, earmarking INR 5 billion (~US$ 56 million) in capital incentives specifically for e-trucks.

Alongside these capital incentives to accelerate BET adoption, the PM E-DRIVE scheme has also introduced guidelines for deploying superfast charging infrastructure (≥ 240 kW) along highways to enable e-freight, coupled with incentives for developing upstream electrical infrastructure. These measures are expected to establish fast-charging networks along key industrial highways, supporting mid- to long-haul e-freight operations.

While these initiatives have laid the groundwork for BET deployment, the scale of transformation requires planning that brings together all ecosystem players to aggregate demand, optimise charging deployment and build investor confidence.

Building EV-ready freight highways can unlock the scale for e-truck deployment.

Freight operations are defined by predictable turnaround times (TATs). For BETs to achieve quick turnarounds, they must operate within ecosystems that offer reliable charging access, and seamless integration with existing freight flows. Highway-based planning can enable end-to-end ecosystems where BETs can move without bottlenecks.

Dedicated EV highways eliminate operational uncertainty and can accelerate freight electrification. Strategically located EV charging infrastructure (EVCI) along dedicated EV highways alleviates concerns on BETs range and charger availability and facilitates mid- to long-haul freight. Coordinated power distribution planning is needed to mitigate grid constraints, thus ensuring high charger uptime. It also helps logistic service providers (LSPs) meet the stipulated TATs for freight delivery, which is a critical performance metric for businesses such as e-commerce, retail, pharmaceuticals, etc.

The Ministry of Heavy Industries (MHI) listed 20 national highways in its operational guidelines for PM E-DRIVE as priority routes for establishing truck charging infrastructure. These include highways such as Delhi–Chandigarh, Bengaluru–Chennai, and Ahmedabad–Mundra.

While the identification of priority highways marks a significant step toward electrifying freight, the creation of a truly enabling ecosystem remains a work in progress. Key elements such as charging infrastructure deployment, grid readiness, demand aggregation, and operational integration must be systematically addressed.

It is in this context that The Climate Pledge (TCP) and C40 Cities launched the Laneshift Programme, an international initiative to decarbonise freight movement in India and Latin America. The programme aims to accelerate the deployment of zero-emission freight vehicles and set the foundation for electric freight (e-freight) highway development in India by 2030. As part of this programme, a first-of-its-kind ***EV highway project*** was conducted along the **Bengaluru–Chennai highway** to demonstrate techno-commercial feasibility of BETs, achieve stakeholder alignment on transition to e-freight, and inform a scalable guidance framework for developing BET-ready highways across India.

The Laneshift demonstration project on the Bengaluru–Chennai highway offers practical guidance on how India can operationalise its EV-ready highway vision.

The Bengaluru–Chennai (BLR–MAA) highway was selected for the demonstration project, based on a Laneshift Programme's study, which identified eight high-potential freight highways around Delhi, Mumbai, Pune, and Bengaluru. The Bengaluru–Chennai highway emerged as a high-priority route due to its significant freight volume coupled with strategic economic relevance. Connecting Chennai, a key port city, and Bengaluru, a major technological and industrial hub, the highway also benefited from existing charging networks along the route, and adequate grid capacity to support additional fast-charging station installations, making it an ideal candidate for e-freight pilot demonstration.

The highway served as a strategic testbed for e-freight, where ecosystem players could collaborate to validate the technical, commercial, and environmental performance of BETs, and provide an evidence-driven foundation for scaling electrification to other highways across the country.

As part of this demonstration project, a comprehensive effort was undertaken to bring together the entire electric freight ecosystem. Targeted consultations were conducted with businesses operating along the Bengaluru–Chennai highway to build awareness, understand operational needs, and identify potential participants for the pilot. In parallel, Laneshift engaged with key stakeholders across the

[1] NITI Aayog, RMI (2022) Transforming Trucking in India Pathways to Zero-Emission Truck Deployment.
[2] Vahan Dashboard
[3] Note: Electric commercial vehicles include e-LCVs and e-MHDTs.
[4] Vahan Dashboard

electric freight value chain, including truck manufacturers, logistics service providers (LSPs), and charge point operators (CPO), to co-design and implement the pilot. This collaborative approach successfully aligned critical partners, including Shippers, OEMs, LSPs, CPOs, and KPMG as the technical partner responsible for coordination, analysis, and pilot implementation along with the C40 Cities team.

Twenty e-trucks across the 14T, 19T and 55T gross vehicle weight (GVW) category were deployed under the "Trucking-as-a-Service" (TaaS) model. In this, the LSP owned and operated the BETs, deployed trained drivers, and leveraged a reliable network of high-speed charging infrastructure provided by the CPO partner. Leading businesses participated in this initiative as anchor customers, providing commercial loads to support and validate the pilot operations along the bengaluru–Chennai highway. A total of 600 trips have been completed, covering over 208,819 kilometres across six use cases, including e-commerce, retail, pharmaceuticals, auto ancillary, automotive and consumer electronics.

The demonstration project also emphasised on strengthening the service ecosystem and integrating gender equality and social inclusion (GESI) considerations. As part of this approach, consultations and primary surveys were conducted with 210 truck drivers, 50 garage owners, and multiple logistics service providers along the Bengaluru–Chennai highway. These efforts aimed to understand stakeholder needs, capture driver preferences and operational realities, and embed inclusive practices that reflect the diverse workforce within the freight sector. Further, GIS mapping and on-ground assessments were also carried out to evaluate infrastructure readiness, and for identifying optimal locations for deploying superfast charging stations, assessing grid capacity, and mapping logistics nodes to support seamless electric freight operations.

The pilot demonstrated that BETs could perform at parity with diesel trucks' performance, across varied payloads, routes, and operational requirements, while yielding environmental benefits.

The pilot established that BETs could deliver reliable technical and operational performance, with key findings including:

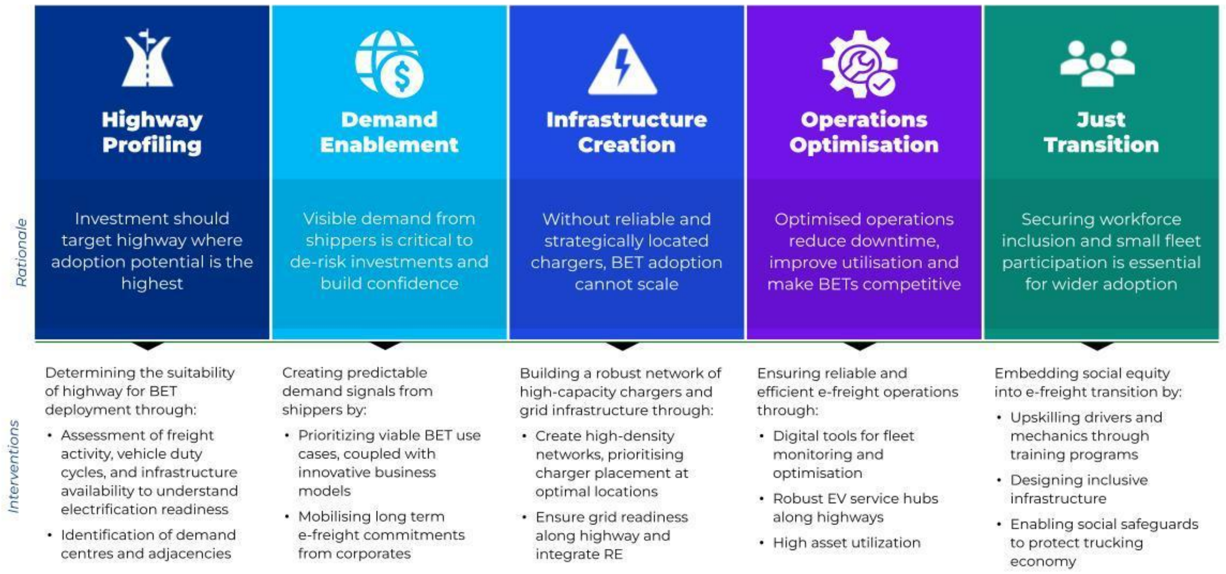
- **Range**: BETs achieved practical ranges of 200–250 kilometres, enabling long trips up to 400 kilometres with just one or two charging stops.
- **Turnaround Time (TAT)**: BETs matched or outperformed internal combustion engine (ICE) trucks on key routes. 14T and 19T BETs covered ~330 kilometres in under 10 hours (compared with 12 hours for ICE trucks). TAT remained competitive even on longer routes, though there were instances where dependence on slower chargers (60 kW) led to longer journey time.
- **Commercial Viability**: TCO of 55T BETs was found to be almost at par with ICE trucks. The TCO of 14T and 19T BETs are currently 10–24% higher than ICE trucks but are fast approaching parity.
- **Environmental Impact**: Over a 10-year lifespan, BETs can reduce 360–550 tCO_2e of emissions per vehicle across the 14T, 19T and 55T category. This potential increases significantly when using renewable energy-based charging.

While the pilot recognised the competitiveness of BETs, it also highlighted gaps in infrastructure that must be addressed to accelerate BET adoption at scale. Instances where the e-trucks had to rely on slow chargers increased the turnaround time by three to five hours. This reinforced the importance of adequate fast charging infrastructure at optimal locations along the highway. Further, it was also understood that availability of a trained driver and mechanic workforce will be critical to facilitate transition to e-freight at scale.

Insights from the pilot have been translated into a practical framework for building EV-ready freight highways.

Building on the insights and outcomes of the Laneshift Bengaluru–Chennai demonstration project, a comprehensive guidance framework was designed to guide the electrification of freight highways across India. This framework defines the **"What"** – the critical components required to make highways EV-ready; the **"How"** – a structured process for translating strategy into action; and the **"Who"** – the key stakeholders responsible for driving implementation at scale. Anchored in five foundational pillars, the framework offers a systematic approach to planning, deploying, and sustaining electric freight highways. These pillars include **Highway Profiling** – to assess operating conditions and electrification readiness of key highways across India; **Demand Enablement** – to catalyse market uptake of BETs; **Infrastructure Creation** – to ensure robust and reliable charging networks; **Operations Optimisation** – to integrate electric freight into mainstream logistics; and **Just Transition** – to embed equity and inclusion through targeted skilling and workforce development. Together, these pillars form a replicable blueprint for national rollout, enabling coordinated action across government, industry, and civil society. These actions must be initiated in tandem across all pillars to accelerate the transition to e-freight.

The illustration below presents the key pillars of the framework:



This framework lays out a structured approach to building EV-ready freight highways in India. Each pillar addresses a distinct barrier to adoption and together they form an ecosystem approach that integrates technology, infrastructure, business models, and social inclusion.

Highway Profiling

Rationale: Highway profiling focuses on understanding the existing operating conditions and electrification readiness of a designated highway. It establishes the analytical foundation to identify highways that are best suited for transitioning to e-freight.

Interventions: This pillar involves comprehensive assessment of freight activity, vehicle duty cycles, and infrastructure availability to determine highway suitability. Through detailed analysis of freight use-cases, truck volumes, logistics hubs, and adjoining industrial demand centres, profiling quantifies the potential for BET conversion and the corresponding charging and energy requirements. It also maps the supporting ecosystem, including existing depots, substations, land parcels for charging hubs, and way-side amenities, to identify existing infrastructure and the necessary upgrades. These insights directly inform investment decisions for CPOs and distribution companies (DISCOMs), guide deployment planning for fleet operators, and provide government agencies with a data-driven basis to coordinate highway-level actions.

Implementation Responsibility: Highway Profiling requires a coordinated effort between public and private actors. National agencies such as Ministry of Road Transport and Highways (MoRTH) and National Highways Authority of India (NHAI) can lead freight data consolidation and integrate EV-readiness criteria into highway development. Public-sector enterprises such as Bharat Heavy Electrical Limited (BHEL), as nodal agency under PM E-DRIVE, can facilitate mapping of existing and planned infrastructure along the highways, in collaboration with state utilities. The resulting output would serve as a national repository to enable evidence-based planning for highway electrification.

Demand Enablement

Rationale: Demand Enablement focuses on creating visible and sustained market demand for battery electric trucks (BETs) to unlock investment confidence and enable large-scale highway electrification.

Interventions: The process begins by identifying viable use cases where BETs can achieve high utilisation and a competitive TCO. These typically include high-frequency, predictable freight use cases such as FMCG, retail, e-commerce, and cement. Targeting such use cases demonstrates commercial viability early and creates anchor freight flows that can sustain high-capacity charging networks. To bridge the remaining viability gap, this pillar promotes policy interventions and innovative business models such as leasing, battery-as-a-service (BaaS), and risk-sharing facilities that reduce upfront costs and improve affordability. Corporate commitments from major freight buyers act as demand multipliers, accelerating private investment in fleet procurement and charging infrastructure. Together, these measures create the foundation for a self-reinforcing demand cycle that drives scale.

Implementation Responsibility: Enabling demand at scale requires coordinated action from both private and public stakeholders. Shippers and LSPs must generate visible demand signals through long-term contracts and fleet commitments. Central and state governments should deploy fiscal levers such as subsidies, tax incentives, and procurement mandates to make BETs cost competitive. Industry associations and platforms can facilitate aggregation of demand and promote shared utilisation of assets. Thus, Demand Enablement ensures that identified highways transition from scattered pilots to steady, scalable electric freight movement.

Infrastructure Creation

Rationale: Infrastructure Creation focuses on developing the physical backbone required to operationalise EV-ready highways – ensuring reliable, high-speed, and low-carbon charging networks that support seamless electric freight movement.

Interventions: This pillar centres on three critical enablers: charging infrastructure, grid capacity, and renewable energy integration.

- **Charging Infrastructure**: Using insights from highway profiling, CPOs can identify optimal sites near freight demand centres, depots, and rest stops. High-capacity chargers (240 kW and above) should be prioritised to minimise BET downtime and support long-haul operations.
- **Grid Capacity**: Grid readiness assessments help determine whether substations can reliably support clustered fast-charging demand. DISCOMs, in coordination with transmission utilities, can upgrade power infrastructure to ensure stable and scalable operations.
- **Renewable Energy Integration**: To align infrastructure with climate goals, renewable energy (RE) supply via open access or on-site solar and BESS can reduce lifecycle emissions of e-trucks. Policy levers such as Renewable Purchase Obligations (RPOs) for CPOs, concessional financing for green energy and storage, and dedicated viability-gap support can accelerate this transition.

Together, these measures ensure that trucks charge reliably and sustainably, making infrastructure the cornerstone of India's EV highway transformation.

Implementation Responsibility: Infrastructure creation requires coordinated action across energy and transport sectors. The Ministry of Power (MoP), state energy departments, and electricity regulators play a key role in enabling streamlined interconnection approvals and differentiated tariffs for high-speed charging. DISCOMs and transmission utilities are responsible for grid upgrades and capacity planning. CPOs can lead site selection and deployment of charging stations, while public-sector enterprises and nodal agencies under PM E-DRIVE can facilitate land allocation and infrastructure mapping. This collective effort ensures that infrastructure is not only available, but also future-ready and climate-aligned.

Operations Optimisation

Rationale: Operations Optimisation ensures that electric freight operations are reliable, efficient, and seamlessly integrated into the broader logistics ecosystem.

Interventions: This pillar focuses on two key enablers: digital enablement and service ecosystem readiness.

- **Digital Enablement:** LSPs, OEMs, and fleet aggregators can adopt digital fleet management tools and predictive analytics to maximise uptime, reduce turnaround times, and streamline operations. Real-time data sharing between CPOs and LSPs on charger availability and uptime enables route optimisation, while data exchange between LSPs and OEMs supports proactive monitoring of battery health and vehicle diagnostics.
- **Service Ecosystem Readiness**: Dedicated EV service hubs along major freight routes equipped with certified technicians, diagnostic tools, and roadside assistance can be developed through collaboration between OEMs, state transport undertakings, and private firms. These hubs build operational confidence and ensure service reliability across electrified highways.

Implementation Responsibility: OEMs and LSPs lead the adoption of digital tools and data-sharing protocols, while CPOs enable real-time charger visibility. State transport departments and private service providers can jointly develop EV service hubs, supported by central schemes under PM E-DRIVE. Industry platforms can facilitate interoperability standards and promote best practices across the logistics ecosystem.

Just Transition

Rationale: Just Transition ensures that the shift toward EV-ready highways is equitable, inclusive, and socially sustainable.

Interventions: This pillar focuses on workforce development, gender inclusion, and livelihood protection.

- **Skilling and Upskilling**: Programmes for drivers and mechanics are essential to adapt to electric drivetrains, EV diagnostics, and digital systems. Certification modules covering BET maintenance, battery safety, and telematics can be co-developed by the Ministry of Skill Development and Entrepreneurship (MSDE), Automotive Skill Development Council (ASDC), and leading OEMs.
- **Gender-Inclusive Infrastructure**: Charging hubs must incorporate gender-sensitive design features such as well-lit rest areas, hygienic sanitation blocks, and secure overnight parking to enable greater participation of women in logistics and service roles.
- **Livelihood Safeguards**: Communities dependent on the diesel freight economy such as roadside enterprises, repair shops, and food stalls can be supported through concessional financing, retraining programmes, and targeted inclusion in the EV value chain.

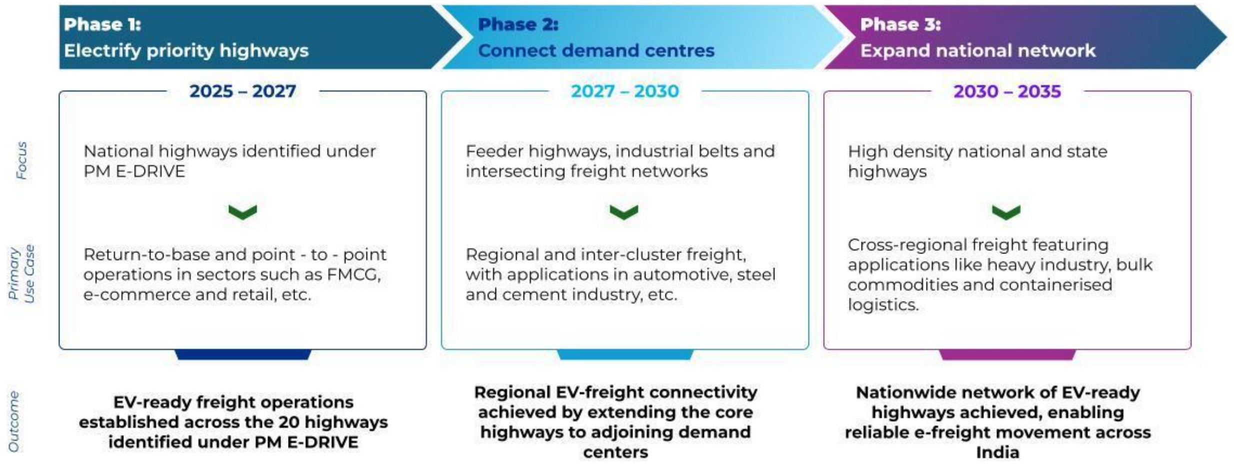
Implementation Responsibility: MSDE, ASDC, and OEMs can lead skilling initiatives, while state transport departments and training institutes integrate modules into existing curricula. NHAI and state highway authorities can mandate inclusive infrastructure design, and local governments can support livelihood transitions through targeted schemes and financial instruments.

Together, these five pillars offer a structured, ecosystem-based roadmap for building EV-ready freight highways across India. Each pillar addresses a key dimension, viz., planning, demand, infrastructure, operations, and inclusion, and their combined impact enables a coordinated national strategy. Grounded in real-world insights, this framework empowers India to scale electric freight with confidence, unlocking economic efficiency, environmental gains, and inclusive growth across its highway network.

India must take a phased approach to highway electrification, starting with priority highways and linking key adjacencies to build a national network.

Several elements of this framework have already been applied and tested under the Laneshift demonstration project on the BLR–MAA highway. This reinforces that the framework is practical, and the next step lies in scaling these learnings systematically across other national highways.

Scaling this transition to a nationwide network of EV-ready highways will require a phased and coordinated approach. The following roadmap presents an indicative pathway to guide sequencing and coordination among stakeholders. It provides a directional view of how the transition could unfold in phases, outlining broad timeframes, focus areas, freight use cases and the outcomes:



Phase 1 – Electrify Priority Highways (2025–2027)

The first phase focuses on electrifying 20 national highways identified by MHI under the PM E-DRIVE, translating India's policy commitment into visible infrastructure on the ground. This stage will ensure that these high-volume freight routes are equipped with reliable charging facilities, grid connectivity, and basic service infrastructure to support continuous e-freight movement.

The emphasis can be on return-to-base and point-to-point freight operations that offer predictable routes and controlled charging environments. These highways will serve as reference models that can offer a replicable blueprint for subsequent expansion.

Phase 2 – Connect Demand Centres (2027–2030)

Building on the electrified priority highways, the second phase would aim to extend coverage to adjoining regional and industrial demand centres, creating a regional EV-freight ecosystem. Many of India's freight flows originate from or terminate at ports, logistics parks, and industrial clusters located along the state or feeder highways. Expanding electrification into these linkages will enable regional and inter-cluster e-freight.

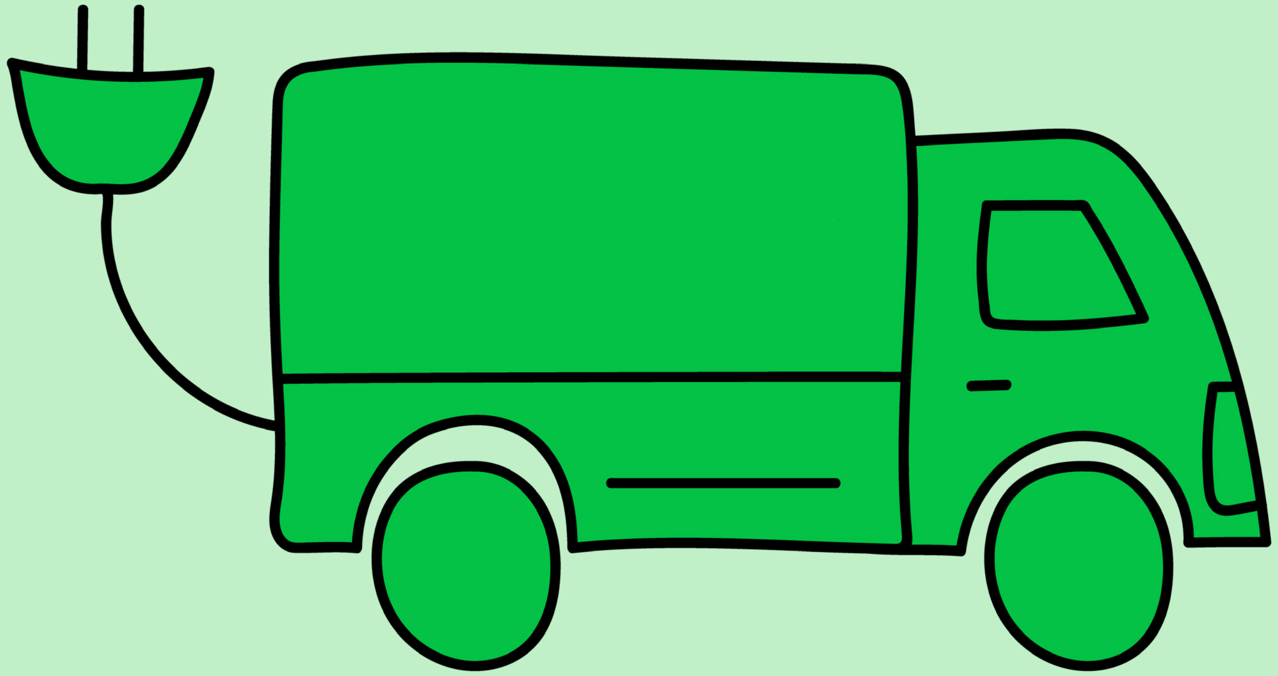
This phase represents a shift from highway-level readiness to network integration, ensuring interoperability between trunk and feeder routes.

Phase 3 – Expand National Network (2030–2035)

The third phase envisions the national scaling of India's EV-ready freight network, expanding electrification to additional high-density national and state highways, and creating seamless pan-India connectivity. This stage will consolidate lessons from earlier phases and the operational emphasis will shift to long haul inter-state movements. By this stage, e-freight is expected to be commercially mainstream.

Implementation of the phased roadmap will require close coordination between national agencies such as MHI, MoRTH, and NHAI for policy planning and highway development, state governments and DISCOMs for grid readiness and land availability, and private CPOs and LSPs for infrastructure deployment. Further, shipper associations, logistics providers, and financiers will have to play a critical role in aggregating demand and structuring viable business models. The detailed set of actions and implementing agency is provided in subsequent chapters of this report.

Together, the framework and roadmap offer a pathway for building an interconnected network of EV-ready highways. By aligning public investment, private participation, and institutional coordination, India can transform its freight highways into zero-emission growth highways supporting climate and energy goals but also boosting industrial competitiveness, logistics efficiency, and social inclusion across the country's transport economy. This transition will not only advance climate and energy goals but also strengthen industrial competitiveness, logistics efficiency, and social inclusion across the country's transport economy.



1 INTRODUCTION

India's freight demand is projected to rise fivefold by 2050, creating an opportunity to embed zero-emission trucking at scale.

India's freight sector is poised for a significant surge over the next three decades. Annual freight volume is expected to rise to ~9.6 trillion tonne-kilometres by 2050, driven by urbanisation, industrialisation, and the rapid expansion of e-commerce. Road transport (i.e., trucks) accounts for ~70% of domestic freight demand in India, which is in sharp contrast with other developed countries such as USA (37%), China (43%), and EU (45%)[5] – indicating a more balanced modal distribution of freight transport. Heavy- and medium-duty trucks (HDTs and MDTs) in India account for 76% and 21% of the road freight demand respectively.[1] As demand for freight grows in India, the size of the truck fleet itself is set to grow sharply, from around 4 million trucks in 2022 to ~17 million by 2050.[6] This unprecedented expansion underscores the freight sector's critical role in driving India's economic growth.

This growth comes with steep consequences. A diesel-heavy trucking future will intensify air pollution and increase GHG emissions. In 2023, MHDTs accounted for 40% of the total transport sector emission in India, with 126 million tonnes of CO_2 emitted.[7] As the MHDT fleet continues to grow, CO_2 emissions from trucks are projected to double by 2050.[4] A larger fleet of ICE MHDTs will also add to India's oil import bill and expose businesses to the volatility of global fuel prices. Without intervention, this cost disadvantage could widen further, impacting India's economic competitiveness and energy security. To avoid this lock-in, India must decarbonise its trucking fleet.

Although technologies such as LNG, hydrogen and other low-carbon fuels are gaining traction, Battery Electric Trucks remain the most practical and mature solution for decarbonising MHDTs.

Battery electric trucks (BETs) have emerged as a suitable alternative to ICE vehicles, as the technology has matured globally and proven itself across segments such as e-2Ws, e-3Ws, e-4Ws, and e-LCVs. In addition to being a mature and robust technology, BETs offer significant socio-economic benefits such as:

(i) **GHG emissions reduction** and **air quality improvement** through zero tailpipe emissions, contributing to substantial reductions in GHG, particulate matter (PM), and nitrogen oxides.

(ii) **Cost savings** by offering lower energy costs than their ICE counterparts, thus reducing the cost of logistics over a vehicle's lifetime.

(iii) **Energy security** by contributing to substantially decreasing oil imports.

BET adoption is being led by e-LCVs, while uptake among e-MHDTs remains limited.

While EVs in India have seen rapid uptake in other segments such as passenger vehicles and light commercial vehicles (LCVs), the market for electric medium- and heavy-duty trucks (e-MHDTs) is still nascent. Across all segments of trucks, electric commercial vehicles presently constitute only ~1.10%[8] of annual sales until 2024, which is dominated by e-LCVs. This has largely been due to high upfront costs of e-MHDTs, limited models and variants of e-trucks in the market, limited fast charging infrastructure, and lack of overall demand for long-haul e-freight from shippers.

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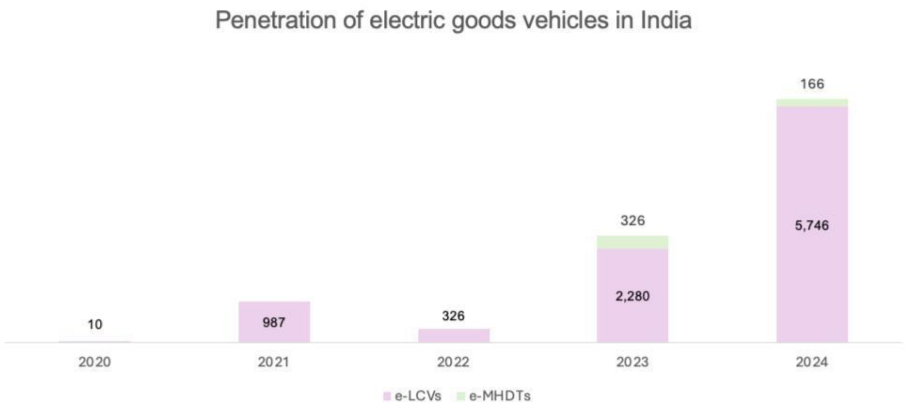
[5] MHI ICCT Report – Roadmap for electric trucks in India.
[6] NITI Aayog, RMI (2021) Fast tracking freight in India. A roadmap for clean and cost-effective goods transport.
[7] International Energy Agency, NITI Aayog (2023) Transitioning India's Road Transport Sector. Realising climate and air quality benefits.
[8] Vahan Dashboard

Figure 1. Sales of e-LCVs and MHDTs in India[9]



Recognising the importance of building momentum, Niti Aayog launched [Electric Freight Accelerator for Sustainable Transport (e-FAST)] as India's first platform to facilitate collaboration between government stakeholders and private sector partners comprising original equipment manufacturers (OEMs), logistic service providers (LSPs), financers, charge point operators (CPOs), businesses, and others to shape strategies and actions that support freight electrification at scale, particularly in the medium- and heavy-duty vehicle segments.[10]

To further the adoption of e-freight in India, the Government of India announced demand incentives for BETs under the PM E-DRIVE scheme in 2024 to spur adoption of e-trucks in the MHDT category. For the first time, capital incentives of INR 5 billion (~US$ 56 million) have been earmarked specifically for electric trucks, aimed at supporting the purchase of ~5,600 e-MHDTs. Incentives are structured around battery size, vehicle cost, and weight category, and linked to the scrapping of older diesel trucks to ensure genuine fleet transition.[11] In addition, as part of the PM E-DRIVE scheme, guidelines have also been provided for deploying superfast charging infrastructure (≥ 240 kW) along highways to support e-freight, along with incentives for development of upstream electrical infrastructure. These measures mark significant steps in creating a market for e-trucks.

Highway-based planning is key to scaling BETs, as it concentrates demand, eliminates operational uncertainty, and creates the conditions for early markets to succeed.

Unlike passenger vehicles, trucks operate on tight TATs, and delays can have financial implications. Freight routes demand predictable charging access and minimal downtime. In the absence of such enablers, logistics operators perceive BETs as a risk to business continuity, even when TCO may eventually favour them. Thus, BETs must operate within ecosystems that offer reliable charging access, and seamless integration with existing freight flows. Highway-based planning creates end-to-end operational ecosystems where BETs can move without bottlenecks.

Dedicated EV highways eliminate operational uncertainty and can accelerate freight electrification. Strategically located EV charging infrastructure (EVCI) along these highways addresses concerns on range of BETs and availability of chargers to facilitate mid to long-haul freight. Coordinated power distribution planning helps mitigate grid constraints, thus ensuring high charger uptime. It also helps LSPs meet the stipulated TATs for freight delivery, which is a critical performance metric for businesses such as e-commerce, retail, pharmaceuticals, etc.

As such, highway-based planning is globally emerging as a viable approach. The USA has developed its zero-emission freight highway strategy, through which it aims to align public policy and investments by prioritising infrastructure deployment along the National Highway Freight Network (NHFN). The strategy aims to begin by electrifying all major ports, inland industrial and logistics hubs and key industrial highways covering 23% of NHFN, and ultimately achieve electrification of up to 94% of NHFN.[12] Similarly, China is also developing BET-ready highways. SANY Heavy Truck has developed a 900-kilometre-long highway connecting Tianjin, Beijing, Hebei Province, and Inner Mongolia as BET-ready by deploying 12 charging stations and 5 direct service hubs.[13] Additionally, China is also developing an extensive network of battery swap stations along its major highways to promote long-haul e-freight.[14]

Thus, building on lessons from global examples, it is understood that dedicated EV highways address barriers to e-freight by creating end-to-end operational ecosystems where BETs can move seamlessly without bottlenecks. Strategically located superfast charging stations along these highways ensure range confidence and adherence to stipulated TATs, while power distribution planning reduces grid constraints. Thus, for businesses, this approach reduces the perceived risk of stranded assets and allows for phased fleet conversion.

A highway-specific approach can also help address land availability, a key barrier for deployment of public superfast EV charging infrastructure (EVCI). Both state and central governments could identify suitable land parcels along key industrial highways, provide access to land at concessional rates, auction these parcels or facilitate deployment of EVCI on these parcels through PPP models.

This highway approach therefore represents a market-making strategy. It aligns businesses, LSPs, CPOs, FSIs and policymakers towards a common goal and paves the way for accelerated adoption of BETs by focusing deployment of investment and resources on developing the necessary supporting infrastructure.

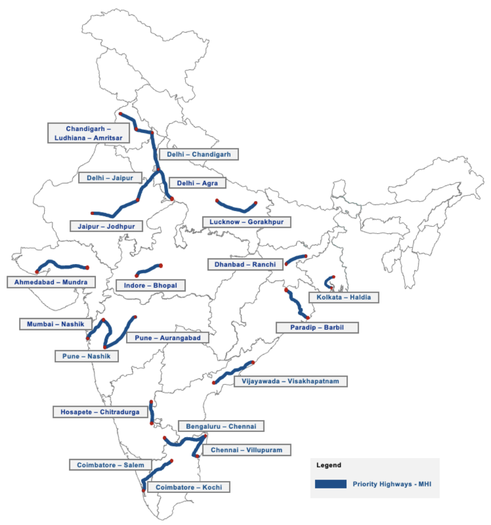
India is also building its BET strategy around highway-based deployment.

The transition to BETs requires not just technology and vehicles, but also the strategic identification of freight routes where adoption can be scaled. In 2025, the Office of the Principal Scientific Adviser (PSA) to the Government of India, identified priority highways based on freight volumes, industrial linkages, grid infrastructure availability, and technical feasibility, providing the first roadmap for where BET deployment could be most impactful.[15]

Building on this technical groundwork, the Ministry of Heavy Industries (MHI) has listed 20 national highways in its Operational Guidelines for PM E-DRIVE as priority routes for the deployment of truck charging infrastructure.[16] These highways include high-volume, industrially critical routes such as Delhi–Chandigarh, Delhi–Jaipur, Bengaluru–Chennai, Coimbatore–Kochi, Vijayawada–Visakhapatnam, and Ahmedabad–Mundra.

The designation of these 20 highways signals clear government intent to build an enabling ecosystem for electric freight, beginning with India's most critical industrial arteries. For businesses and financiers, this provides confidence that early BET investments will be supported by infrastructure. For policymakers, it creates a framework to channel incentives, grid upgrades, and private sector participation in a targeted manner.

Figure 2. Priority highways identified by MHI



[9] Vahan Dashboard
[10] https://efastindia.org/
[11] Gazette of India (2025) Gazette 264519-E-Trucks dated 10.07.2025.pdf. Data for 2025 reflects the status as of September 2025; uptake of electric goods vehicles may have changed in the subsequent months.

[12] Joint office of Energy and Transportation (2024) National zero-emission freight corridor strategy.
[13] SANY Heavy Truck launches 900-kilometer electric corridor in China | Telematics News
[14] Hongyang, C., Yihao, X., and Tianlin, N. (2023) China is propelling its electric truck market by embracing battery swapping. *International Council on Clean Transportation*, 9 August.
[15] Office of the Principal Scientific Adviser to the Government of India (2023) India's Priority Corridors for Zero-Emission Trucking.
[16] MHI (2024) Draft Guidelines: PM E-DRIVE Scheme.

By anchoring the transition to these highways, India is ensuring that BET adoption does not remain fragmented across pilot projects, but instead develops around high impact highways with immediate economic and environmental benefits.

Designating priority highways is the first step but scaling BET adoption requires addressing the wider ecosystem to ensure highway level readiness.

The identification of 20 priority highways for electric trucking provides a strong policy signal but does not guarantee BET uptake. BETs cost ~2.5x more than diesel trucks, and despite PM E-DRIVE incentives, fleet operators face financing hurdles as banks and non-banking financial companies (NBFCs) remain cautious in the absence of proven large-scale demonstrations, lack of a secondary market for BETs, uncertain residual (end-of-life) value of BETs and battery packs, etc.[17] Without affordable financing, the transition risks stalling at the pilot stage.

While highways may be designated for electrification, deploying ultra-fast charging solutions for e-trucks requires land availability, substation augmentation, and coordination with DISCOMs. Typically, high tension (HT) connections would be required for superfast EVCI along with distribution transformers, HT cables, circuit breakers, other protection equipment, etc.[18] Thus, high-power charging for BETs could strain local networks if planning is not synchronised and the requisite infrastructure is not deployed in line with projected freight demand. Lastly, ensuring charger uptime, and integrating digital payment systems are critical for ensuring usability at scale. Addressing these systemic barriers will require coordinated efforts from all stakeholders.

The operational pathway to creating a truly enabling ecosystem for making highways truly EV-ready remains a work in progress and key elements such as charging infrastructure deployment, grid readiness, demand aggregation, and operational integration must be systematically addressed. [The Climate Pledge](), co-founded by Amazon (TCP) partnered with [C40 Cities]() on the Laneshift Programme, taking an ecosystem approach to tackle carbon emissions through zero-emission freight by reimagining medium- and heavy-duty trucks (MHDTs) and the routes they travel. Through the Laneshift Programme, TCP and C40 Cities, aim to kick-start the deployment of BETs and charging infrastructure across major cities in India and Latin America.

As part of Laneshift, TCP and C40 Cities commissioned a first-of-its-kind ***EV Highway Project*** along the **Bengaluru–Chennai highway** to demonstrate the feasibility of electric freight transition and provide a practical guide for developing BET-ready highways in India. This report presents the key outcomes of this study, with a focus on the guidance framework to make Indian highways ready for e-truck adoption.

[17] International Council on Clean Transportation (2024) Financing Zero Emission Trucks in Emerging Markets.
[18] MHI (2025) Operational Guidelines For Deployment of EV Public Charging Stations (EV PCS) under the PM E-DRIVE Scheme.

2 ABOUT THE DEMONSTRATION PROJECT

TCP in collaboration with C40 Cities, is working at the forefront of addressing the challenge of freight decarbonisation through the Laneshift Programme – an international initiative to decarbonise freight in India and Latin America. The Laneshift Programme (2023–2026) aims to accelerate the deployment of zero-emission freight vehicles and set the foundation for electric freight (e-freight) highways between Indian cities by 2030. As part of it, the "Bengaluru–Chennai Highway E-truck Pilot Demonstration" was undertaken to demonstrate the techno-commercial viability of long-haul e-freight transport.

The Laneshift demonstration project aimed to achieve two primary objectives: demonstrating the economic, environmental, and operational feasibility of BETs through real-world pilots, and developing a strategic framework that leverages evidence-based insights from the demonstration project to equip key Indian highways be BET-ready.

The pilots were conducted along the Bengaluru–Chennai (BLR–MAA) highway, a critical freight artery linking two major industrial and consumer hubs in the country. The BLR–MAA highway was selected based on a study conducted under the Laneshift Programme, which identified eight high-potential freight highways around Delhi, Mumbai, Pune, and Bengaluru. The BLR–MAA highway emerged as a high-priority route due to its significant freight volume coupled with strategic economic relevance. Connecting **Chennai**, a key port city, and **Bengaluru**, a major technological and industrial hub, the highway also benefited from existing charging networks along the route, and adequate grid capacity to support additional fast-charging station installations, making it an ideal candidate for e-freight pilot demonstration.

The intent was not just to deploy BETs, but to create an integrated testbed where shippers, LSPs, OEMs, and CPOs could collaborate to validate the technical, commercial, and environmental benefits of BETs. Further, it aimed to provide an evidence-driven foundation for scaling electrification to other highways across the country, ultimately feeding into the development of India's ***EV Highway Roadmap***.

The Laneshift BET demonstration project brought together all the stakeholders required for conducting the pilot, viz., businesses, LSPs, CPOs, and OEMs.

Under Laneshift, a comprehensive effort was undertaken to bring together the entire electric freight ecosystem. Targeted consultations were conducted with businesses operating along the BLR–MAA highway to build awareness, understand operational needs, and identify potential participants for the pilot. In parallel, Laneshift engaged with key stakeholders across the electric freight value chain, including truck manufacturers, logistics service providers (LSPs), and charge point operators (CPOs), to co-design and implement the pilot. This collaborative approach successfully aligned critical partners, including Shippers, OEMs, LSPs, CPOs, and KPMG as the technical partner responsible for coordination, analysis, and pilot implementation along with the C40 Cities team.

Twenty e-trucks across the 14T, 19T and 55T GVW category were deployed under the "Trucking-as-a-Service" (TaaS) model. In this, the LSP owned and operated the BETs, deployed trained drivers, and leveraged a reliable network of high-speed charging infrastructure provided by the CPO partner. Leading businesses joined the initiative as anchor customers, providing commercial loads to facilitate the pilot along the BLR–MAA highway. A total of 600 trips have been completed, covering over 208,819 kilometres across six use cases, viz., e-commerce, retail, pharmaceuticals, auto ancillary, automotive and consumer electronics.

The demonstration project also emphasised on strengthening the service ecosystem and integrating gender equality and social inclusion (GESI) considerations. As part of this approach, primary surveys were conducted with 210 truck drivers, 50 garage owners, and multiple logistics service providers along the BLR–MAA highway. These efforts aimed to understand stakeholder needs, capture driver preferences and operational realities, and embed inclusive practices that reflect the diverse workforce within the freight sector. Further, GIS mapping and on-ground assessments were also carried out to evaluate infrastructure readiness, and for identifying optimal locations for deploying superfast charging stations, assessing grid capacity, and mapping logistics nodes to support seamless electric freight operations.

The pilot demonstrated that BETs could perform at parity with diesel trucks across varied payloads, routes, and operational requirements, and yield environmental benefits.

The pilot established that BETs could deliver reliable technical and operational performance in long-haul conditions. Some of the key findings include:

1. **Range of BETs:** The demonstration project gave confidence to shippers and LSPs on the practical range of the MHDTs, which was observed to range between 200–250 kilometres. The 14T e-truck demonstrated a range as high as 250 kilometres whereas the 55T e-truck had an average range of 200 kilometres. This allowed BETs to undertake long-haul freight trips of up to 400 kilometres with just one or two charging stops.
2. **Turnaround Times (TATs):** BETs consistently achieved TATs at par with ICE trucks, which typically took 12 hours to cover the distance between Bengaluru and Chennai.
   - 14T and 19T BETs achieved TATs of under 10 hours while covering ~330 kilometres, thereby adhering to the stringent TATs stipulated by e-commerce and retail businesses.
   - For distances greater than 350 kilometres, BETs were still able to achieve a TAT of 12 hours, which was at par with that achieved by ICE trucks on the same route.
   - There were certain instances, especially for the 19T and 55T BETs, where the TAT exceeded 12 hours. This was primarily due to slower charging sessions at slow 60 kW chargers on specific routes, thereby increasing the turnaround time. These instances underscored the need for fast and ultra-fast charging infrastructure for operational feasibility of BET.
3. **Commercial feasibility of e-trucks:** The commercial assessment of e-trucks' basic pilot data demonstrated that the total cost of ownership (TCO) of 14T and 19T BETs are about 10–24% higher than their ICE counterparts. However, the cost of ownership for the 55T BETs is almost at par with the ICE trucks, being only 3–4% higher. Detailed analysis on TCO is presented in subsequent chapters.
4. **Expected TCO Parity:** It was understood that 14T and 19T GVW BETs could achieve TCO parity with ICE trucks in three to four years. This is primarily driven by declining battery costs and supportive government policies that are expected to improve the economic viability of BETs. The 55T BET is expected to achieve TCO parity with its ICE counterpart within the next one year itself. This is largely due to lower differential in the upfront costs of ICE and electric variants in the 55T category, thus suggesting that initial offtake of BETs may be in the heavier GVW category.
5. **GHG reduction potential of BETs:** Over a 10-year life of an e-truck, BETs can offset 360 to 550 tCO_2e across 14T, 19T, and 55T GVW category. This potential can increase significantly if the charging is completely powered by renewable energy.

The study laid the foundation for developing EV-ready highways, informed by insights from the BLR–MAA highway.

The study also provided insights on accelerating BET adoption, highlighting operational strategies and infrastructure enablers that are essential for scaling e-freight. Some of these key insights were:

- **Long-term contracts**: By demonstrating the reliability of e-trucks through successful pilot runs, LSPs operating along the BLR–MAA corridor secured long-term (five-year) contracts for the 19T and 55T GVW trucks. Such long-term contracts help enhance creditworthiness of LSPs, enabling them to secure better financing terms for fleet expansion and scaling operations.
- **Technology integration:** Analysis of pilot data revealed a consistent improvement in BET performance over successive trips, mainly due to optimised charging strategies and the integration of advanced technologies to monitor vehicle performance in real time. These digital interventions proved instrumental in enhancing operational efficiency, highlighting their role as enablers of sustained and scalable BET performance.
- **Trained driver workforce:** As part of the pilot deployment, drivers received formal training on handling automatic transmissions, charging protocols, telematics, and breakdown procedures. These targeted interventions proved essential in building driver confidence, reducing operational errors, and ensuring consistent vehicle performance, thus laying a strong foundation for fleet expansion.
- **Need for a service ecosystem**: Insights from pilot deployments highlighted a critical gap in roadside support for e-trucks. To maintain shipper confidence and ensure delivery reliability, the LSP had to keep an ICE truck on standby to manage potential breakdowns. This workaround underscores the urgent need for a robust service ecosystem, which is essential for scaling e-freight operations sustainably and confidently.

In addition to the above, a key enabler for successfully scaling the pilot runs in the Laneshift project was the comprehensive pilot design which brought together key stakeholders across the ecosystem to create enabling operating conditions.

Hence, **ecosystem alignment** forms the foundation for scaling e-freight across highways in India. In this context, the pilot findings were synthesised to create a practical framework for building BET-ready freight highways. This framework can be replicated along other key highways, to equip them with the requisite infrastructure to enable e-freight adoption at scale, thereby charting a pathway for India to transition its road freight toward zero-emission growth. The next chapter presents this framework in detail.

3 FRAMEWORK TO DEVELOP BET-READY HIGHWAYS ACROSS INDIA

The pilot demonstration along the BLR–MAA highway offered a unique opportunity to deploy e-trucks across GVW categories for multiple businesses. This highlighted various real-world challenges in undertaking long-haul commercial e-freight operations, in the e-MHDT segment. Some of the key challenges experienced during the pilot were:

(i) Shipper apprehension for adopting BETs due to higher TCOs for BETs and uncertainties around vehicle range.
(ii) Limited superfast charging infrastructure along the highway and absence of fast chargers at key adjacencies such as Ennore Port and container freight stations.
(iii) Lack of service support for BETs along the highway.
(iv) Limited availability of trained workforce of drivers and technicians, etc.

This highlighted that a holistic approach must be adopted to equip highways with the necessary ecosystem to facilitate adoption of e-freight.

Building on these insights, a comprehensive guidance framework was designed to guide the electrification of freight highways across India. This framework takes an ecosystem approach and defines the **"What"** – the critical components required to make highways EV-ready; the **"How"** – a structured process for translating strategy into action; and the **"Who"** – the key stakeholders responsible for driving implementation at scale. Anchored in five foundational pillars, the framework offers a systematic approach to planning, deploying, and sustaining electric freight highways. These pillars include **Highway Profiling**, which assesses operating conditions and electrification readiness of key highways across India; **Demand Enablement**, which catalyses market uptake of battery electric trucks (BETs); **Infrastructure Creation**, which ensures robust and reliable charging networks; **Operations Optimisation**, which integrates electric freight into mainstream logistics; and **Just Transition**, which embeds equity and inclusion through targeted skilling and workforce development. Together, these pillars form a replicable blueprint for national rollout, enabling coordinated action across government, industry, and civil society.

This ecosystem approach presented in the framework recognises that highway electrification is not only a matter of technology deployment but also involves understanding highways freight profile, demand centres and key adjacencies enabling demand, mobilising finance, strengthening operations, and ensuring a just transition for communities and workers. It integrates these dimensions into a coherent structure that can inform both policy design and industry action, serving as a guide for stakeholders across government, logistics, automobile manufacturing, finance, energy, and infrastructure sectors.

This replicable and scalable framework aims to support development of BET-ready highways in India, thereby, helping India meet its decarbonisation commitments while ensuring efficiency and resilience of the freight ecosystem. The framework is presented below.

Figure 3. Framework for developing BET-ready highways

Vision: Developing BET-ready freight highways that deliver reliable charging, seamless operations and an inclusive ecosystem

Strategic Pillars	Relevance	Action Areas	Learnings from EV Highway Project
1. Highway Profiling	Investment should target corridors where adoption potential is the highest	**Understanding freight profile and demand centers along a highway.** This will comprise of: (a) Readiness Assessment • Understand the **freight profile**, use cases, truck traffic, etc. • Map the **existing charging infrastructure**, amenities etc. (b) Demand Center & Adjacencies • Outline the **major demand centres**, i.e., industrial hubs, warehousing centres, etc. • Identify the **adjacencies** and interconnecting highways	An assessment of freight profile, demand centres, traffic density, etc., proved effective in estimating adoption potential and can be replicated across corridors
2. Demand Enablement	Visible demand from shippers is critical to de-risk investments and build confidence	**Moving from pilot to scale by mobilising demand.** This will require: (a) BET Viability • **Anchor viable use** cases that offers high utilization, route predictability, etc. • Innovative **business models** • Explore **financing models** (b) Demand Visibility • Secure **corporate commitments** and set fleet electrification targets • **Risk sharing** – Establish long-term contracting	Detailed feasibility analysis using real-world data from the pilot provided clear insights on cost drivers and enablers for scaling demand.
3. Infrastructure Creation	Without reliable and strategically located chargers, BET adoption cannot scale	**Rolling out high-capacity charging and grid infrastructure.** This will entail: (a) Charging Infrastructure • Deploy **high-power** charging hubs • Create **high-density networks,** prioritising charger placement at optimal locations (b) Reliable Grid Infrastructure • Ensure **grid readiness** • Promote **RE-powered charging**	Pilot findings underscored the need for high-capacity chargers as well as the need for reliable electricity for a seamless freight operations.
4. Operations Optimisation	Optimised operations reduce downtime, improve utilisation and make BETs competitive	**Driving operational efficiency in BET operations.** This can be achieved through: (a) Digital Technology • Promote telematics and AI-based route optimisation (b) Service Readiness • Strengthen **service ecosystem**, building roadside assistance, OEM-backed service networks (c) Asset Utilisation • Promote **greater asset utilization** through dedicated corridors, priority lanes, etc.	Analysis of BET data showed improvements in operational parameters as the pilot progressed. It provides replicable strategies to optimise BET performance.
5. Just Transition	Securing workforce inclusion and small fleet participation is essential for wider adoption	**Enabling workforce and community to thrive in an electric future.** This will entail: (a) Skilling • Conduct **driver and mechanic training** for EV operations and safety (b) Inclusive Infrastructure • Develop **accessible and gender inclusive** infrastructure for charging and service ecosystem (c) Social Safeguards • Safeguard the wider **truck economy**	A detailed primary survey covering 200+ truck drivers and 50 garage owners provided valuable insights to ensure a just and inclusive transition.

The framework presented above lays out a structured approach to building EV-ready freight highways in India. It draws on both global best practices and learnings from the BLR–MAA pilot. Each pillar of the framework highlights a distinct but interlinked requirement for successful BET deployment viz., planning, demand, infrastructure, operations, and inclusion. Together, they offer a structured, ecosystem-based roadmap for building EV-ready freight highways across India.

The subsequent chapters delve into each pillar of the framework. For every pillar, the discussion begins with its context and importance, followed by the specific activities required to enable it. Embedded within these sections are the key learnings and takeaways from the BLR–MAA pilot, ensuring that the framework is not only conceptual but also grounded in practical experience.

4 PILLAR 1 - HIGHWAY PROFILING

The successful deployment of electric freight transportation hinges on a complex interplay of factors that significantly impact its viability and efficiency. BETs require strategically placed charging locations that align with natural stopping points, while the supporting grid infrastructure must be capable of meeting high-power charging demands at these key locations. The operating range of electric vehicles necessitates a precise understanding of freight movement patterns to ensure seamless operations. Moreover, the capital-intensive nature of infrastructure investments underscores the critical importance of making informed decisions from the outset.

Early adoption strategies must target routes with the highest probability of success to build momentum and demonstrate viability. The intricate nature of these factors introduces substantial deployment risks: misplaced charging infrastructure can result in stranded assets, inadequate grid capacity can create operational bottlenecks, poor route selection can lead to underutilisation, and disconnected planning can result in isolated pockets of electrification with limited network effects.

Given these complexities, ***highway profiling*** emerges as the critical first step in electric freight transformation, serving as the cornerstone for informed decision-making and targeted investments. Highway profiling is a structured assessment that maps freight demand and supporting infrastructure along a highway to determine its suitability and readiness for EV deployment. This primarily entails understanding the key characteristics of the highway such as traffic volume, freight profile, trip patterns, origin-destination characteristics, industry presence, etc. A detailed understanding of these aspects helps pinpoint the potential freight applications for early adoption. Complementing this, a mapping of existing assets such as chargers, grid capacity, and wayside amenities can offer a baseline against which readiness can be measured and gaps clearly identified.

In addition, profiling extends beyond the highway itself to cover key adjacencies that influence freight flows such as ports, container freight stations, inland depots, industrial hubs, etc., within 40–50 kilometres of the main highway. Including these nodes in the profiling process ensures that electrification supports end-to-end e-freight movement, transforming priority stretches into a connected network rather than isolated electric highways with limited utility.

The specific activities that constitute highway profiling are described below.

4.1 Assessing Operational and Infrastructure Readiness

A readiness assessment will help evaluate the operational preparedness of a highway – its traffic profile, energy infrastructure, and supporting facilities – to host e-freight operations. This exercise will help determine where charging and grid investments are needed to achieve the desired scale and reliability of BET deployment. Broadly, this assessment will include following:

4.1.1 Freight profiling

Identifying potential use cases for BET adoption and understanding freight flows along the highway.

Freight profiling along highways provides essential data for understanding the types of commodities transported, the vehicle categories used (based on GVW), and the spatial distribution of freight flows. Analysing the origin-destination (OD) patterns reveals key highways and nodes that serve as major freight demand centres.

The OD insights help identify high-frequency highways with consistent truck movement, critical for assessing e-truck deployment potential. Linking this with trip characteristics such as average trip length, duration, frequency, nature of trips such as point-to-point or return-to-base, etc., pinpoints highway stretches where BETs can replace diesel fleets with minimal operational disruption.

For instance, highways with high monthly trip frequency, consistent payloads, and one-way distances of 300–400 kilometres are especially suitable for e-trucks, given their alignment with current range capabilities and charging needs. Such data-driven assessments allow LSPs to identify use cases where e-trucks can operate with predictability and efficiency, thereby supporting phased electrification strategies.

Box 1. Freight profiling in the BLR–MAA Highway Project provided key insights

The combination of medium-range, high-frequency trips, especially in the 14–19T GVW segment, and the presence of major freight-generating clusters, makes the Bengaluru–Chennai highway a strong candidate for early-stage e-truck deployment.

The BLR–MAA highway caters to a wide range of commodities such as automobile, e-commerce, capital goods, etc., resulting in significant freight movement across all GVW categories. Further, a primary survey revealed that 45% of the trips on the highway are up to 400 kilometres long and are completed within a TAT of up to 12 hours. Given the advancements in BET range (offering more than 200 kilometres of range on full charge), 400 kilometres becomes very much feasible for e-truck operations with just one charging stop.

These insights can inform charging infrastructure planning, fleet electrification strategies, and operational optimisation for logistics service providers operating on this route. They also help planners prioritise highways and freight categories that can shift to e-trucks with minimal operational disruption.

4.1.2 Truck traffic assessment and BET adoption projection

Projecting truck traffic and BET uptake to inform infrastructure planning.

Traffic assessment quantifies the current and future freight flows and forms the foundation for estimating potential demand for BETs along a highway. By using toll and OD data, it projects truck volumes that can be then used to size infrastructure requirements to make the highway EV-ready, considering future expansions as well.

Toll transaction data from IHMCL provides a robust baseline of truck volumes, which can be complemented with indicators such as industrial growth trends, planned manufacturing or logistics hubs, truck sales projections, and port throughput expansion to forecast freight activity for target years such as 2030 or 2035.

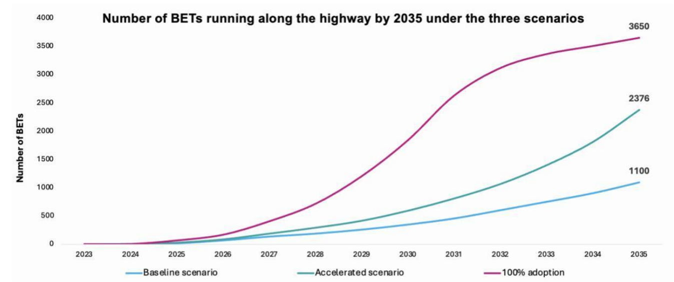
Integrating these forecasts with shipper commitments and operational use cases allows scenario modelling of BET adoption across highways. This helps identify highway stretches with dense, predictable, and growing truck movement, where e-truck deployment would be most viable and infrastructure investments most impactful. Such forward-looking assessments are essential for prioritising highways for phased electrification and aligning charging network development with projected demand.

Box 2. Existing truck traffic estimate was leveraged to understand potential BET adoption along the BLR–MAA highway by 2030 and 2035

Truck traffic assessment along the BLR–MAA highway provided a critical analytical input for evaluating the highway's readiness for BET deployment. Toll transaction data analysis estimated an Average Daily Truck Traffic (ADTT) of about 3,300 trucks, establishing the existing freight intensity along the route. Incorporating projected growth in freight movement, based on historical traffic trends, Vahan-based truck sales data, and MHDT market projections, yielded an estimated ADTT of around 3,650 by 2035.

Building on this traffic baseline, scenario-based modelling was undertaken to assess the potential scale and pace of BET adoption. Two adoption pathways were developed: a baseline scenario, reflecting a moderate transition with 30% fleet electrification by 2035 under current market and policy conditions; and an accelerated scenario, reflecting a faster transition (65% adoption) driven by stronger policy incentives, technology cost declines, and corporate commitments. The analysis indicated a potential demand of 1,100–2,400 e-trucks by 2035 across different pathways.

Figure 4. Number of BETs running along the highway by 2035 under the three scenarios



The resulting demand projections informed the sizing of charging infrastructure, assessment of upstream grid augmentation requirements, and estimation of investment needs, thereby guiding phased planning for making the highway BET-ready.

4.1.3 Infrastructure mapping

Mapping existing infrastructure to assess readiness for long-haul BET deployment.

Mapping existing infrastructure establishes how ready a highway is to support BET operations. It reveals infrastructure strengths and gaps that influence the technical feasibility and operational viability of BET adoption. The mapping focuses on four dimensions, each directly tied to highway readiness:

i. **Charging infrastructure:** Mapping existing charging infrastructure enables planners to assess charger density and identify capacity gaps that could constrain BET operations. Evaluating parameters such as location, capacity, availability, and interoperability provides a realistic picture of the highway's ability to deliver reliable and cost-competitive charging services. Beyond availability, this exercise also tests functionality, revealing which chargers are operational and which require upgrades – thereby highlighting the true infrastructure gap along the route.

   BETs depend on high-capacity, superfast chargers (≥ 240 kW) that can replenish large battery packs within an hour, enabling efficient trip turnarounds and maintaining fleet schedules. Mapping these assets and identifying priority locations for superfast charging upgrades ensures that the highway can support continuous, high-utilisation freight movement – an operational hallmark of an EV-ready highway.

ii. **Power infrastructure:** Mapping power infrastructure enables planners to assess whether the highway's electrical backbone can support high-capacity charging and to identify where grid upgrades may be required. Substations, feeders, and distribution transformers (DTRs) determine both the availability and reliability of power supply, which are critical prerequisites for reliable and uninterrupted energy supply to power superfast chargers.

iii. **Wayside Amenities:** Wayside amenities can serve as strategic nodes for integrating e-truck charging and support infrastructure along highways. Their large parking areas, existing driver facilities such as dormitories, food joints, washrooms, etc., and their proximity to grid connections make them well-suited for hosting high-capacity charging stations and service centres for BETs. Identifying and leveraging these sites can help optimise land use, reduce development timelines, thus making them valuable anchor points in highway electrification plans.

iv. **Other Points of Interest:** Co-locating charging infrastructure with driver-preferred stops such as truck terminals, large fuel retail outlets (ROs), parking bays, and popular rest and meal points, can significantly improve operational efficiency. By enabling drivers to charge during scheduled meal or rest breaks, these sites reduce downtime and support improved TATs and higher fleet utilisation. Thus, GIS mapping of such nodes to incorporate them into highway planning would ensure that charging infrastructure is aligned with real-world freight operations.

Overall, these assessments lay the groundwork for evaluating priority highways and ensuring they are assessed not only on connectivity but also on their readiness to support BET adoption.

4.2 Mapping Demand Centres and Adjacencies to Build EV-Ready Networks

Beyond the main highway, adjoining freight hubs such as ports, container freight stations (CFS), inland depots, and intersecting highways play a decisive role in freight movement and must be included in the electrification plan. Mapping these adjacencies ensures that EV infrastructure extends seamlessly from the highway to key demand nodes, creating an interconnected e-freight network.

Key demand centres of freight could include:

i. **Industrial Hubs** such as clusters of cement and steel industries, manufacturing zones, SEZs, automobile hubs, capital goods hubs, etc. These hubs generate significant freight volumes and form both origin and destination of freight along a highway.

ii. **Warehousing and Logistics Hubs** such as distribution centres and third-party logistics (3PL) clusters that act as consolidation points for freight flows. E-commerce, retail, and FMCG businesses often have warehouses and distribution facilities in the outskirts of major towns, and these also form critical demand centres for freight movement.

iii. **Ports and Container Freight Stations**: These facilities often located away from main highways, guarantee significant and predictable freight volumes. Hence, these points need to be identified and aptly equipped with charging, upstream electrical, and service ecosystem for e-trucks.

Significance of deploying superfast chargers around ports and CFS was highlighted during the pilot demonstration. Use cases for which trips originated from CFS near Ennore port had significantly higher TATs because BETs had to rely on 60 kW chargers, due to absence of any superfast chargers in the vicinity. This increased the charging duration for 14T and 19T BETs by up to 2 hours and for the 55T BET by up to 4 hours, thus, increasing the overall TAT.

iv. **Intersecting Highways:** Often state and/or other national highways intersecting the main highway contribute significant freight from surrounding industrial towns and ports. Thus, electrifying these intersecting highways is critical for achieving network effects and scaling e-freight transition.

Thus, aligning charging infrastructure near these important nodes could help maximise utilisation of both trucks and chargers.

Box 3. The importance of demand centres and adjacencies was highlighted during freight analysis along the BLR–MAA highway

Detailed assessment of traffic flows along the highway revealed the following insights:

- Seven key demand centres for freight were identified along the highway, viz., Bengaluru, Hosur, Shoolagiri, Krishnagiri, Vellore, Sriperumbudur, and Chennai.
- About 80% of all trips either originate or terminate at Bengaluru, Chennai, Hosur and Sriperumbudur.
- Highways originating from nearby industrial towns in Tamil Nadu such as Salem, Erode, Trichy, Coimbatore, etc., contributed nearly 38% of the overall load.

This reaffirmed the importance of electrifying these adjacent intersecting highways to form a maze of BET-ready highways to achieve transition to e-freight at scale.[19]

Figure 5. Major industrial highway intersections in Peninsular India

Learnings and insights from the BLR–MAA study highlight that mapping demand centres and adjacencies can ensure that highway electrification is not done in isolation. By considering these critical freight flow nodes, planners can identify last-mile linkages that must also be electrified for the main highway to function as a seamless e-freight ecosystem.

Highway profiling forms the analytical backbone for developing EV-ready highways.

It highlights optimal use cases for early BET adoption and enables identification of nodes where electrification can deliver the greatest impact. Further, it also guides optimal investment and resource allocation along priority highways.

This exercise can be anchored by national-level nodal agencies. The Government of India has identified Bharat Heavy Electricals Limited (BHEL) as the nodal agency under PM E-DRIVE to facilitate deployment of fast charging infrastructure. Thus, a key task that BHEL will undertake is a mapping of existing and planned infrastructure along the highways. This ongoing effort provides a strong foundation for the highway profiling exercise.

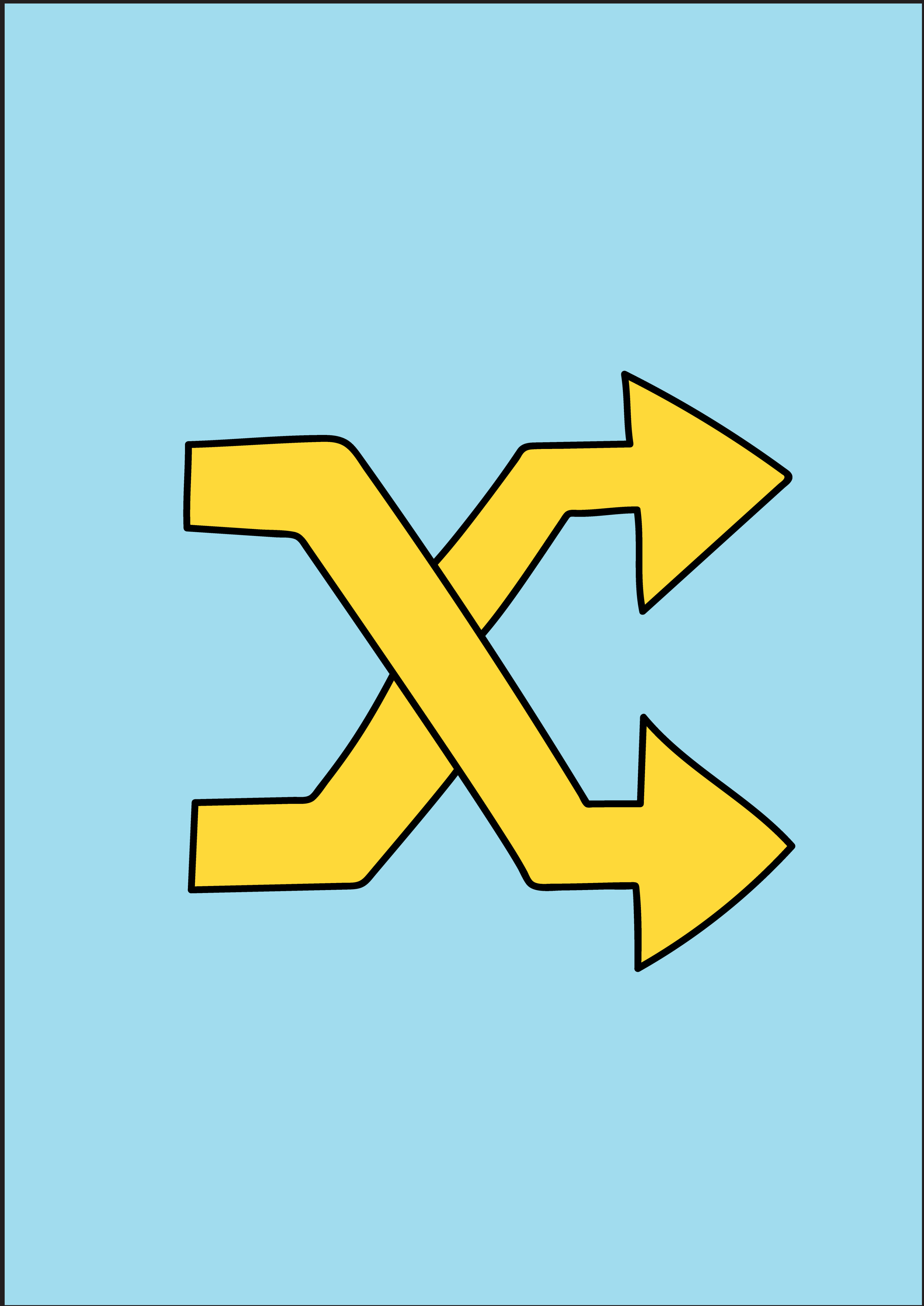
Working in close coordination with stakeholders such as the National Highways Authority of India (NHAI) and other State Nodal Agencies under PM E-DRIVE, BHEL can facilitate detailed highway profiling to undertake infrastructure and investment planning. This will require integration of multiple data sources including toll and freight records, VAHAN registration data, industrial cluster maps, etc., into a unified spatial platform. The resulting output would serve as a repository that enables evidence-based planning for highway electrification.

[19] The map is not to scale and is only for representation purpose. It does not represent any international or state borders.

Call to action: Fast-tracking highway profiling through collaborative action

- **Establish a task force under PM E-DRIVE** to coordinate planning and data integration across agencies. The task force can include BHEL (as nodal agency), NHAI, State Nodal Agencies, and utilities.
- **Develop a unified digital platform for data sharing and analytics.** A centralised repository may be created, integrating data from toll plazas, FASTag systems, VAHAN vehicle registries, and industrial cluster maps. The task force can anchor this platform, supported by private logistics platforms for freight movement data.
- **Integrate grid readiness assessment** within the profiling exercise by overlaying grid capacity, substation locations, and planned upgrades. This may be facilitated by DISCOMs and State Transmission Utilities, to ensure that electrical readiness is planned concurrently with physical infrastructure expansion.
- **Adopt digital tools to accelerate profiling and visualisation**, by deploying GIS mapping and freight flow analytics to visualise corridors and identify optimal charging nodes. Implementation can be jointly led by BHEL with technical support from other stakeholders.

Once highway profiling is conducted, generating e-freight demand along these highways will be key to enabling transition to e-freight for long-haul transportation. Measures to spur BET demand along these priority highways are discussed under the next pillar of the framework.



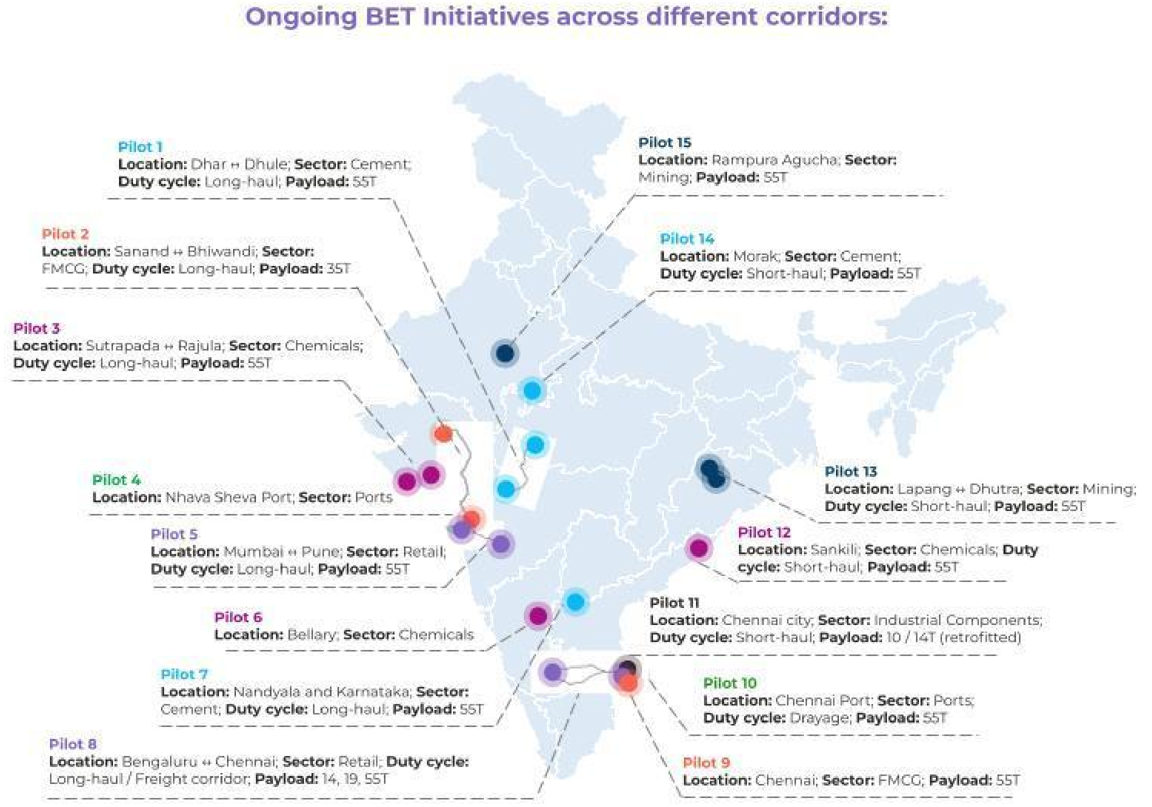
5 PILLAR 2 - DEMAND ENABLEMENT

Transitioning to BETs will depend significantly on creating viable and visible demand. While supply-side investments can build physical readiness, the real momentum will come when fleet operators and shippers see clear economic and operational advantages in switching to electric.

Demand enablement therefore focuses on unlocking freight demand through policy interventions and business models to improve the total cost of ownership (TCO) of BETs. It also includes levers that signal long term demand certainty to manufacturers and financiers. Together, these interventions bridge the viability gap, de-risk private participation, and create a sustained market pull essential for scaling e-freight across priority highways.

Today, e-trucks are gradually attracting interest from large corporates in India, particularly as companies seek to decarbonise long-haul freight. Several businesses such as Ultratech Cement, Amazon, Delhivery, Adani Ports, Dalmia Bharat, IKEA, etc., have already initiated pilots. Complementing these initiatives, the Government of India has launched the e-FAST platform under NITI Aayog to aggregate demand, align policies, and accelerate the transition to zero-emission freight. Together, these initiatives have led to deployment of over 650 e-MHDTs across India.[20] The map represents some of these pilots:[21]

Figure 6. Ongoing BET pilots conducted across India



For highways to truly become EV-ready, there must be corresponding demand for e-trucks. While these pilots mark an important first step, adoption remains at an early stage and is still characterised by fragmented, small-scale deployments. Freight transport in India is largely driven by Logistic Service Providers (LSPs), who own and operate trucks on behalf of shippers. These LSPs are typically small- and

[20] Vahan Dashboard
[21] Information regarding various BET pilots was collated through multiple secondary sources, and the map was prepared by KPMG. The map is for representation purpose only. It does not present official international or state borders.

medium enterprises (SMEs) with thin margins and limited access to affordable finance. The logistic market in India leans towards smaller enterprises, with small fleet operators (those owning less than 6 trucks) constituting 75% of the market.[22] Hence, the high upfront cost of BETs becomes a major deterrent for them. In addition, the lack of assured demand from shippers discourages LSPs from building e-truck fleets at scale – creating a cycle of hesitation across the value chain.

Stakeholder consultations reaffirmed these challenges with businesses expressing strong interest in transitioning to electric freight but citing persistent barriers such as the high upfront cost.

Hence, the **transition from pilot to scale** will require bridging the viability gap and mobilising demand from shippers. Without clear, sustained demand, investments in vehicle supply, e-truck fleet expansion, deployment of charging infrastructure, and advent of tailored financing solutions will remain constrained. Accordingly, the demand enablement pillar of the framework focuses on the two aspects:

(i) **Enabling BET Viability** innovative business and financing models and policy initiatives.
(ii) **Generating e-freight Demand** by mobilising long term commitments from businesses.

5.1 Enabling BET Viability

The BET viability gap can be bridged through various measures such as identifying favourable use cases offering high utilisation for early adoption, deploying innovative business models and tailored financing mechanisms, and through specific policy interventions. All these measures are discussed in detailed in the following sub sections.

5.1.1 Identification of optimal use cases

BET viability is use-case driven. Hence, to drive early adoption, it will be important to identify the right use cases that offer favourable cost economics.

The Laneshift Programme conducted a detailed TCO analysis using real-world operational data from the BLR–MAA pilot. It allowed the study to benchmark e-truck performance against comparable diesel vehicles and identify conditions under which cost parity can be achieved.

The analysis showed that BET viability varies dramatically across use cases. While 55T trucks are near cost parity with diesel (just 3–4% higher TCO), smaller trucks still face a 10–24% cost gap. The higher TCO for 14T and 19T GVW BETs are mainly attributed to:[23]

(i) **Difference in capital cost:** The cost of 55T BET is 2.8 times that of its ICE counterpart, while both 14T and 19T BETs are about 3.3 times more expensive.
(ii) **Savings in energy cost:** 55T BET offers around 37% saving on energy costs, vis-à-vis, the 14T and 19T BETs which offer ~33% savings. This saving is on account of poor mileage of 55T diesel trucks which translates into relatively higher ICE TCO.

Therefore, success hinges on targeting the right combinations of vehicle size, monthly utilisation, and payload characteristics. High-volume, regularly scheduled routes carrying lightweight goods show the strongest economics – particularly in e-commerce and retail. These optimal use cases create the foundational demand needed to drive charging infrastructure and accelerate broader adoption.

The following table highlights the TCO findings from the BLR–MAA pilot:

Table 1. Details of use-case wise TCO for each GVW category of BETs

GVW	Use Case	BET TCO (₹/km)	ICE TCO (₹/km)	Difference	Expected Parity
14T	Retail	32.06	28.28	13.5%	2030
	E-commerce	31.25	28.41	10.0%	2029
	Pharmaceutical	33.51	29.77	13.0%	2030
	Auto Ancillary	35.10	30.60	15.0%	2032
	Electronics	34.0	30.2	12.6%	2028
19T	Retail	35.75	30.41	17.5%	2029
	E-commerce	35.50	31.60	12.5%	2028
	Pharmaceutical	42.46	34.25	23.5%	2029
	Auto Ancillary	43.60	35.20	24.0%	2029
55T	Retail	54.68	53.27	2.6%	2026
	Automobile	55.49	53.44	3.8%	2026

Further, it is observed that within the same GVW category, viability improves significantly for use cases that offer high monthly utilisation and volumetric payloads (e.g., FMCG, packaged goods). In such operations, the lower effective load carried by e-trucks enhances energy efficiency, bringing TCOs much closer to parity. The text box below illustrates this by presenting analysis from the pilot.

Box 4. High monthly utilisation and volumetric payload significantly improve TCO across use cases within GVW category

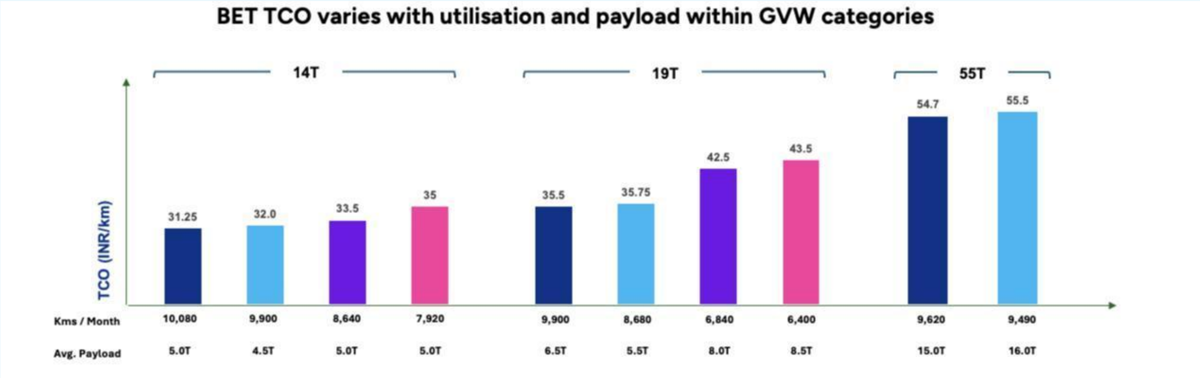
E-commerce and retail use cases have more competitive TCOs as compared to that of pharmaceutical and auto ancillary use cases due to two main factors:

i. **High Monthly Utilisation:** These use cases and instances where monthly utilisation was more than 9,000 kilometres, helped normalise the higher capital costs of BETs over greater number of kilometres over a truck's life.

ii. **High Energy Efficiency:** The e-trucks recorded higher average mileage, 1.40–1.57 km/kWh (14T) and 1.32–1.45 km/kWh (19T), for both these use cases as the payload was volumetric in nature and the average load was lower than for other use cases,

[22] Global Drive to Zero (2022) Industry Assessment & Roadmap Outline for ZE-MHDTs in India.
[23] Note: These findings are based on real-world data from the BLR–MAA pilot and may not be universally representative. Actual TCO outcomes could vary depending on route characteristics, operational patterns, and regional cost structures.

Figure 7. BET TCO varies with utilisation and payload within GVW categories



Deploying BETs first in favourable segments can demonstrate early commercial success and build operator confidence. By concentrating on such high-utilisation routes and use cases, India can move from experimental pilots to scale-ready operations, creating the base demand necessary to justify large-scale charger deployment and grid augmentation – key ingredients of EV-ready highways.

5.1.2 Business models

Innovative business models can help bridge the viability gap.

Business model innovation plays a pivotal role in enabling the transition from pilots to large-scale e-freight operations. Given the high upfront cost of BETs and limited access to affordable finance, many small and medium LSPs are unable to invest in fleet electrification on their own. Alternative ownership and service models can bridge this gap by distributing risk, improving utilisation, and converting high capital costs into manageable operating expenses. Some of these business models may include:

1. **Battery-as-a-Service (BaaS):** This model decouples battery ownership, which accounts for nearly 30% of an e-truck's price, from vehicle ownership, by enabling operators to pay a subscription or pay-per-use fee for the battery. This converts a large capital expense into a manageable operating cost, lowers entry barriers for small operators, and shifts concerns around battery degradation, replacement, and residual value away from fleet owners.

   To enable this model in India, OEMs could also collaborate to develop battery swappable e-truck designs and offer e-trucks to LSPs through this model. This would not only improve cost competitiveness of BETs, but also improve operational performance as battery swapping would reduce recharging time, thus improving TATs.

Box 5. MG Windsor's BaaS unlocking India's EV market in the 4W segment

In late 2024, MG Motors India, launched the Windsor EV – at a market disruptive entry price of INR 990,000 under the BaaS model, decoupling battery price from vehicle cost and charging users per kilometre of battery use. This business model significantly cut upfront cost and resonated well across Indian customers.

Windsor became the fastest selling EV in India, selling around 20,000 units[24] in FY25. It was also the top selling EV during that period, which saw a total EV sales of 115,716 units.[25] This model has helped MG Motors garner 31% share in the passenger e-4Ws segment second only to Tata Motors at 38% market share.[26]

Battery swapping model for electric trucks in India[27]

Blue Energy Motors has introduced a 55-tonne battery electric truck equipped with a swappable battery architecture and offered under a BaaS model. Through this approach, fleet operators pay only for energy use and battery swaps rather than owning the battery outright.

The swap mechanism enables full battery replacement in under five minutes, ensuring high vehicle uptime for long-haul freight operations. By combining rapid energy replenishment with lower capital barriers, this model demonstrates how battery-swapping solutions can make electric trucking more viable for small and medium fleet operators and accelerate the transition toward EV-ready freight highways in India.

2. **Trucking-as-a-service (TaaS):** This model brings together fleet operators and CPOs to offer e-trucks and charging infrastructure as a bundled offering to shippers. This assures shippers of access to reliable superfast charging networks thus addressing range and charge anxiety. Further, it ensures CPOs of minimum utilisation of chargers and assures fleet operators of availability of reliable energy for charging. Such a bundled offering can help fleet operators offer better commercial terms to shippers as it enables them to seek more competitive charging tariffs through partner CPOs.

   This model was successfully deployed during the Laneshift pilot, demonstrating its ability to generate demand and accelerate e-freight adoption through strategic partnerships and bundled service delivery.

3. **Demand Aggregation Model:** Government agencies such as Convergence Energy Services Limited (CESL) can aggregate demand across public sector units, ports, government organisations, small fleet operators, etc., and issue bundled procurement orders for BETs. Such aggregation reduces capital costs by enabling manufacturers to plan production at scale and achieve economies of scale.

   A precedent for this model exists in the e-bus sector, where CESL successfully aggregated demand from multiple state transport undertakings and issued procurement orders for up to 10,000 e-buses. This approach led to price discovery that was 23–27% lower than prevailing diesel or compressed natural gas (CNG) bus costs, primarily due to scale efficiencies.

   A similar model could be leveraged for e-trucks, particularly by aggregating demand across India's major ports, which account for significant volumes of freight movement in port drayage, inter-port movement and port to CFS movement of freight.

[24] Singh, A. (2025) MG Windsor becomes fastest-selling EV in India with 20K units in 6 months | Auto – Business Standard, *Business Standard*, 11 April.
[25] Bikramjit, H. (2025) MG Windsor EV Was The Best Selling EV In FY2025, Check Out The Sales Of The Other EVs In India, *CarDekho*, 3 July.
[26] Kailash, J. (2025) 3 Out of 5 MG Cars Sold Are Windsor EVs: Why it's so Popular, *Cartoq*, 13 July.
[27] Times of India (2025) Mumbai–Pune Electric Corridor: First Made-in-India Electric Heavy-Duty Truck with Battery Swapping and Unlimited Range By Blue Energy Motors: Marking a Milestone Toward Future-Ready Transport, 18 October.

Thus, innovative business models could be critical enablers for highway electrification. By reducing capital barriers, increasing utilisation, and providing commercial certainty to fleet operators and CPOs, these models could create viable pathways for early adoption along priority highways.

5.1.3 Financing mechanisms

Tailored financing mechanisms can help bridge the viability gap.

Access to affordable finance remains one of the key barriers to e-truck adoption. While diesel trucks enjoy established financing ecosystems, e-trucks face higher cost of debt due to several perceived risks such as: (i) uncertain residual value – lack of a secondary market for e-trucks, (ii) technology risk – concerns about evolving technology standards and alternate solutions such as hydrogen fuel cell, and (iii) operational risks – uncertainties around asset utilisation and consistent stream of cash flows, and others.

A similar challenge was also observed during the pilot, where the cost of debt for procuring e-trucks (15% rate of interest) was higher than the existing interest rates for diesel counterparts (which is typically 12%). This difference is significant – TCO modelling reveals that if the e-trucks were offered interest rates at par with those for ICE trucks, the BET TCOs could be optimised by 3–4%, making them more viable.

Some mechanisms to reduce the cost of capital may include:

1 **First Loss Default Guarantee:** Under this model, public agencies or Development Finance Institutions (DFI) collaborate to create a risk sharing facility/credit pool to provide a first-loss cushion that absorbs initial defaults. This helps lower perceived risks for commercial banks/NBFCs, enabling them to lend at lower rates to fleet operators. Such facilities could be set up for providing guarantees for e-truck operators.

Box 6. SIDBI and Shell Foundation collaborate to pilot Risk Sharing Facility[28]

Small Industries Development Bank of India (SIDBI) and Shell Foundation launched a Risk Sharing Facility (RSF) in October 2023 to enable the ecosystem to foster 50,000 EVs. The US$6Mn fund (US$3Mn SIDBI + US$3Mn Shell Foundation) will provide partial credit guarantee to EV ecosystem players who support EVs for commercial use. The agreed cap for the second loss layer is 7.5%. This RSF is expected to unlock approximately US$81m of commercial capital for EV asset financing in the e-2Ws and e-3Ws segment in India.

2 **Leasing Models:** Leasing models allow fleet operators, particularly SMEs with limited balance sheets, to access e-trucks without large upfront investments, by instead paying on a per-kilometre or per-trip basis. Asset ownership and financing risks are shifted to OEMs, fleet aggregators, or leasing companies.

Such models, already widespread for 2Ws, 3Ws and 4Ws through companies such as MoEVing[29] and Alt Mobility,[30] are now emerging for heavy vehicles, i.e., e-buses and e-trucks. This approach reduces capital barriers and makes it easier for smaller operators to participate in early highway electrification initiatives.

3 **Carbon Financing:** Carbon credits generated through BET deployment can be monetised to improve project economics. Emissions reduction relative to diesel baselines translate into tradable credits, providing an additional revenue stream for logistics service providers (LSPs) and shippers. For shippers, using BETs reduces Scope 3 emissions and dependence on external offsets, while LSPs can sell carbon credits to offset operating costs. This mechanism can narrow the viability gap and enhance the financial attractiveness of BET projects along key highways.

Strengthening these financing mechanisms directly supports the development of EV-ready highways by enabling fleet operators to procure vehicles and use charging networks at scale. Banks, NBFCs, DFIs, fleet operators and government agencies could collaborate to develop and deploy such financing mechanisms that lower interest rates, spread capital costs across stakeholders, and unlock new revenue streams. Integrating such financing approaches into highway electrification strategies can accelerate fleet uptake, attract private investment, and support the accelerated adoption of e-freight along BET-ready highways.

5.1.4 Policy incentives

Policy measures, such as demand incentives, toll waivers, interest subvention are needed to bridge the viability gap.

Policy support plays a critical role in improving the commercial viability of BETs and accelerating their adoption along key freight highways. A combination of policy levers, such as demand incentives, interest subventions, tax exemptions, toll waivers, etc., would be needed to make e-trucks more viable.

The demand incentives under the PM E-DRIVE scheme, of up to INR 5,000/kWh is expected to reduce BET TCO across GVW categories by up to 3%, as demonstrated through sensitivity analysis conducted under the Laneshift study. PM E-DRIVE is expected to support the deployment of approximately 5,643 e-trucks.

Other policy measures will also be needed to further optimise BET economics. Sensitivity analysis highlights that initiatives such as toll waivers on national highways could reduce TCO by up to 11% across GVW categories. Similarly, interest subvention to bring e-truck financing costs on par with ICE trucks could lower TCO by an additional 3–4%. Collectively these policy incentives could make BETs across GVW categories more cost competitive than ICE trucks.

The impact of these initiatives, as assessed during the pilot, are presented below.

Table 2. Results of sensitivity analysis of BET TCO with different policy levers

GVW	Avg. BET TCO (₹/km)	Optimisation of BET TCO (₹/km)			Optimised Avg. BET TCO (₹/km)	Avg. ICE TCO (₹/km)
		Demand Incentive	Interest Subvention	Toll Waiver		
14T	35.62	(1.03)	(1.12)	(3.5)	29.97	29.95
19T	41.42	(1.32)	(1.71)	(4.0)	34.39	36.18
55T	55.08	(1.1)	(1.75)	(6.0)	46.23	53.35

An illustrative analysis, conducted for **19T BETs** under the BLR–MAA pilot demonstration is presented in the adjacent chart to highlight the benefits of policy levers on BET TCO.

Stakeholder alignment for policy enablement at the highway level will be critical. For instance, the Ministry of Road Transport and Highway (MoRTH) could offer toll waivers on key industrial highways (20 priority highways identified by MHI). State governments can also complement central support with region specific measures such as exemption of road taxes and permit fees, priority access for electric fleets, etc. For instance, the State Government of Maharashtra under its 2025 state EV policy announced 100% toll waiver for passenger EVs on Samruddhi Mahamarg, Yashwatrao Chavan

[28] SIDBI (2025) Press release.
[29] MoEVing – Electric Vehicle Rental |Cargo/Pickup | EV Vehicle On Lease.
[30] Alt Mobility – India's most reliable EV Leasing & Asset Management Provider.

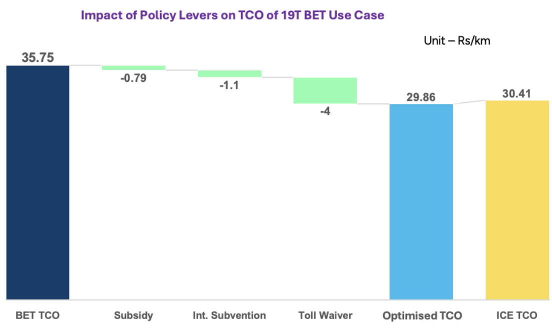
Mumbai–Pune Expressway, and Atal Setu.[31] Similar exemptions could be extended to e-trucks across states. Such a targeted approach would accelerate BET deployment and help scale the national network of EV-ready highways.

Thus, enabling BET viability demands a coordinated strategy across the four pillars highlighted above, viz., identifying favourable use cases, deploying innovative business models, and financing mechanisms, and receiving the right policy push from the government. High utilisation use-cases with predictable routes and duty cycles, such as e-commerce, retail, FMCG, etc., could unlock favourable economics while innovative business models lower the entry barriers for service providers across the e-freight value chain. Lastly, policy levers such as targeted subsidies, toll waivers, and interest subvention can catalyse and enhance BET competitiveness.

5.2 Generating E-freight Demand

While improving the economics of e-trucks is essential, scaling adoption ultimately depends on visible, long term demand signals from shippers. Without clear visibility on future freight volumes and commitments, LSPs, CPOs, and financiers remain hesitant to invest in large e-truck fleets and superfast charging infrastructure. Therefore, clear demand visibility through corporate commitments, assured contracts, and creation of anchor fleets would be crucial to provide market confidence and unlock ecosystem-wide investment.

Figure 8. Impact of policy levers on TCO of 19T BET use case



Clear demand signals from shippers through announcement of clear BET adoption targets and timelines could facilitate market development for e-freight.

Announcements of clear BET adoption targets and timelines by large shippers can play a catalytic role in market development. BET adoption commitments from sectors such as cement, steel, mining, e-commerce, FMCG, and manufacturing can send strong signals to OEMs, LSPs, financiers, and CPOs. These commitments could be in the form of companies coming together to pledge to transition to e-freight, such as EV100 and TCP, announcement of clear targets of BET adoption within a given timeframe, and/or embedding EV adoption targets within the business strategy. Such announcements help identify early adopters of e-freight and enable coordinated planning of charging and fleet deployment along priority highways.

Long-term contracts between shippers and LSPs signals commitment from shippers and enables ecosystem enablement.

Corporate commitments must be backed by long-term freight contracts between shippers and LSPs to create financial visibility and de-risk investments in BETs. Short-term, transactional freight contracts discourage fleet operators from committing capital to electric trucks. In contrast, five- to seven-year contracts offering high monthly utilisation (preferably >9,000 kilometres), provide LSPs with assured utilisation and stable cash flows, which are crucial for securing favourable financing terms and ensuring consistent use of charging infrastructure. Such arrangements enable both pillars of e-freight, viz., trucks and chargers, to operate at high utilisation, improving overall cost economics of e-freight. It also increases investor and operator confidence in making high capex commitments, both for procuring e-trucks and for developing charging infrastructure, by reducing demand uncertainty and ensuring predictable returns.

[31] Department of Information Technology, Government of Maharashtra (2025) Maharashtra Electric Vehicle Policy.

Box 7. UltraTech signs transport service contract to deploy 100 e-trucks in its logistics operations[32]

UltraTech Cement Limited signed a transport service contract with Transvolt to deploy 100 BETs for transportation of 75,000 million tonnes of clinker per month. Trucks are expected to undertake 400-kilometre-long roundtrips between Dhar Cement Works, in Madhya Pradesh, to Dhule Cement Works, in Maharashtra. UltraTech is also evaluating additional routes for deployment of more e-trucks in its logistics operations, and it aims to deploy up to 500 e-trucks as part of the government's e-FAST initiative.

More long-term contracts by corporates, such as the one evidenced in the box above, are needed to spur demand in the market and scale e-freight across multiple highways.

Anchor fleets can offer assured utilisation of assets, required for establishing feasibility.

Anchor fleets play a critical role in demonstrating the commercial and operational feasibility of e-truck deployment along highways. Industries such as e-commerce, retail, FMCG, etc., with predictable freight volumes and high utilisation can serve as early anchor customers for BET-ready highways. Their scale and consistency of demand create stable freight pools that enable fleet operators to achieve high asset utilisation and unlock economies of scale.

Large corporates and public sector enterprises with substantial freight requirements and strong decarbonisation commitments must proactively step forward as anchor customers. Their participation is critical not only for assuring utilisation of trucks and charging infrastructure, but also for sending strong demand signals to OEMs, financiers, and infrastructure providers.

By assuring utilisation of both trucks and charging infrastructure, anchor fleets give financiers greater confidence to support investments and enable CPOs to plan infrastructure more efficiently. This, in turn, accelerates highway electrification by providing clear demand signals to OEMs, operators, and financiers. Early anchor deployments can help the ecosystem reach commercial maturity faster, creating the foundation for wider adoption across industries and highways.

Demand visibility along priority industrial highways could become the catalyst for developing the wider ecosystem.

Creating visible and sustained demand for BETs is fundamental to realising EV-ready highways. Corporate commitments and anchor fleet contracts ensure that once charging infrastructure is deployed, it is fully utilised – enhancing economic returns and investor confidence. In turn, the presence of reliable, high-power charging networks enables further BET adoption, forming a virtuous cycle of demand and readiness.

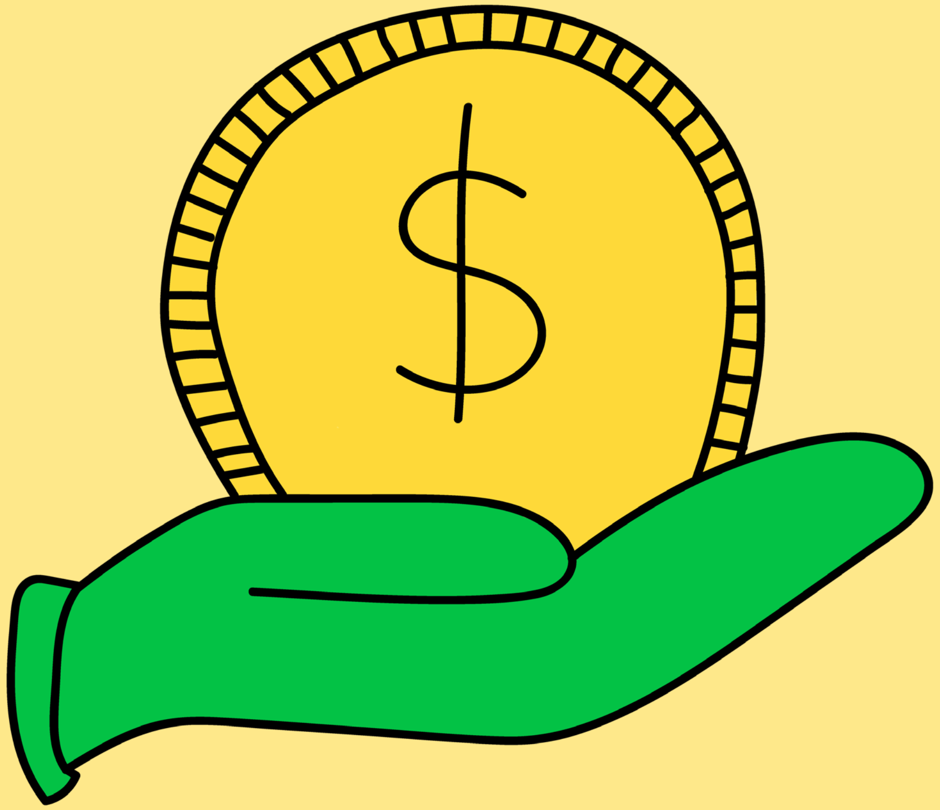
Call to action: Stimulating Early Demand for Electric Trucks

- **Implement targeted incentives for early adopters and anchor users**. Ministries (MHI) and State Transport Departments should introduce time-bound incentives, such as toll concessions, green freight accreditation, or operating subsidies for logistics companies and shippers that pioneer electric truck fleets on the designated highway.

[32] UltraTech Cement Limited (2024) UltraTech to deploy 100 more EV trucks in its logistics operations.

- **Aggregate freight demand** with large corporates, logistics majors, and public sector undertakings jointly declaring demand commitments for BET deployment along priority corridors. This initiative could be driven under the e-FAST platform.
- **Financial institutions to design risk-mitigation and leasing instruments.** Institutions such as SIDBI and multilateral banks, in partnership with private companies, can develop tailored financial products to improve TCO viability for fleet operators.

Once commercial viability and strong demand signals are in place, infrastructure expansion becomes the next critical step. A dense network of superfast chargers, supported by grid upgrades, will be required to ensure the technical feasibility of long-haul e-freight.



6 PILLAR 3 - INFRASTRUCTURE CREATION

The transition to electric freight hinges on the availability of a reliable, high-capacity charging network strategically deployed along key freight corridors. Unlike light-duty vehicles, electric trucks require high-capacity charging systems, grid upgrades, and high-voltage connectivity, which demand significant upfront planning and investment.

A strong infrastructure backbone is therefore critical for successful e-freight transition. Freight operations are defined by stringent turnaround times and delivery schedules. For e-trucks to compete with diesel trucks, they must be able to charge quickly and consistently without disrupting logistics timelines. This makes fast-charging infrastructure, built around high-capacity systems, a foundational requirement for e-truck adoption.

Chargers must deliver the necessary power for heavy-duty vehicles within the limited windows available during mandated breaks. Equally important, this charging infrastructure must be supported by adequate grid capacity, capable of handling clustered megawatt-scale demand at strategic freight nodes. Without reliable, high-speed charging underpinned by strong grid systems, electric freight will struggle to meet the performance benchmarks expected in India's logistics sector.

Thus, to ensure a robust infrastructure to support long-haul e-freight the following two key levers must be prioritised:

(i) **Dense network of superfast charging infrastructure**
(ii) **Upstream grid infrastructure**

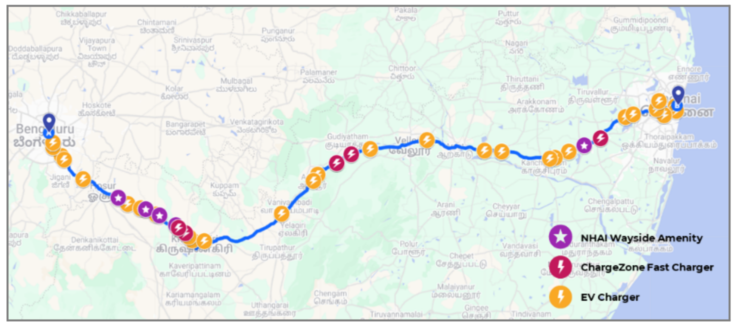
The following sections detail the two key levers for developing a strong infrastructure to enable e-freight.

6.1 Charging Infrastructure Network

India's public charging network has expanded rapidly, with more than 26,000 stations installed to date.[33] Yet, most of this infrastructure is designed for passenger EVs and small commercial vehicles. As per the PM E-DRIVE operational guidelines, the minimum charger capacity for heavy-duty vehicles is 240 kW, but most highway chargers today fall in the 30–120 kW range. While these are adequate for cars, they fall below the needs of electric trucks.

A highway-level assessment of the BLR–MAA highway, conducted under the Laneshift Programme, also highlighted this gap, where 80% of the chargers were between 20–60 kW, catering largely to passenger cars.[34,35,36] **Only five stations offered chargers in the 180–360 kW range**, highlighting how under-equipped India's highways remain for freight operations.

Figure 9. Map of existing charging and wayside amenity infrastructure along the BLR–MAA highway



Thus, highway-specific charging plans must consider **three key levers**, i.e., **capacity** of chargers, suitable **locations** for deploying chargers, and ensuring availability of **land** for CPOs to develop charging infrastructure along highways.

[33] BEE | Homepage
[34] BEE | Public Charging Stations (beeindia.gov.in)
[35] PlugShare – EV Charging Station Map – Find a place to charge your car!
[36] Fast EV Charging Stations for Car & Bike Near Me – Jio-bp | Jio-bp (jiobp.com)

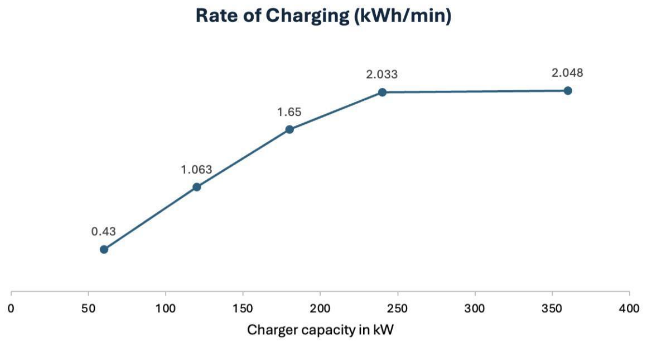
6.1.1 Capacity of chargers

High-capacity charging systems are critical to making highways e-truck ready.

For electric trucks to compete with diesel trucks, they must recharge within short, mandated driver breaks to maintain logistics efficiency. Slow charging undermines this efficiency, leading to longer TATs and reduced fleet productivity.

This was evident in the BLR–MAA pilot, where trucks relying on 60 kW chargers experienced turnaround delays of three to five hours. 43% of the trips of the 55T BET had to rely on 60 kW charger, and several trips for the 19T BET relied on 60 kW charger. These resulted in higher TATs for such trips. The 60-kW charger took up to five times longer than with a 240-kW charger (Figure 10), significantly impacting truck operations.

Figure 10. Rate of charging across different capacities of chargers achieved during the pilot



To address this, in the immediate next phase of highway electrification, CPOs must focus on developing multi-bay charging hubs equipped with 240–360 kW chargers. This will enable simultaneous charging of multiple trucks, minimise queuing, and ensure infrastructure readiness for e-trucks with large battery capacities. Such hubs will be essential to maintain industry-standard TATs and prevent operational bottlenecks as BET adoption scales.

Looking ahead, as BET adoption picks up at national scale, India can prepare for the global shift toward Megawatt Charging Systems (MCS),[37] which are already being deployed in markets like the USA for MHDTs. MCS solutions offer up to 3.75 MW of charging capacity, enabling significantly faster charging for larger trucks. Developing national standards and guidelines for MCS, through coordination between MHI, MoP, OEMs, and CPOs, will be a critical step toward future-proofing highway infrastructure.

6.1.2 Location assessment

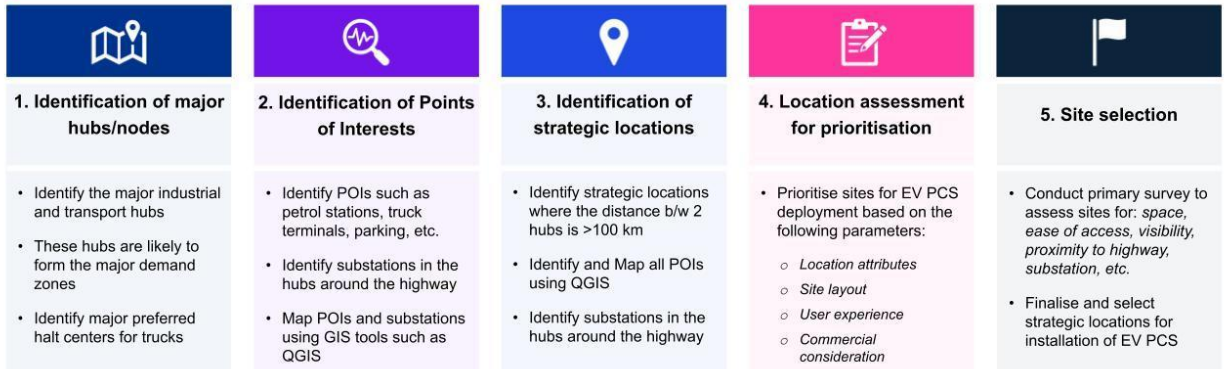
Optimal siting of charging infrastructure is just as important as its capacity.

Optimal sitting of charging infrastructure is critical for enabling efficient long-haul e-freight. High-capacity chargers deliver value only when positioned at strategic freight touchpoints such as logistics parks ports, toll plazas, large warehousing clusters, and highway way-side amenities. These are nodes where trucks already stop for mandated breaks, payload delivery, meal breaks, etc. Thus, integrating superfast charging stations at these locations ensures seamless integration of BETs with existing freight operations.

Additionally, such optimal siting also maximises charger utilisation, reduces downtime of BETs as charging sessions can be clubbed with meal breaks for drivers, loading/unloading of payloads, etc. Further, highway-level planning should also guarantee continuous coverage of the highway, by ensuring presence of superfast charging stations every 100 kilometres in line with MoP's guidelines for charging infrastructure deployment for heavy vehicles.

In the above context, the Laneshift demonstration project developed a comprehensive five-step location assessment framework (Figure 11) based on stakeholder consultations, primary survey, and on-ground assessments. This framework was used to identify optimal locations for setting up charging infrastructure on the BLR–MAA highway. It includes guiding principles for the identification of industrial/logistics hubs (to assure EV demand) and points of interest (to understand where EV drivers prefer to halt). It then provides guidance to prioritise the identified locations based on parameters including site layout, parking space for trucks, civil work requirement, proximity to highway and grid infrastructure, etc. Finally, it also provides the methodology for primary site assessment for final selection.

Figure 11. Framework for developing the corridor charging plan

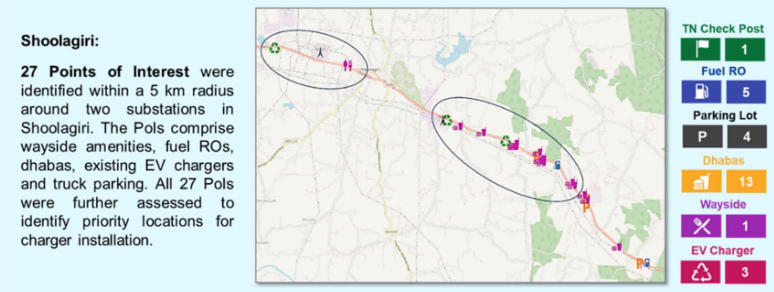


Box 8: Application of the framework on BLR–MAA highway

The framework started with identification of seven key industrial hubs between Bengaluru and Chennai, i.e., Hosur, Shoolagiri, Krishnagiri, Vellore, Sriperumbudur, Ambur and Kanchipuram. Over 200 points of interest were identified across these hubs using GIS analysis. These sites were then evaluated based on select criteria such as space availability, proximity to substations, truck traffic density, and the presence of amenities which led to a list of 48 shortlisted sites.

The adjacent image shows an illustrative example from one of the identified hubs, i.e., Shoolagiri wherein 27 points of interest were identified through secondary assessment.

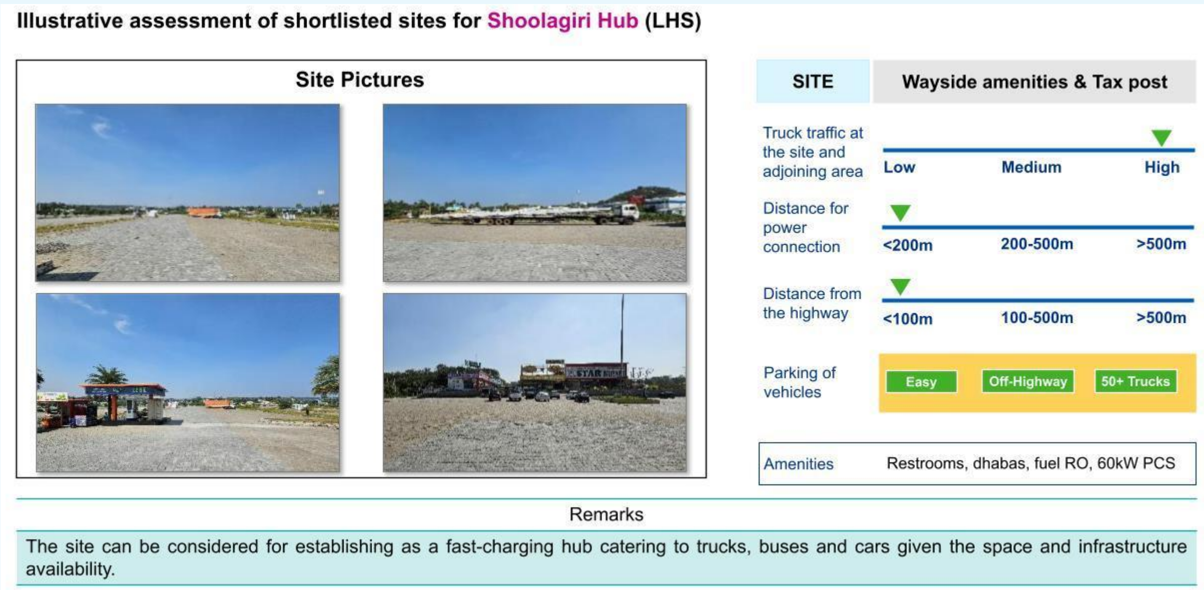
Figure 12. Identification of major hubs / nodes (eg. Shoolagiri)



Primary assessments were then conducted on these shortlisted sites to validate the feasibility of installing fast chargers by assessing practical factors such as power access, parking space, manoeuvrability, and site visibility.

[37] MCS refers to charging infrastructure capable of delivering very high DC power of the order of > 1 MW to allow fleets of heavy trucks to quickly charge in parallel. In 2023, the EU and USA produced a set of recommendations for MCS that allowed charging at up to 3.75 MW. This provided recognition of adoption of MCS by international standardisation organisations such as SAE International and the International Organization for Standardization (ISO). CharIN has also released specifications for MCS. Thus, progress is being made globally on developing standards for MCS, with the aim of achieving maximum interoperability. While MCS hardware is still being rolled out globally, the direction of travel is clear and future-ready freight corridors will need to accommodate it.

Figure 13. Illustrative assessment of shortlisted sites for Shoolagiri Hub (LHS)



Laneshift created a recommendation list of 15 potential locations using this framework, for deployment of superfast charging stations, along the BLR–MAA highway. This approach ensured that the sites would support high utilisation of chargers and ensure operational efficiency for BETs. This framework can be used along other priority highways in India as well, for identification of optimal sites for EVCI deployment.

The framework outlined above has not only been conceptualised but also applied in practice along the BLR–MAA highway as highlighted in the box item above. This underscores the potential for this framework to be replicated by CPOs, highway planners, and State Nodal Agencies for identification of optimal sites for deploying superfast charging infrastructure across other priority highways in India.

6.1.3 Land availability

Securing suitable land parcels is another critical prerequisite for deploying fast charging infrastructure along key freight highways.

Large, well-located sites are required to develop charging hubs with adequate parking space, minimal civil work requirements, and proximity to robust upstream grid infrastructure. High land costs, fragmented ownership, and complex allocation processes often make land access a major bottleneck for CPOs. Recognising this, the draft PM E-DRIVE guidelines identify land access as one of the five key ecosystem enablers for EV public charging infrastructure.

The guidelines emphasise the role of state governments and central ministries in facilitating land access at strategic locations. This includes coordination with municipal bodies, state highway authorities, public works departments (PWDs), and Central Public Sector Enterprises (CPSEs) to identify suitable sites. States are also encouraged to provide land on concessional terms, in line with MoP's guidance on land provision, to reduce development costs for CPOs.

Agencies such as the Uttar Pradesh Expressways Industrial Development Authority (UPEIDA)[38] in Uttar Pradesh[39] and Delhi Transco[40] have already piloted tenders with land provided at concessional lease rates. Specifically, UPEIDA has invited bids to set up public charging infrastructure through a public private partnership on key expressways such as Yamuna Expressway, Agra-Lucknow Expressway, Gorakhpur Link Expressway. UPEIDA will lease land at a nominal rate for 10 years to the selected bidder. This model can be replicated along freight-heavy highways such as Delhi–Mumbai, Bengaluru–Chennai, Ahmedabad–Mundra, etc.

Call to action: Building a robust charging infrastructure network

- **NHAI to integrate e-truck charging at all wayside amenities**, by offering land to CPOs at concessional rates.
- **State governments to offer land leases at concessional rates** within logistics parks and truck terminals to lower the cost of rent for CPOs and to anchor charging hubs at existing points of freight aggregation.
- **Develop a national- and state-level bank of EV-ready land parcels,** coordinated by MHI and SNAs, with details on location, grid connectivity, and truck traffic to guide investment.

By aligning central, state, and local land-planning institutions, the barrier of land availability can be addressed, thus accelerating deployment of superfast charging stations needed for a BET-ready highway network.

Hence, some of the proposed actions that can be considered to facilitate land access include:

- **NHAI to integrate e-truck charging at all wayside amenities**, by offering land to CPOs at concessional rates
- **State governments to offer land leases at concessional rates** within logistics parks and truck terminals to lower the cost of rent for CPOs and to anchor charging hubs at existing points of freight aggregation
- **Develop a national and state-level bank of EV-ready land parcels,** coordinated by MHI and SNAs, with details on location, grid connectivity, and truck traffic to guide investment

By aligning central, state, and local land-planning institutions, the barrier of land availability can be addressed, thus, accelerating deployment of superfast charging stations needed for a BET-ready highway network.

6.2 Upstream Grid Infrastructure

To power a dense network of superfast chargers, a robust and reliable grid is a necessity. Measures to ensure access to reliable and green energy to CPOs to power their charging stations are discussed in the following sub-sections.

6.2.1 Grid capacity and reliability

Charging hubs are only as effective as the grid that powers them.

High-capacity chargers and optimal siting may define where trucks should charge, but it is the grid that determines whether they can charge. Grid infrastructure, both in terms of capacity and reliability, will ultimately decide if India's freight highways can become truly e-truck ready. Without adequate power at the right nodes, charging stations risk becoming stranded assets rather than the enablers of a zero-emission freight system. Stakeholder consultations have highlighted several instances where the charging infrastructure remains inoperable despite installation, due to lack of power supply. The following two key challenges must be addressed:

[38] Uttar Pradesh Expressways Industrial Development Authority
[39] Hazarika, G. (2023) Uttar Pradesh invites bids for Public Charging Stations on Expressways, *MERCOM India*, 26 October.
[40] State EV Cell, Department of Transport, Government of NCT of Delhi (2022) Charging / Swapping Infrastructure Action Plan for Delhi 2022 – 2025.

i. **Grid capacity:** Heavy-duty charging hubs create power demands very different from today's passenger EV network. A single site with multiple 240–360 kW chargers can require several megawatts of supply – comparable to a small industrial estate. However, most substations along highways are not designed for such concentrated demand, and grid augmentation takes time. DISCOMs typically require long lead times (ranging from 30 to 90 days as defined in their supply code) to sanction new feeders, augment substations, or build dedicated infrastructure. This lag means that even when chargers are physically installed, their operationalisation can be delayed for months until the supporting grid is ready. Unless highway-level load forecasting and proactive upgrades are undertaken, highway fast-charging risks being held back by the pace of grid expansion.

   Thus, grid upgradation projects should be planned along all priority highways and their corresponding expenses should be included in DISCOMs' capex plans submitted to state electricity regulatory commissions.

ii. **Reliability of supply:** Even where grid connections exist, power on many highways stretches, particularly in semi-urban and rural areas, is prone to outages, voltage fluctuations, and feeder overloading. For freight operators, such unpredictability is unacceptable: a failed charging session can disrupt entire supply chains. Thus, ensuring reliable supply of electricity is crucial for reliable e-freight.

   Ensuring dependable power along highways will therefore require not just upgrades to grid capacity, but also measures to enhance resilience, redundancy, and integration of local renewable and storage systems.

Call to action: Strengthening upstream grid infrastructure for e-freight corridors

- **Develop integrated grid upgrade plans** for priority freight corridors, jointly led by DISCOMs and highway authorities, to forecast demand and pre-plan dedicated high-capacity feeders (33kV or 66kV) for upcoming superfast charging hubs.
- **Transmission and distribution utilities to integrate grid upgrade** needs into the national and state investment plans, which will be critical for timely deployment and cost recovery.
- **Upgrade highway-connected feeders** with smart grid technology and predictive maintenance capabilities for increased grid resilience.

6.2.2 Access to green energy

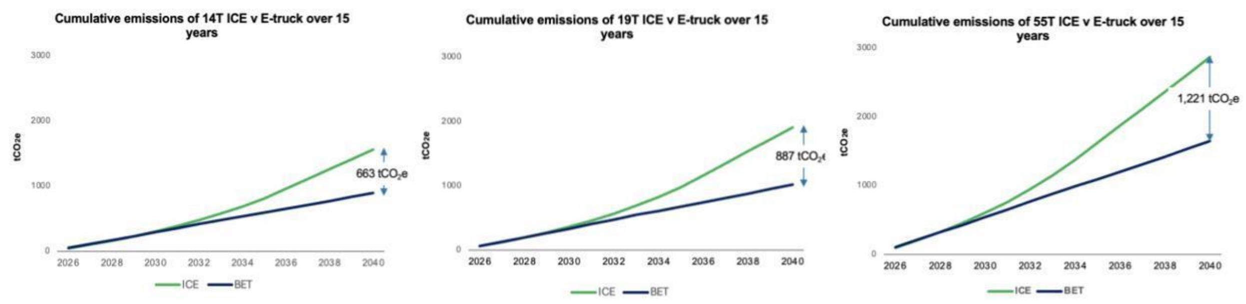
The full climate potential of e-trucks is unlocked only with renewable charging.

The primary motivation behind the transition to electric freight is emissions reduction. While the tailpipe emissions of e-trucks are zero, they still contribute to emissions on account of energy consumption during charging session. With India's grid still drawing around 70% of its electricity from fossil fuels,[41] e-trucks powered purely by grid electricity can only partially deliver on the promise of decarbonisation.

An analysis conducted under the Laneshift project underscores this point. Under a baseline scenario, where electric trucks are charged entirely from the grid, emissions are lower than those of diesel trucks.

[41] Press Information Bureau, Delhi (2023) Shri R. K. Singh exhorts industry leaders to set targets for going green; asks them to bring to government's notice such cases where the Green Energy Open Access Rules are not being followed, Press release.

Figure 14. GHG emissions reduction potential across all 3 categories of BETs over a 15-year life



But a similar modelling for a scenario where all charging was powered by renewable energy, the emissions reduction was substantially greater. If charging stations are powered by on site solar and BESS, and/or source 100% RE generated energy through open access, the GHG emission saving potential for an BETs could be as high as 1,558 tons, 1,908 tons, and 2,872 tons of CO2e, for 14T, 19T, and 55T BETs respectively.

The above comparison highlights a critical takeaway, i.e., the environmental case for e-trucks is strongest when charging is powered by clean energy. Thus, to facilitate green energy at charging stations, certain initiatives have been undertaken such as enabling renewable energy (RE) sourcing through open access. In addition, the MoP's Green Energy Open Access Rules reduce the open access limit to 100 kW which enables small consumers, including charging stations, to purchase RE.[42]

Box 9. CPOs are integrating solar and battery with charging infrastructure for greener and reliable power

To ensure green well to wheel operations for e-trucks and for improved reliability of power for charging infrastructure, CPOs in India are exploring solar and battery storage solutions. Case in point is the ChargeZone's ultra-fast supercharging hub at Shri Annapurna Hotel on the BLR–MAA highway.

With a total capacity of 1.2 megawatts and 5 ultra-fast 240 kW superchargers, this hub allows EV owners to charge their vehicles in record time. It features a 55 kW rooftop solar panel system combined with a 1.2 MW battery energy storage system, ensuring uninterrupted, grid-independent charging even during power outages.

This approach ensures reliable supply even in areas with unstable grid power — without resorting to diesel backup. This model demonstrates how RE and storage can enhance both the sustainability and reliability of highway charging infrastructure, offering a scalable alternative to diesel generator sets.

[42] Press Information Bureau, Delhi (2023) Shri R. K. Singh exhorts industry leaders to set targets for going green; asks them to bring to government's notice such cases where the Green Energy Open Access Rules are not being followed, Press release.

Call to action: Enabling green power for BET charging

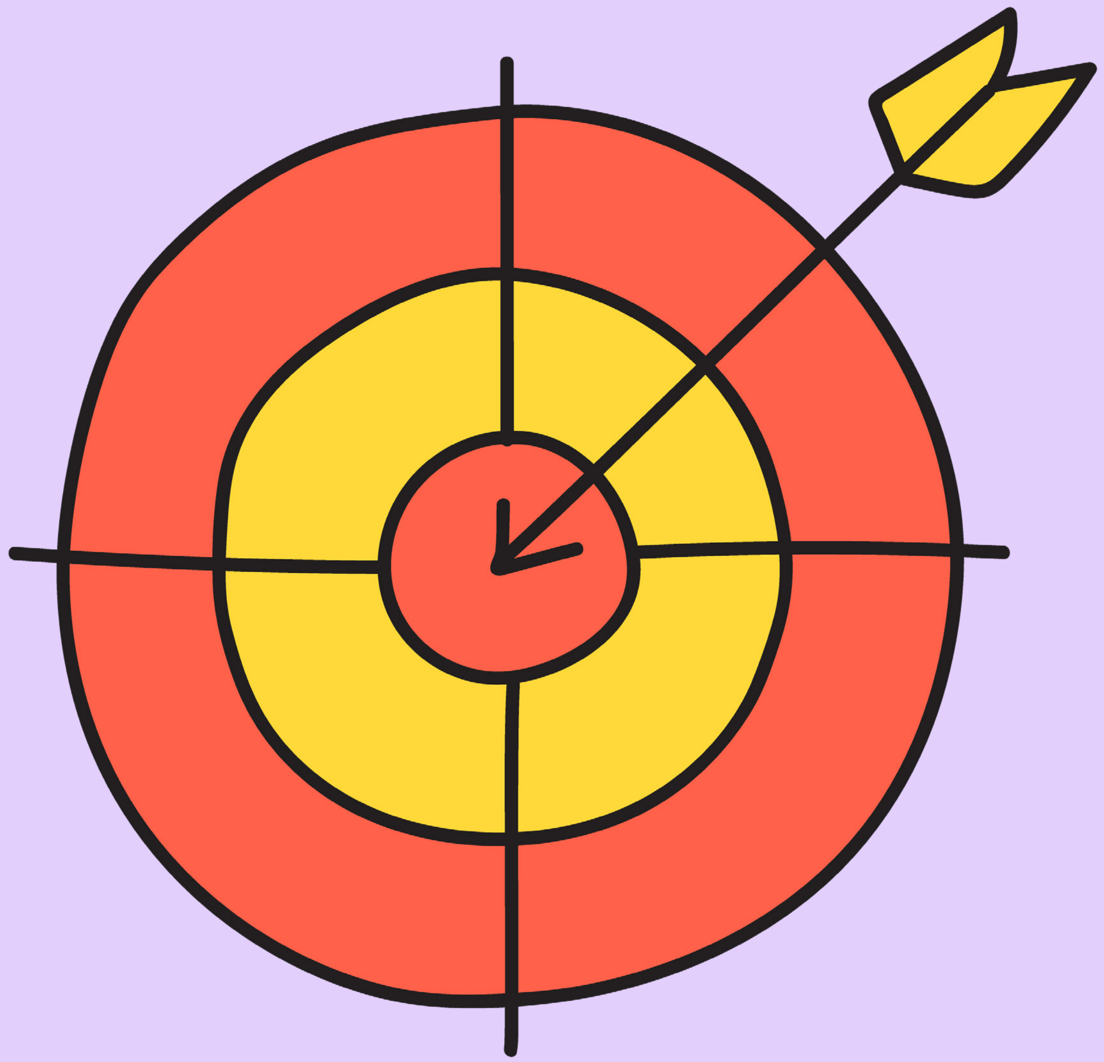
In addition to existing policies, other measures that can be undertaken to promote greater integration of RE at charging hubs could be:

- **Set progressive Renewable Purchase Obligations (RPOs)** for charging operators, with progressively increasing targets for renewable energy powered charging.
- **Provide capital support or concessional finance** to CPOs for RE and storage integration at highway charging hubs, through state EV policies or central schemes.
- **Pilot 100% RE-powered charging** in select highways, such as those identified in the MHI's priority list, to demonstrate feasibility and create early success stories.

The infrastructure backbone must deliver efficiency today and sustainability for tomorrow.

Building a robust infrastructure backbone goes beyond installing chargers along highways. It requires a holistic approach that integrates multiple enablers such as high-capacity charging systems at optimal locations, reliable grid capacity and embedding renewable energy to align with national decarbonisation goals.

Together, these elements form a technically sound, economically viable, and environmentally credible system. By planning infrastructure through this integrated lens, India can move beyond piecemeal deployments and develop freight highways that are future-ready.



7 PILLAR 4 - OPERATIONS AND SERVICE DELIVERY OPTIMISATION

As the technical foundations for highway electrification are established through dense charging networks and grid upgrades, the focus of the transition will increasingly shift towards ensuring the operational reliability of BETs.

BETs differ significantly from conventional ICE trucks in both performance and complexity. Unlike diesel fleets, BETs generate vast volumes of real-time data, from battery health and charging cycles to driver behaviour, which require intelligent systems to interpret and act upon. The presence of new components such as high-voltage battery packs, and the need for coordinated charging even more important.

Without robust digital oversight, issues such as suboptimal charging, unplanned downtime, and poor route planning can undermine fleet performance. As adoption scales, the ability to monitor, predict, and optimise these variables becomes critical, not just for maintaining service reliability, but also for improving utilisation, reducing TATs, and demonstrating the commercial viability of e-freight at scale.

Operational reliability will be underpinned by two key enablers: digital systems that provide real-time visibility and coordination across the logistics value chain, and a robust service ecosystem that ensures quick response during any unforeseen breakdowns. The service ecosystem will require strategically located maintenance facilities and roadside assistance both along highways and at critical freight nodes. Together, these measures are expected to ensure that BET operations are not only technically viable but also operationally reliable and predictable. This, in turn, would strengthen confidence among shippers and other ecosystem actors, enabling adoption at scale.

7.1 Digital Interventions

Digital technology interventions form the backbone of operational optimisation, enabling e-trucks to deliver reliable, efficient, and predictable performance at scale.

Digital systems are expected to play a central role in enabling the transition from pilot deployments to efficient, reliable, and large-scale e-freight operations. Freight electrification involves the coordination of multiple operational variables, i.e., route planning, charger availability, battery health, turnaround time (TAT), and asset utilisation across multiple stakeholders including LSPs, CPOs, OEMs, and drivers.

By leveraging advanced analytics, Internet of Things (IoT) sensors, artificial intelligence (AI)-enabled monitoring, and connected fleet platforms, digital interventions can reduce operational uncertainty, improve TATs, and optimise both vehicle and charging assets. These capabilities ensure that BET fleets can deliver reliable, efficient, and predictable service at scale.

Some of the key interventions that can be adopted by operators are:

- **Smart Charging and Control Centres**: Data sharing between CPOs and LSPs can ensure that LSPs have clear visibility about real-time availability of slots, tariff, and energy at charging stations along the highway. This would help remove range and charge anxiety from driver behaviour. Additionally, control centres can help LSPs automate charging sessions and minimise human intervention, thereby optimising charging time. For example, once a vehicle is connected to a charging station, charging sessions can be centrally regulated, to limit charging to 80% battery's state of charge (SoC), thus, ensuring quick TATs.

  This could also help increase battery life, as real-time data on availability of chargers would allow LSPs to plan charging stops before e-trucks consume 80% of battery's SoC, thus, avoiding deep discharge of batteries. Further, top-ups up to 80% could also ensure shorter charging sessions at superfast charging stations, thus, improving battery life. This in turn could help reduce overall maintenance cost for BETs eventually, as it would lead to higher overall kilometres run across the life of a battery pack.

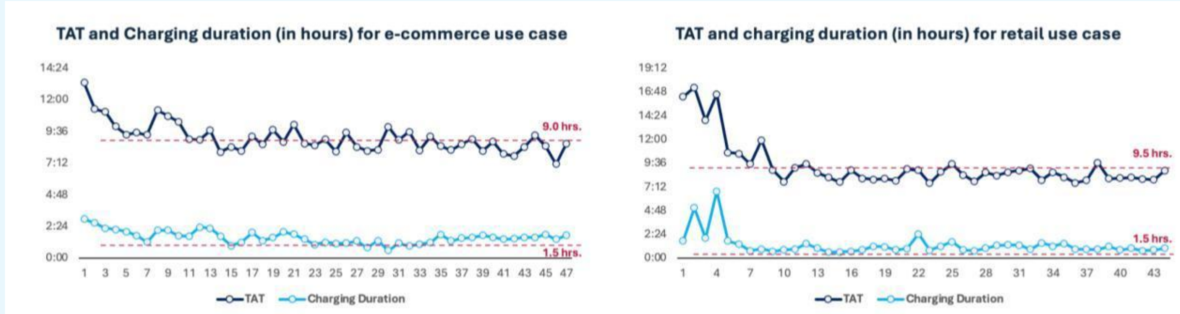
- **AI-driven Driver and Trip Monitoring:** AI and telematics can track driver fatigue, route adherence, and vehicle speeds in real time. Alerts for unscheduled stops or deviations help ensure service commitments and safety standards are maintained. Such AI and IoT solutions can offer improved service delivery to shippers, by ensuring safe and on-time delivery of goods.
- **Advanced Driver Assistance System (ADAS):** ADAS encompasses a range of technologies designed to enhance vehicle performance, safety, and driving comfort by offering features such as automatic emergency braking, lane departure alerts, and adaptive cruise control.[43] Deployment of ADAS across BET fleets will ensure safety on high-speed highways. In recognition of improving safety in road freight, The Ministry of Road Transport and Highways in India has mandated all new models of N2 and N3 category trucks to be equipped with ADAS capability effective from 01 April 2026. This is expected to further improve safety for BETs on national highways.[44]
- **Battery and Vehicle Health Monitoring:** IoT sensors embedded in the truck can continuously monitor the battery's state of health (SoH), charging cycles, and temperature variations. This data can be leveraged for predictive analytics, to detect early signs of degradation, enabling pre-emptive maintenance and reducing risk of unexpected breakdowns. In the context of highway electrification such systems are critical for ensuring that BETs maintain high levels of fleet availability and minimise unplanned downtime through predictive maintenance. Volvo's "Uptime Centers" is a strong example where predictive maintenance has significantly improved vehicle availability. Similar capability could be developed by Indian OEMs to facilitate predictive analytics and maintenance of battery packs to ensure longer battery life.
- **Route Optimisation and Energy Forecasting:** Telematics platforms can combine data on payload, terrain, traffic and weather to recommend the most efficient routes, minimising charging stops, and driving hours, thereby optimising overall TATs. This ensures consistent range predictability and better trip planning.

Box 10. The LSP integrated digital centres, AI-driven driver and trip monitoring, and leveraged telematics for improved route planning to optimise operations

During the initial pilot trips, charging sessions were being conducted by drivers, and due to range and charge anxiety, the drivers were charging the trucks up to 100% battery SoC at every top up charging session. This led to high charging durations and in turn higher TATs. To address this, the LSP developed a digital control centre, which enabled to reduce human intervention in charging, and ensured trucks didn't charge beyond 80% battery SoC during enroute charging sessions. This also removed charge anxiety from driver behaviour as control centres could take data driven decisions on the amount of top-up charge needed to ensure enough range to complete the journey.

The illustrative below highlights how integration of data analytics and control centre helped the LSP optimise charging duration and TATs for e-commerce and retail use cases.

Figure 15. TAT and Charging Duration (in hours) for e-commerce and retail use case



Further, AI-driven route planning and trip monitoring enabled the LSP to ensure that trucks followed the designated routes, stopped at pre-decided charging stations, and didn't have any unplanned downtime. Additionally, it also enabled monitoring of truck speeds, driver fatigue, etc., thereby, increasing safety over long trips.

Together, these digital interventions transform e-truck operations from **static to dynamic systems**, where every trip generates data that can be fed back into control centres for continuous improvement. Over time, this digital foundation can ensure predictable and optimal e-truck operations and thus, build shipper confidence. This will ensure that e-trucks can scale competitively alongside conventional fleets.

7.2 Service Ecosystem

A robust service ecosystem with skilled technicians, roadside, and EV-ready service hubs is vital to keeping e-truck operations reliable.

Unlike ICE trucks which have access to a well-established service ecosystem, the service and maintenance needs of e-trucks are still evolving. There is a gap in the presence of a service ecosystem to support e-trucks in instances of vehicle breakdown during journeys. This makes it critical to establish infrastructure and capabilities, tailored to BETs, such as:

- **Specialised Service Facilities and Trained Workforce**: Establishing service centres equipped with e-truck diagnostic tools, high-voltage safety equipment, and dedicated spare parts will be critical to ensuring operational reliability along highways. The availability of mechanics and technicians trained in BET maintenance and safety protocols at these locations will minimise downtime and support continuous fleet operations. Such facilities could initially be located at major industrial hubs and logistics nodes, including ports, container freight stations, and inland container depots (ICDs).

Box 11. Volvo is leading the way in developing a network of EV-certified dealership network

In the USA, Volvo is developing a network of "EV-certified" dealerships, which are equipped with dedicated BET service bays, diagnostic tools, trained technicians, personal protective equipment for technicians working with high voltage systems, etc.[45] OEMs in India can establish similar networks of EV-certified dealerships by either upgrading existing facilities or establishing new dealerships along major highways to ensure access to a reliable service ecosystem to fleet operators.

[43] Suzuki R&D Centre India (2024) ADAS Explained: What is Advanced Driver Assistance System?
[44] MoRTH (2025) GSR 184(E) dated the 20th March 2025.
[45] Volvo Trucks Continues Electromobility Leadership: Ten New Locations Join Certified EV Dealership Network

- **Roadside Assistance:** To reduce operational risk, fleets would need access to 24/7 breakdown response, towing services, and mobile repair and charging vans that can support drivers during breakdown incidents on highways.
- **Integration with Wayside Amenities:** Wayside amenities are present along major highways. They are equipped with service centres and repair shops for ICE trucks, along with other driver-friendly facilities. This network can be leveraged to host BET-certified service stations, which can also be used for roadside assistance.
- **Supply chain of Spares:** Availability of diagnostic tools and critical spare parts will be essential to ensure that service centres along highways can undertake both regular maintenance and unplanned repairs for BETs. A strategically designed spare parts distribution network, maintained by OEMs, will be required to keep EV-certified service centres and dealerships adequately stocked with components.

While the service ecosystem for BETs develops, in the interim, fleet operators may adopt contingency measures such as maintaining an ICE truck on standby, to safeguard operational continuity. This practice was successfully demonstrated by the LSP operating on the BLR–MAA corridor during the Laneshift pilot with businesses. This helped build customer confidence and ensured zero disruption in freight movement.

Call to action: Enabling a robust service ecosystem for BETs

- **Develop roadside assistance and network of service hubs**: OEMs to establish BET-certified service hubs at logistics nodes and NHLML to facilitate integration of BET service facilities at wayside amenities along national highways.
- **Launch targeted technician training programmes**: OEMs and State Skill Missions to collaborate under Skill India to develop certified training programmes for BET diagnostics, high-voltage safety, and maintenance.

Thus, a strong service ecosystem combines trained workforce, network of BET-certified service facilities, and responsive roadside support. Embedding these along priority highways and adjacencies would ensure that e-trucks can achieve the uptime and reliability benchmarks necessary for freight operators and shippers to confidently scale adoption.

7.3 Green Channel

Process innovation such as enabling green channels for e-trucks can help boost BET throughput and increase utilisation.

A dedicated priority lane or processing queue, commonly referred to as a **Green Channel,** for e-trucks at ports, CFS, ICDs, and warehousing hubs can significantly reduce idle times and improve utilisation. It was observed during the pilot that giving BETs preferential access to loading and unloading zones at shipper's warehouses helped BETs gain operational advantages and improved their viability by increasing overall utilisation. It allowed BETs to undertake more trips by reducing idle time at loading and unloading bays. This made adoption of BETs even more attractive for shippers. Thus, following key elements of green channels could be integrated in highway planning for improved e-freight operations:

- **Priority Access Lanes** at terminal gates of major ports and container freight stations to bypass congestion and reduce queue times.
- **Dedicated Bays** for loading/unloading at ports and warehouses of shippers to minimise idle time especially during peak hours.
- **Pre-scheduled docking assignments** via digital systems to ensure seamless entry and exit.
- **Charging Integration** at loading zones could also be piloted to streamline battery top-ups alongside cargo operations, thus, optimising overall operations, TATs, and utilisation of BETs.

Box 12. The Port of Gothenburg in Sweden has pioneered Green Channels for e-trucks[46]

Since January 2022, electric and fuel-cell trucks were fast-tracked through entry gates at Stena Line Gothenburg-Kiel Terminal and the Gothenburg Ro-Ro Terminal. These "green" trucks were allowed to skip standard queues and move directly to dedicated loading spaces. This initiative was aimed to reward fleet operators plying BETs with faster TATs, enabling them to complete more assignments and accelerate ROI. This initiative has catalysed fleet electrification in the port region. APM Terminals later extended this approach by offering priority lanes and handling in its large container terminal, further reinforcing Gothenburg's green logistics leadership.[47]

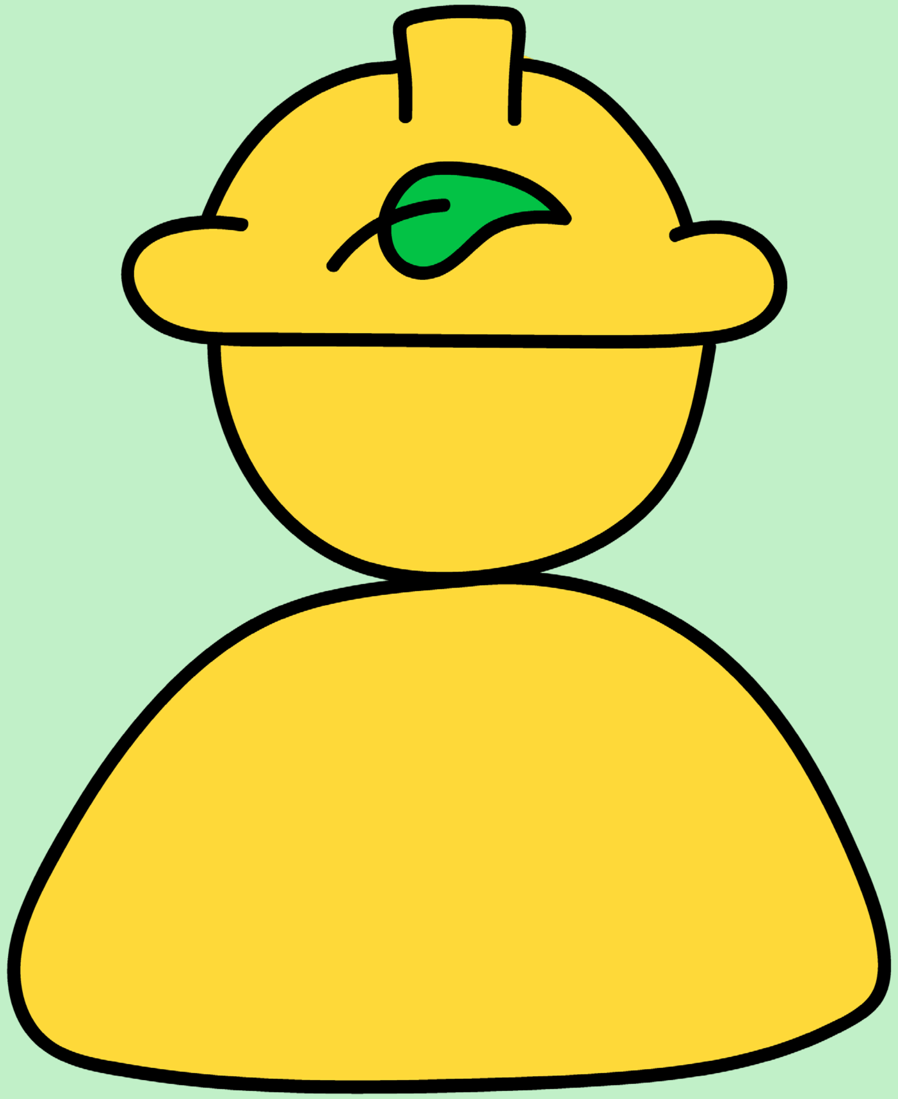
Thus, **shippers, port authorities**, **port terminal operators**, and **container freight stations** could all facilitate **green channels** and **preferential access** for BETs to loading and unloading bays, thereby improving overall operational efficiency of BETs and enabling higher asset utilisation.

Operational reliability of BETs through process and digital innovation will drive large-scale adoption.

As India moves from pilots to scaled deployment of e-trucks, operational reliability will hold the key to building shipper confidence and driving adoption. Digital interventions, network of certified service centres, and green channels when deployed parallelly, can create a reinforcing loop, enabling reliable, predictable, and efficient BET operations.

Deployment of these measures will require close coordination between all industry stakeholders. OEMs would need to lead the development of a robust service network by enabling the requisite technical and human capacity along highways. CPOs and LSPs will need to collaborate and ensure seamless real time data flow. Further, port authorities, shippers, and logistic parks/ICDs could enable green channels for BETs, thus, incentivising e-freight over diesel trucking. Together, these interventions can develop e-freight as the dependable backbone of highway freight.

[46] Port of Gothenburg (2021) Green trucks to get priority at Port of Gothenburg terminals | Port of Gothenburg.
[47] Cyprus Shipping News (2023) APM Terminals introduce priority for electric trucks in the container terminal at the Port of Gothenburg.



8 PILLAR 5 - JUST TRANSITION

As India charts its path toward battery-electric freight, it is critical to ensure that the transition does not leave behind the very people and communities that make the logistics system function. Truck drivers and mechanics form the lifeline of road freight and will need to be equipped with new skills to thrive in an electric future. Drivers will have to adapt to automatic drivetrains, charging interfaces, telematics, and new safety protocols, while mechanics must be trained to service high-voltage systems, electronic components, and specialised parts unique to e-trucks. Preparing this workforce is essential not only for safety and reliability but also for building confidence in the new technology.

Today, India faces a significant shortage of truck drivers, with 2 million truck drivers at present and a driver-to-truck ratio below 750 per 1000. This means approximately 25% to 30% of India's trucks lie idle at any given point of time and those employed in the sector are overworked.[41] Poor working conditions, low wages, inadequate healthcare, and limited social security benefits deter individuals from pursuing trucking careers. Surveys show that 53% of the drivers earn between INR 10,000 to INR 20,000 per month,[48] and often suffer from various health issues, such as backaches and joint/muscle pain. Without urgent measures, this driver shortage could hinder India's economic ambitions.

The transition to BETs provides a unique opportunity to address many above-mentioned barriers. The lower operational cost of e-trucks, when passed on to consumers and shippers, can pave the way for increased access and expansion of freight services, thus creating a more formal job market for drivers. Adoption of advanced technology in e-trucks can enhance the efficiency and safety for drivers by minimising the risks associated with long hours and challenging routes. Moreover, improvements in truck ergonomics can enhance drivers' working conditions for drivers and wellbeing. All these aspects combined can boost job satisfaction and make driving a more aspirational career.

Targeted actions will be required to harness these opportunities. Training and upskilling programmes will be needed to equip the drivers with skills needed to operate BETs. These will be equally important for the mechanics as they will have to understand the electric motor assembly, battery management systems, battery's end-of-life management, etc. In addition to skilling, creating an inclusive and socially sustainable ecosystem will also be critical. Gender-responsive infrastructure at charging hubs and wayside amenities, such as secure restrooms, well-lit facilities, and surveillance, can encourage greater participation of women in trucking, a sector that has traditionally been male-dominated.

Simultaneously, transition planning must protect and strengthen the local roadside economies of dhabas, food stalls, and service shops that depend on long-haul trucking activity. By combining workforce training, inclusive design, and local economic preservation, the just transition pillar ensures that the shift to e-trucks uplifts communities and creates a resilient, people-centred freight ecosystem.

To ensure a just and equitable transition to BETs, three key levers must be prioritised:

(i) **Driver and Mechanic Training** to equip the workforce with skills for operating and maintaining BETs.

(ii) **Gender Inclusive Infrastructure** at charging hubs and rest stops to foster safer, more welcoming spaces for people of all genders.

(iii) **Social Safeguards** aimed at preserving local community livelihoods and ensuring inclusion of small fleet operators in this transition.

The following sections detail the three key levers for a just transition:

[48] SaveLIFE Foundation (2020) Status of Truck Drivers in India.

8.1 Driver and Mechanic Training

Workforce training and upskilling will be crucial for just and equitable transition to e-freight.

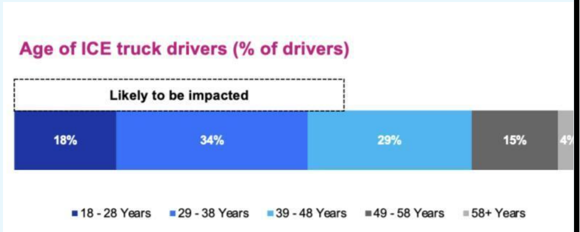
The transition to BETs will fundamentally change how freight is operated and maintained, demanding new skill sets. Drivers will need to go beyond traditional vehicle handling to adapt to automatic drivetrains, high voltage charging systems, telematics interfaces, and digital route planning tools. Mechanics, meanwhile, will require reskilling to manage the unique characteristics of BETs, including power electronics, battery management systems, and specialised drivetrain components.

However, the shift to e-freight is taking place in the backdrop of an existing workforce shortage in the trucking industry. The truck-to-driving partner ratio in India has dropped to from 75:100 to around 55:100 in recent years, underscoring the urgency of retaining the existing workforce and attract new driver partners.[49] The transition would therefore have to be designed to address not just technical readiness but also workforce sustainability.

Box 13. Primary survey conducted along the Bengaluru–Chennai highway, across truck drivers, garage owners and mechanics highlighted a clear need for targeted upskilling to support them in transitioning to BETs

Driver Perspectives:

Figure 16. Age of ICE truck drivers (% of drivers)

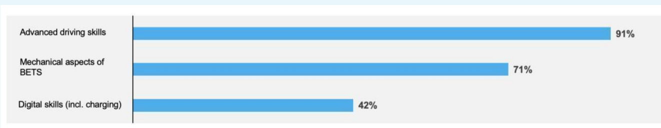


The survey revealed that the average age of drivers was about 38 years, with over 50% being younger than 40 years. This indicates that a significant proportion of drivers stand to be impacted by the transition to BETs and highlights a window of opportunity for long-term workforce readiness.

The survey also inquired about ICE truck drivers' willingness to upskill, with the majority expressing strong interest in undergoing reskilling for BET adoption: 70% of the respondent drivers and 90% of garage owners indicated their willingness to reskill to prepare for e-truck transition. The following skill areas were identified as priority:

- **Advanced driving skills** to operate automatic transmission trucks.
- **Training on BET's mechanical aspect** to understand the moving parts of the truck, thus, equipping them to manage BETs in case of any minor breakdown.
- **Digital proficiency** for operating charging stations, understanding truck telematics, route planning, etc.

Figure 17. Survey results about ICE truck drivers' willingness to upskill



Service Ecosystem Perspectives:

While surveying garage owners and mechanics, the survey also inquired about their willingness to transition to BETs, and the kind of service ecosystem support that would be needed to ensure a just transition in shifting to BETs. It was understood that over 90% of the garage owners expressed willingness to reskill their workforce, indicating a strong readiness to adapt if the right support systems are in place.

The garage owners and mechanics also suggested the following top four priority areas where they would need support to equip themselves to adopt e-trucks: (i) **Technical Training on EV systems**, (ii) **Hands-on exposure and certification**, (iii) **Access to advanced diagnostic tools**, and (iv) **Availability of spares.**

Thus, training modules for drivers and mechanics can be curated to address the following aspects:

- **Driver Training Programmes**:
  - Driving automatic transmission drivetrains, and assisting truck drivers get accustomed to acceleration, braking capacity, and top speeds of e-trucks.
  - Breakdown protocols for BETs, safety measures, charging protocols, etc.
  - Digital proficiency to enable drivers to understand truck telematics, undertake route planning if required, make digital payments, etc.
- **Mechanic and Technician Programmes**:
  - Handling specific diagnostic tools used to identify issues with e-trucks.
  - Breakdown and safety protocols, training on understanding drivetrain and electronic components of BETs.
  - Battery health management, thermal management, and other components of battery packs.

Thus, systematic investment in driver and mechanic training is essential to ensure that a skilled logistics workforce powers the transition to electric freight. OEMs and their dealer networks must lead the delivery of technical training and certification programmes, while state governments should support skilling through EV policy mandates and integration with existing livelihood and skill development schemes. A coordinated effort across industry and government will be key to building a future-ready, inclusive freight ecosystem.

8.2 Gender Inclusive Infrastructure

Safe, inclusive amenities at charging stations and wayside amenities can open the door for greater women's participation in India's trucking sector.

The Indian trucking industry faces a significant gender imbalance, similar to the global scenario where women constitute only about 6% of the truck-driving workforce. In contrast, women represent over 10% of the workforce in the broader transport sector globally.[50] This is slightly higher in other advanced economies such as the USA wherein women account for ~14% of the driver workforce in the trucking sector.[51] While conducting the BLR–MAA highway study, it was highlighted by over 70% truck driver respondents during the primary survey that harsh working conditions and lack of safe and women centric infrastructure at fuel ROs, wayside amenities, warehouses, etc., is a major deterrent for women to join trucking as a profession. Thus, the shift to e-freight provides us an opportunity to create more inclusive new aged gender inclusive infrastructure, thus, creating inclusive employment opportunities. This is also in line with the government's efforts to increase female workforce participation in the country. Women empowerment being a key driver for national progress, the government aims to ensure 70% women workforce participation by 2047.[52]

As driver-friendly infrastructure gets established at wayside amenities and charging stations, some of the specific actions that can be taken to ensure that they are gender inclusive are:

[49] Vasudha Foundation (2024) Enabling a Just Transition for India's Truck Driving Partners Amid the Adoption of Zero Emission Trucks, 2024.

[50] Vasudha Foundation (2024) Enabling a Just Transition for India's Truck Driving Partners Amid the Adoption of Zero Emission Trucks, 2024.
[51] Maury, D (2024) How to attract more women to the trucking industry.
[52] Press Information Bureau (2025) Nari Shakti se Viksit Bharat: Women Leading India's Economic Transformation Story, Press release.

- Install **separate, hygienic washrooms for women drivers** at charging hubs, wayside amenities, ports, container freight stations, warehouses, etc.
- Ensure **CCTV coverage, panic buttons, and LED lighting** at charging stations and wayside amenities to improve safety and security, especially during night operations.
- Develop **rest lounges** for women drivers in high-traffic hubs to support longer trips and attract more women into logistics roles.
- Integrate gender-inclusive design guidelines into national- and state-level policies for any new public or PPP-based logistics infrastructure projects to follow.

Box 14: Global examples have shown that developing inclusive infrastructure can encourage women participation in trucking

1. The Women in Motion Council (American Trucking Associations) partnered with Trucker Path to mark over 100 truck stops offering safety-focused amenities (lighted parking, well-lit bathroom access, secure lounges, 24/7 shower and laundry facilities, and onsite security), all designed to make stops safer and more accessible for women drivers.[53]

2. Swedish startup, Drivers First, has created truck rest areas equipped with essential amenities such as 24-hour shops, restrooms, showers, secure lighting, etc., designed for driver comfort and safety, especially for female drivers operating on major industrial routes.[54]

Organisations such as Azad Foundation, Self Employed Women's Association (SEWA) and UN Women India can partner with CPOs and infrastructure concessionaries to co-develop women-centric infrastructure along highways in India.

8.3 Social Safeguards

Highway electrification and shift to e-freight shall be mindful of not disrupting the local economies that thrive from trucker rest and maintenance stops.

The trucking economy in India refers to the interconnected network of livelihoods, services, and microenterprises that support long-haul freight movement across the country's highways. It includes truck drivers, small fleet operators (fleet size 1–5 trucks, driver owner), dhabas/food plazas, rest stops, roadside repair shops, fuel stations, and small vendors, many of which have evolved over decades to serve the needs of truck drivers while sustaining local communities along freight highways.

Highway electrification must be designed to strengthen, not displace, these local ecosystems of dhabas/food plazas, repair shops, small vendors, and small fleet operators that have thrived on trucking activity along highways. These establishments are not only essential for driver comfort and wellbeing, but also form the economic lifeline of thousands of families along freight highways. Transitioning to battery-electric trucking should therefore preserve their role while enabling new opportunities. If left unaddressed, it could adversely impact the number of associated livelihoods and informal jobs, thereby hindering EV adoption.

Specific actions in this regard could include:

- Integration with charging hubs: Locating charging stations at existing wayside amenities or near existing clusters of dhabas, fuel ROs, and repair shops, to the extent possible, would ensure that truckers continue to use these facilities for rest and meals while their e-trucks charge.

  This aspect has also been integrated in the identification framework developed under the BLR–MAA study and has been presented under the infrastructure enablement pillar of this framework.
- Microenterprise participation: Allowing small vendors to set up food, beverage, and convenience stalls within or around formal charging plazas, thereby embedding traditional livelihoods into modern highway infrastructure.

  With increased focus on developing charging stations as commercial precincts for truck drivers that offer integrated facilities such as food plazas, convenience stores, lounge areas, etc. It offers immense opportunities for microenterprise participation.
- **Inclusion of small fleet operators**: Driver-owners and small fleet operators can be integrated into the e-freight transition through platform-led models that aggregate demand and deploy centrally owned e-trucks. These platforms retain ownership of the vehicles and lease them to small operators on a per-kilometre or per-trip basis, allowing them to operate BETs without upfront capital investment. This ensures inclusive participation by shifting financial risk away from small operators while enabling them to benefit from early electrification opportunities.

By bridging legacy livelihoods with modern infrastructure, the transition can avoid economic disruption, promote social acceptance of e-trucking, and demonstrate that decarbonisation can go hand in hand with inclusive growth. In line with the primary survey conducted as part of the BLR–MAA highway, periodic surveys would be necessary to gauge the dynamic challenges as well as impact on the trucking workforce.

Call to action: Ensuring a just and inclusive transition to electric freight

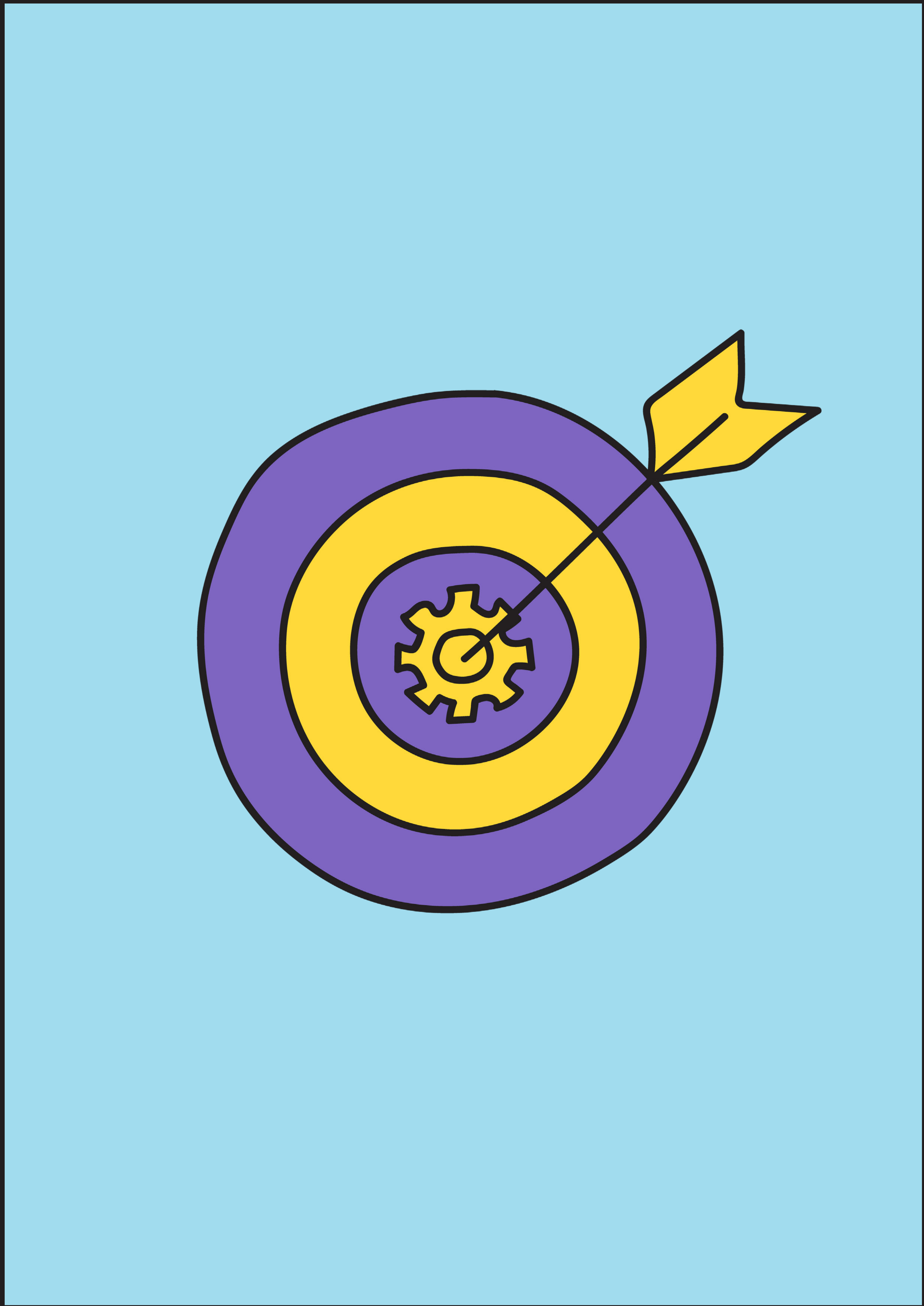
- **Institutionalise skilling pathways for truck drivers and mechanics,** anchored by the Ministry of Skill Development and Entrepreneurship (MSDE), in collaboration with MoRTH, Automotive Skills Development Council (ASDC), and OEMs.
- **MoRTH and MoP may mandate gender-sensitive design norms** for all new charging hubs and way-side amenities, covering restrooms, lounges, surveillance systems, and lighting.
- **Create sectoral just transition alliances** comprising logistics majors, OEMs, and CPOs to co-invest in reskilling, certification, and employment opportunities for drivers and service technicians. These alliances can also pilot women-inclusive recruitment drives and mentorship programmes, building a diverse next-generation logistics workforce.

A just transition will ensure that the shift to battery-electric trucking is not only about technology and infrastructure but also about people, communities, and inclusivity.

By empowering drivers and mechanics with new skills, creating safer and more gender-responsive spaces, and safeguarding local livelihoods along freight highways, the transition can build broad social acceptance and resilience. Together, these measures can ensure that the benefits of e-trucking extend

[53] American Trucking Association (2024) Women In Motion, Trucker Path Build on Partnership to Enhance Truck Stop Safety and Convenience | American Trucking Associations.
[54] TrasportoEuropa (2024) Swedish start-up develops truck rest areas – TrasportoEuropa.

beyond emissions reduction to create a more equitable and future-ready logistics ecosystem that supports livelihood creation and women participation.



9 WAY FORWARD

The framework discussed in the previous sections lays out an ecosystem approach to developing EV-ready highways. Scaling this to a nationwide network will require a phased and coordinated approach. The immediate priority lies in electrifying the select set of 20 high-volume freight highways that have been identified by MHI, and build confidence among shippers, fleet operators, and financiers. Once these initial highways prove reliable and cost-effective, the next step would be to extend connectivity to adjoining routes, industrial clusters, and logistics hubs – gradually creating a contiguous network of EV-ready highways across the country.

A Phased Roadmap for EV-Ready Highways

The following roadmap presents an indicative pathway to guide sequencing and coordination among stakeholders. It provides a directional view of how the transition could unfold in phases, outlining broad timeframes, focus areas, freight use cases and the outcomes:

Figure 18. Phased Roadmap for EV ready highways

Phase 1 – Electrify Priority Highways (2025–2027)

The first phase focuses on electrifying the 20 national highways identified by MHI under the PM E-DRIVE, translating India's policy commitment into visible infrastructure on the ground. This stage will ensure that these high-volume freight routes are equipped with reliable charging facilities, grid connectivity, and basic service infrastructure to support continuous e-freight movement.

The emphasis can be on return-to-base and point-to-point freight operations that offer predictable routes and controlled charging environments. These highways will serve as reference models, providing a replicable blueprint for subsequent expansion.

Implementation will require close coordination between national agencies such as MHI, MoRTH, and NHAI for policy planning and highway development, state governments and DISCOMs for grid readiness and land availability, and private CPOs and LSPs for infrastructure deployment. The following table outlines the specific actions, responsible stakeholders, and indicative timelines that will operationalise this first phase.

Table 3. Action plan to develop BET-ready highways and drive adoption of BETs (Phase 1)

Pillar	Action Item	Stakeholders
Highway Profiling	Conduct GIS mapping of existing charging infrastructure on the priority highways	BEE, BHEL, SNAs[55]
	Undertake mapping of truck traffic and key infrastructure on the 20 highways	NHAI, NHLML
	Prepare standard highway planning templates, keeping in view aspects such as site spacing, power norms, land use, etc.	NHAI, BEE
Demand Enablement	*Capital incentives:* Provide State-level demand incentive for e-trucks under respective EV policy	State governments
	Operational incentives: Provide toll waiver, road tax waiver, etc., for BETs on the priority highways	MoRTH, State governments
	Explore fiscal measures such as interest subvention to improve BET viability in the short term	MoRTH, MHI, State governments
	Secure anchor commitments from businesses in high utilisation sectors, such as E-commerce, retail, FMCG, etc.	Shippers and Fleet Operators
Infrastructure Creation	Identify and develop high capacity charging hubs, targeting the priority highways first	CPOs, BHEL, SNAs
	Auction land banks along highways through transparent time-bound process for development of EVCI	NHLML, SNAs
	Enable joint planning between DISCOMs and highway authorities to upgrade distribution infrastructure	State DISCOMs, NHAI
	Capital Incentives: Provide subsidies on land and electrical infrastructure to CPOs for developing charging infrastructure	Central and State governments
Operations Optimisation	Introduce priority lanes for BETs at ports, CFS, warehouses and manufacturing facilities of shippers, etc.	Port authorities, Shippers
	Adopt predictive analytics for fleet and battery health, forecast maintenance needs, and ensuring minimal downtime	OEMs, LSPs
	Integrate service facilities, roadside assistance, and towing assistance at wayside amenities	OEMs, Third-Party Garage Owners, NHLML
Just Transition	Develop BET training modules for drivers and mechanics, in regional languages, co-designed with OEMs, LSPs	MSDE[56], OEMs, LSPs, Driver aggregators
	Pilot women driver programmes in partnership with shippers and LSPs	Large LSPs, Shippers
	Co-locate charging hubs around existing dhabas and repair clusters to preserve footfall.	CPOs, Highway planners

Phase 2 – Connect Demand Centres (2027–2030)

Building on the electrified priority highways, the second phase would aim to extend coverage to adjoining regional and industrial demand centres, creating a regional EV-freight ecosystem. Many of India's freight flows originate from or terminate at ports, logistics parks, and industrial clusters located along the state or feeder highways. Expanding electrification into these linkages will enable regional and inter-cluster e-freight.

This phase represents a shift from highway-level readiness to network integration, ensuring interoperability between trunk and feeder routes. Implementing this will require joint planning between national and state transport authorities, DISCOMs, and private CPOs to coordinate infrastructure expansion and grid strengthening. Shipper associations, logistics providers, and financiers will play a critical role in aggregating demand and structuring viable business models. The key interventions and stakeholder roles for achieving this regional integration are presented in the following table.

Table 4. Action plan to develop BET-ready highways and drive adoption of BETs (Phase 2)

Pillar	Action Item	Stakeholders
Highway Profiling	Identify and prioritise adjoining state or regional highways for integration with the 20 electrified highways	MoRTH, NHAI
	Undertake detailed assessments to map existing demand hubs, power infrastructure, etc., on the identified highways	NHAI, BEE
Demand Enablement	Aggregate regional freight demand and scale innovative business models such as BaaS, CaaS, etc.	OEMs, LSPs, CPOs
	Develop and deploy financing models that lower cost of capital and spread financial risk across stakeholders	DFIs, Banks, NBFCs, OEMs, LSPs
	Facilitate long-term contracts to guarantee BET utilisation and reduce risk for fleet operators	Shippers, Fleet Operators
Infrastructure Creation	Augment grid infrastructure capacity along regional or feeder highways	State DISCOMs
	Establish regional charging hubs at major industrial parks, ports, and logistic clusters	CPOs
	Develop single window facility for CPOs to seek electricity connections (to scale charging stations)	State DISCOMs, CEA, BEE
	Tariff standardisation: Implement uniform charging rates and EV metering costs across states to eliminate pricing disparities	MoP
	Develop a common charging app with simplified User Interface and Experience and Open Network for Digital Commerce-based interoperability to eliminate fragmentation	BEE, CPOs
Operations Optimisation	Develop BET-certified dealerships and service centres along highways and at adjacencies	OEMs and Third-Party Garage Owners
Just Transition	Mandate gender-friendly amenities at all charging stations and wayside amenities	NHLML, CPOs, ICs[57]
	Introduce local employment schemes for charging hubs operations	CPOs, State governments

[55] State Nodal Agencies
[56] Ministry of Skill Development and Entrepreneurship

[57] Infrastructure concessionaires

Phase 3 – Expand National Network (2030–2035)

The third phase envisions the national scaling of India's EV-ready freight network, expanding electrification to additional high-density national and state highways and creating seamless pan-India connectivity. This stage will consolidate lessons from earlier phases and the operational emphasis will shift to long haul inter-state movements. By this stage, e-freight is expected to be commercially mainstream.

The public sector's role will evolve towards policy alignment and performance monitoring, while industry will drive investments, operations, and service delivery. The subsequent table details the actions and institutional responsibilities required to achieve nationwide coverage and ensure the long-term reliability of the EV-ready highway network.

Table 5. Action plan to develop BET-ready highways and drive adoption of BETs (Phase 3)

Pillar	Action Item	Stakeholders
Highway Profiling	Ensure accessibility of key highway level information for informed planning and e-freight expansion	MoRTH, NHAI
	Integrate highway electrification into long term logistic or infrastructure master plans – at national and state level	MoRTH, State governments
Demand Enablement	Demand side regulations: Promote clear BET adoption targets with timelines from large corporates and institutes	MoRTH, MHI, Shippers
	Supply side regulations: Introduce e-truck sales mandates for OEMs to promote BET adoption	MHI
Infrastructure Creation	Enforce reliability standards on CPO, for select high-capacity infrastructure or those supported through central/state subsidies	MoP, MHI
	Set progressive Renewable Purchase Obligations (RPOs) for charging operators to promote clean power	MoP
	Extend high-capacity or Megawatt charging stations across new highways	CPOs, DISCOMs
Operations Optimisation	Create National Freight Data Sharing Platform for data sharing between fleets operators, CPOs and governments to institutionalise performance monitoring	MoRTH, MHI
Just Transition	Institutionalise skilling programmes for logistic workers within existing vocational/technical education systems	MSDE, OEMs, State governments
	Promote inclusion of women in EV charging operations as well as service delivery roles within e-freight value chain	OEMs, LSPs, State governments

The above roadmap provides a directional pathway for operationalising EV-ready highways in India. It lays out how India can move in a structured manner and the importance of coordinated actions among Ministries, States, utilities, and private players.

Effective monitoring will be central to translating this roadmap into tangible outcomes. A performance-tracking framework could be established to measure progress, identify course corrections, and inform future expansion decisions. Key indicators may include number of EV-ready highways, total installed charging capacity, utilisation levels, e-freight ton-kilometres moved, cost parity of BETs, etc.

The broader framework presented in this report brings together the key building blocks for enabling electric-freight readiness across India's highways. Together, the framework and roadmap outline a practical, evidence-based strategy to accelerate the transition of India's highway freight system toward sustainability. As India advances towards its decarbonisation goals, Laneshift's pilot demonstration project provides a foundation for a cleaner, smarter, and more resilient freight ecosystem.

By combining infrastructure readiness with operational reliability and social inclusion, the framework provides a blueprint that can be replicated across regions and refined with every phase of rollout. If pursued with consistency and intent, India can move from isolated pilots to a nationwide ecosystem of zero-emission freight highways, setting a global benchmark for clean, efficient, and future-ready transport infrastructure.

Laneshift

THE CLIMATE PLEDGE

C40 CITIES