



Smart Freight
Centre India



Gearing for an E-Freight Future: A Landscape Study and Favorability Analysis



ABOUT SMART FREIGHT CENTRE

Smart Freight Centre is an international non-profit organization working on Freight Decarbonization to minimize the climate impact of the global freight and logistics sector. Smart Freight Centre has also undertaken a host of Freight Decarbonization initiatives in India under its India program, working in close collaboration with the India Freight Industry, Policy Offices (national and sub-national), Academia & Research and other ecosystem partners, targeting one of the world's largest freight markets with the urgent mission to address the projected 400% increase in CO₂ emissions by 2047. Smart Freight Centre, with its India program, is deeply engaged with NITI Aayog's e-Fast India program, collaboratively working with various knowledge partners to advance specific aspects of ZET ecosystem development, while also leading on Freight Emissions Guidance Development and Industry adoption in India. Through these strategic partnerships and a collaborative approach, SFC India envisions and works toward a freight and logistics sector that is sustainable, environmentally responsible, and actively engaged in mitigating climate impact, seeking commitments from logistics service providers and shippers to adopt emission reduction strategies for a more sustainable future.

For more information, please visit: <https://www.smartfreightcentre.org/en/our-programs/regional-offices-and-programs/smart-freight-centre-india/>

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SFC India. e-Truck Landscape in India: Accelerating the Transition to Zero-Emission Freight. Smart Freight Centre India

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Gearing for an E-Freight Future: **A Landscape Study and Favorability Analysis**

Acknowledgements

This report would not have been possible without the valuable insights and contributions from numerous stakeholders across the e-truck ecosystem in India. We extend our sincere gratitude to all the individuals and organizations who participated in consultations, workshops, and interviews, sharing their expertise and experiences to enrich this study.

We would particularly like to acknowledge the contribution from distinguished partners of NITI Aayog's e-FAST India platform, including Shippers, Logistics Providers, Original Equipment Manufacturers, Financial Institutions, Charge Point Operators and knowledge partners, particularly WRI and UC Davis.

We would also like to extend our special appreciation to all our e-Freight network partners, including SFC's global community members, who participated in various stakeholder consultation workshops conducted by SFC India in different cities who contributed valuable insights on ZET adoption challenges, financing solutions, infrastructure development, technological innovations, and strategic deployment strategies.

We also acknowledge the contributions of individuals and organizations not specifically named here but who have played important roles in shaping our understanding of the e-truck landscape in India.

This report builds upon valuable research and insights from organizations including the International Council on Clean Transportation (ICCT), International Transport Forum (ITF), CALSTART, Climate Group, Rocky Mountain Institute (RMI), World Resources Institute (WRI), and Center for Study of Science, Technology and Policy (CSTEP), whose prior work has significantly advanced knowledge in this field.

We would like to acknowledge the valuable contributions and insights from the following workshops, events, and partner platforms, which have significantly informed the findings and direction of this report:

- e-FAST India Partners <https://efastindia.org/partners>
- Workshop - Accelerating the Shift: Transition to Zero Emission Trucks (Thiruvananthapuram) https://www.smartfreightcentre.org/documents/537/New_Summary_Report_-_Trivandrum_5th_Feb.pdf
- Workshop - Accelerating the Shift: Transition to Zero Emission Trucks (Indore) https://www.smartfreightcentre.org/documents/518/Summary_Report_-_Indore_Oct_24_2024.pdf
- Workshop - Accelerating the Shift: Transition to Zero Emission Trucks (Hyderabad) https://www.smartfreightcentre.org/documents/463/New_Summary_Report_-_Hyderabad_Oct_2024.pdf
- Workshop - ZET Technologies: An Ecosystem Perspective https://www.smartfreightcentre.org/documents/462/Summary_Report_-_ZET_Technologies_Workshop_Chennai_Aug_22_2024.pdf
- Workshop - Driving ZET Deployment at Scale https://www.smartfreightcentre.org/documents/435/SUMMARY_REPORT_ZET_deployment_at_Scale_24th_July_Mumbai.pdf
- Workshop - Accelerating Low Emission Logistics in India https://www.smartfreightcentre.org/documents/379/SFC_Workshop_Low_Emission_Logistics_ZET_12th_June_Delhi_Summary_Report.pdf
- Freight Decarbonization Roundtable https://www.smartfreightcentre.org/documents/215/Summary_Report_SFC_Roundtable_Freight_Decarbonization_Mumbai_29th_Nov_2023.pdf

As India strides toward its ambitious net-zero emissions target by 2070, the transformation of our freight transportation sector stands as a critical frontier in our sustainability journey. The road freight sector, while essential to our economic growth, contributes disproportionately to our national carbon footprint. Medium and heavy-duty trucks (M&HDTs), though constituting only 2% of the total vehicle stock, account for approximately 34% of the CO₂ emissions from total transport-related activities.

This report emerges at a pivotal moment when the confluence of technology, policy, and market forces is creating unprecedented opportunities for the electrification of India's trucking industry. The launch of initiatives like PM E-DRIVE and e-FAST India signals the government's commitment to accelerate this transition. Meanwhile, leading manufacturers are introducing innovative zero-emission truck (ZET) models tailored to Indian conditions, and logistics companies are increasingly recognizing the economic and environmental benefits of fleet electrification.

The path ahead, however, is not without challenges. High upfront costs, charging infrastructure gaps, and operational uncertainties remain significant barriers. This comprehensive study addresses these challenges head-on, providing a detailed analysis of the e-truck ecosystem and developing practical business cases for various applications and segments.

What distinguishes this report is its holistic approach. It not only examines the technological and economic aspects of e-truck adoption but also highlights the social and environmental benefits. By considering the unique characteristics of India's trucking landscape—from its fragmented ownership structure to its diverse operational requirements—the report offers targeted strategies for different stakeholders.

As we navigate this transformative period, collaboration will be essential. Government agencies, vehicle manufacturers, logistics operators, financial institutions, and energy providers must work in concert to create an enabling ecosystem for e-trucks. This report provides a roadmap for such collaboration, identifying priority segments for electrification and proposing innovative business models to overcome current barriers.

The electrification of India's trucking fleet represents not just an environmental imperative but an economic opportunity. By taking decisive action now, we can establish India as a global leader in sustainable freight transportation, create new jobs, reduce our dependence on imported fossil fuels, and improve air quality for millions of citizens.

I commend this report as an essential resource for all stakeholders committed to accelerating the transition to zero-emission trucking in India.

Warm Regards,

Prof. Dr. Christoph Wolff, CEO, Smart Freight Centre



श्री कृष्ण की जय श्री जय

श्री परशुपती

नाथ की जय

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MUSIC

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IS LIFE

म.श.ख.
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LOVE

सुनौलो हरेक मोड मा परिवार को याद गर्थे बिहानी

India's freight sector, a significant contributor to the national GDP (13-14%) and a major employer (over 22 million people), is experiencing rapid growth, with freight activity projected to increase fivefold by 2050. However, Medium and Heavy-Duty Trucks (M&HDTs), which account for only 2% of vehicles, contribute a disproportionate 34% of transport-related CO₂ emissions, making their electrification a critical sustainability priority. This comprehensive report assesses the e-truck ecosystem and develops viable business cases for adoption in India. The report undertakes a thorough analysis, including **stakeholder mapping, policy assessment, freight market analysis (current state and e-truck penetration), evaluation of technology trends and supplier capabilities, exploration of market opportunities, global ecosystem benchmarking, and assessment of potential economic, environmental, and social impacts (like GHG reduction and job creation).**

The Indian trucking industry is characterized by fragmentation on the demand side, with nearly 70% of owner-operated small fleets, but consolidation on the supply side, where five OEMs dominate over 95% of the market. E-truck adoption remained slow until 2023 but is projected to see a significant surge in 2024-25, primarily in the M&HDT segments, supported by government initiatives such as FAME, PLI, and the PM E-DRIVE scheme, alongside increasing model availability from key manufacturers.

Key findings reveal significant demand-side challenges, including high upfront costs (2-3 times those of ICE counterparts), financing hurdles, operational limitations such as reduced payload, and scarce charging infrastructure. Supply-side challenges include achieving economies of scale, managing material supply variability, and adapting to evolving battery technology. The report systematically **identifies specific adoption opportunities across segments and use cases, analyzes associated challenges, develops tailored business models (evaluating financial viability through Total Cost of Ownership (TCO) analysis and financing options), establishes a compelling value case highlighting environmental and social benefits beyond commercial factors, and recommends targeted policy interventions** to overcome barriers. Opportunities exist through innovative financing, shared charging solutions, government incentives that support R&D and manufacturing, and the development of diverse, customizable e-truck models suited to Indian conditions. Lessons from global markets (the US, Europe, and China) emphasize the importance of robust policy, comprehensive charging networks, strong battery supply chains, and supportive service models.

To guide adoption, the report proposes an electrification favorability framework, recommending a phased approach to implementation. Initially, efforts should focus on **short-term (1-2 years)** applications achieving Total Cost of Ownership (TCO) parity on shorter routes (200-300 km) with predictable charging. This can be expanded in the medium term (2-5 years) by targeting the organized sector, which is capable of supporting the transition for medium-haul routes (300-500 km). Finally, **long-term (5+ years)** adoption can address challenging long-distance or high-payload routes requiring advanced range or charging capabilities, potentially leveraging range-extender technologies. Furthermore, a practical six-step process is outlined to guide fleet managers through suitability assessment, planning, piloting, roadmap development, procurement, and operational setup. Facilitating this transition requires collaborative action, with key recommendations urging the **Government** to expand EV policies for M&HDTs (including purchase subsidies), entry time waivers, and ensuring the right quality and quantity of power supply. **OEMs** are encouraged to develop India-centric e-trucks, exploring modular and swappable battery options, leverage global technology, build robust service networks, and scale up localized manufacturing. The **Logistics Industry** should integrate e-trucks for cost and environmental benefits, initiate pilot projects for suitable use cases, implement training programs, and collaborate on end-to-end solutions. Lastly, **Financial Institutions** play a crucial role by creating tailored financial products, offering innovative models like leasing, implementing risk mitigation strategies, and supporting demand aggregation.

THE REPORT IS STRUCTURED AS FOLLOWS:

- **Chapter 1: Introduction** sets the stage for the entire study by outlining the rationale and goals, thereby linking directly to the overall objective of promoting e-truck adoption in India.
- **Chapter 2: Trucking Landscape** delves into the detailed segmentation of trucks based on gross vehicle weight (GVW), application, body type, and fuel type. It analyzes the industry structure, demand-side trends, supply-side trends, and the policy and regulatory framework. This chapter also explores opportunities for transitioning the Indian freight ecosystem towards e-trucks. By providing a comprehensive analysis of the current trucking landscape, this chapter links to the study's objective by identifying the existing conditions and potential areas for electrification, thereby setting the context for further exploration.
- **Chapter 3: e-truck Market Perspective - Demand Side** examines usage characteristics, infrastructure assessment, business and financing models, and challenges faced on the demand side. This chapter aligns with the study's objective by exploring the market readiness and identifying the demand-side factors that influence the adoption of e-trucks in India. It provides insights into the practical considerations and barriers that need to be addressed to facilitate the transition to e-trucks, thus directly supporting the study's goal of developing a viable business case for e-trucks in India.
- **Chapter 4: e-truck Market Perspective - Supply Side** explores trends in alternative technologies, current suppliers, technological capabilities for production, and anticipated advancements. It also addresses the challenges faced on the supply side. This chapter supports the study's objective by identifying the supply-side dynamics and technological readiness necessary for e-truck adoption.
- **Chapter 5: India e-truck Ecosystem Updates** provides updates on the current state of e-truck adoption in India, including technology and product roadmaps, pilot initiatives, key partnerships, adoption scenarios, impacts, and barriers. This chapter links to the study's objective by offering a snapshot of the progress and challenges in the Indian e-truck ecosystem, thereby informing future strategies.
- **Chapter 6: Global Benchmarking of e-truck Adoption** presents case studies from the USA, Europe, and China, highlighting key learnings and takeaways. This chapter supports the study's objective by providing global insights and best practices that can be adapted to the Indian context.
- **Chapter 7: ZET Adoption Opportunities: Segment and Use Case View** introduces a framework for electrification favorability, analysis, result interpretation, and challenges and opportunities for zero-emission trucks (ZET) transition. This chapter aligns with the study's objective by identifying specific segments and use cases, where e-trucks can be effectively adopted, thereby facilitating targeted strategies.
- **Chapter 8: Business and Value Case Selection** offers a step-by-step handbook for medium and heavy-duty electric truck adoption, including suitability assessment, planning, pilot stage, roadmap phase, procurement, and setup and operation phases, along with the value proposition for e-truck adoption. This chapter directly supports the study's objective by providing a practical guide for businesses to adopt e-trucks.
- **Chapter 9: Conclusion** summarizes the findings and recommendations, linking all the chapters to the study's overarching objective of promoting e-truck adoption in India.



In conclusion, transitioning India's freight sector to zero emissions presents substantial challenges but also significant opportunities. Overcoming barriers like cost and infrastructure requires concerted effort based on a deep understanding of the market, technology, and policy landscape. By implementing a strategic, phased approach guided by robust analysis and fostering collaboration across the entire ecosystem—government, manufacturers, logistics operators, and financiers—India can successfully decarbonize its freight sector, contributing to climate goals, enhancing energy security, improving air quality, and driving economic growth.

A large white box truck is driving away from the viewer on a multi-lane highway. The truck is white with a red and white striped bumper. The rear of the truck is visible, showing the back door and taillights. The truck is moving towards the horizon where the sun is setting, creating a warm orange and yellow glow. The sky is filled with scattered clouds, and the overall scene is captured in a cinematic style with a color grade that emphasizes the sunset tones. The road has white lane markings and a yellow center line.

India's freight sector is a dynamic and rapidly evolving landscape, integral to the nation's economic fabric. Playing a pivotal role in driving economic progress by facilitating the efficient movement of goods and services across the supply chain, the logistics sector contributes around 13-14% to GDP and provides livelihoods for more than 22 million people.

1. Introduction

India's freight sector is a dynamic and rapidly evolving landscape, integral to the nation's economic fabric. Playing a pivotal role in driving economic progress by facilitating the efficient movement of goods and services across the supply chain, the logistics sector contributes around 13-14% to GDP and provides livelihoods for more than 22 million people.¹

Since the year 2000, freight activity in India has quadrupled, driven by the expansion of industries, the rise of e-commerce, and the increasing demand for goods and services in urban and rural areas alike. This growth trajectory is expected to continue, with projections indicating that freight activity will increase fivefold by 2050. However, this rapid growth brings with it both opportunities and challenges. One of the most notable shifts in India's freight sector is the declining share of rail freight. Historically, railways were the backbone of India's freight transportation, accounting for 89% of the freight share. Today, that share has dwindled to around 35%, as road transport has become more dominant. An Overview of India's freight modal split across road, rail, air, and waterway is shown in Figure 1.²

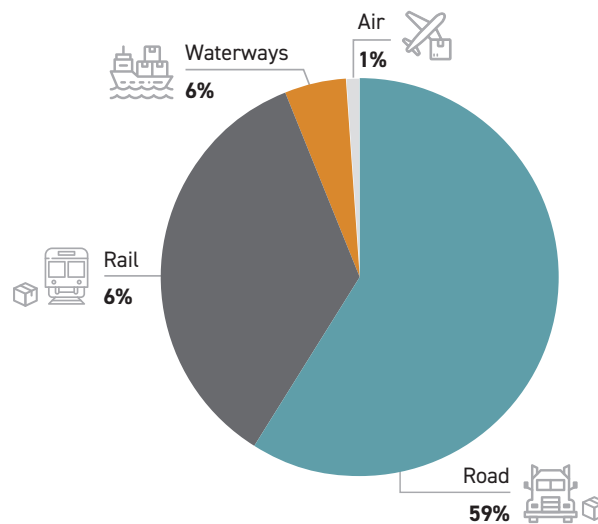


Figure 1 Freight Modal Mix (2018)

NEED FOR ELECTRIFICATION OF MHDTS IN INDIA

Road freight plays a critical role in India's economy and is expected to remain the dominant mode for freight movement both in India and globally. According to a CSTEP study titled "The Potential to Electrify Freight Transportation in India" on exhaust emission characteristics of light and heavy-duty diesel vehicles in India, heavy-duty diesel vehicles emit higher levels of carbon dioxide (CO₂) and other pollutants compared to passenger vehicles like cars and motorcycles^{3&4}. This is primarily due to their larger size, higher load capacity, and typically lower fuel efficiency. A comparison of emissions from freight vehicles to all road transport vehicles shows that in India, light-duty trucks (LDT), medium-duty trucks (MDT), and heavy-duty trucks (HDTs) - accounting for just 5% of the total vehicle stock and 18% of the vehicle kilometers driven - contribute to approximately 55% of the CO₂ emissions annually. The high emission intensity and disproportionate impact on climate change and air pollution compared to other vehicle types makes medium and heavy-duty trucks (M&HDTs) a priority for electrification.

¹ Transforming India's Logistics Sector: Challenges and Opportunities, IBEF, 2024

² Goods on the Move, NITI Aayog and RMI India, 2018

³ Tracking Transport, IEA, 2024



Without any policy changes to the road freight sector, diesel HDTs remain the dominant powertrain and CO₂ emissions continuously rise, reaching 365 million metric tons (MMT) in 2070—2.5 times greater than 2021 levels.⁴ Hence, significant efforts will be needed to bring India's road freight sector on track to meet its 2070 net-zero goal. India would need at least one-quarter of its truck fleet (on-road) to have zero emissions by 2050. It would also need the fuel efficiency of diesel trucks to improve by at least 35% from 2021 levels to be on the net-zero pathway. However, at the current fuel efficiency levels of the truck fleet, fuel consumption and CO₂ emissions will be about 10% higher by 2030.⁶

These efforts include incentivizing alternative fuel sources like biofuel, hydrogen internal combustion engines (H2-ICEs), hydrogen fuel-cell electric vehicles (FCEVs), and Compressed Natural Gas/Liquefied Natural Gas (CNG/LNG), introducing stricter emission standards such as Bharat Stage (BS) to reduce criteria pollutant emissions from diesel trucks, corporate average fuel economy (CAFE) standards (for the fleet of new sales), investing in operational efficiency, energy-efficient technologies, and embracing progressive technologies such as advanced routing systems, which greatly minimize GHG emissions.

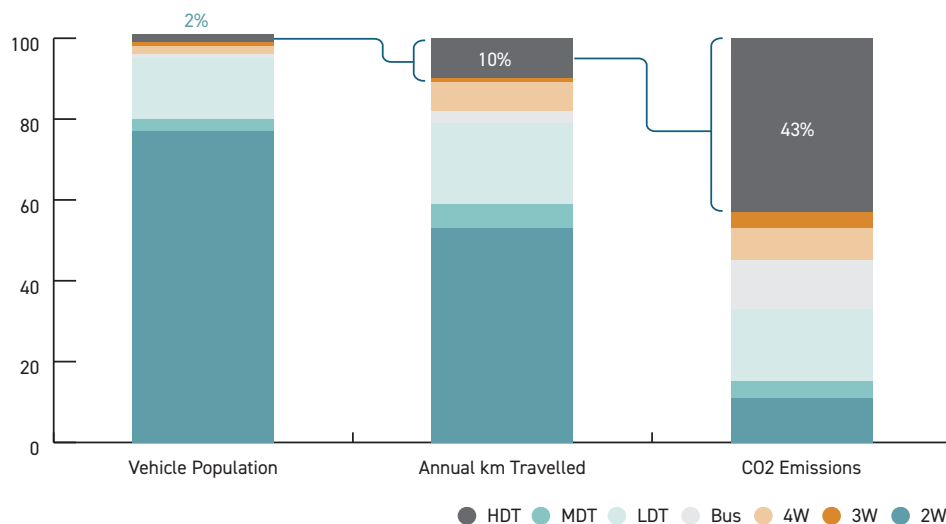


Figure 2 Vehicle Population, Annual km Travel & CO₂ Emissions comparison of freight vehicles w.r.t. all road transport vehicles⁵

In comparison to different alternative fuel technologies, studies have shown that electric trucks (e-trucks) emit 30% less GHG emissions (with 2023-2037 grid mix) compared to their diesel counterparts over their entire lifecycle⁷. This reduction in emissions is critical for combating climate change and achieving global climate goals. While e-trucks face challenges such as shorter ranges and lower payload capacities compared to traditional diesel trucks, numerous opportunities exist to enhance their popularity. Several manufacturers and startups have entered the e-truck segment, offering innovative solutions to address the specific needs of the Indian market.

⁴ Assessing the scale of zero-emission truck deployment required for meeting India's net-zero goal, ICCT, 2024

⁵ The Potential to Electrify Freight Transportation in India, CSTEP, 2022

⁶ A Pathway to Zero-Emission Trucking in India, ITF, 2024

⁷ A comparison of the life-cycle greenhouse gas emissions from combustion and electric heavy-duty vehicles in India, ICCT, 2024

Key takeaways:

1

India's freight sector is crucial, contributing 13-14% to GDP and employing over 22 million people.

2

Freight activity has quadrupled since 2000 and is expected to increase fivefold by 2050.

3

The medium and heavy-duty truck (M&HDT) sector, although low in volume, is a significant contributor to pollution due to moving more mass and traveling longer distances compared to small vehicles.

Electric trucks emit 30% less GHG emissions over their lifecycle compared to diesel trucks with the current grid mix.

4

5

There is a favorable case for zero-emission trucks (ZETs) due to high tailpipe emissions from M&HDTs. However, electrification of M&HDTs is still at a nascent stage compared to other segments.

2. Trucking Landscape

India ranks as the fourth-largest market globally for commercial vehicles, encompassing buses and trucks, in terms of sales volume, and stands as the third-largest manufacturer in the Global South. The domestic sales of commercial vehicles have demonstrated a compound annual growth rate (CAGR) of ~12% from 2014 to 2024¹. The accelerators of road freight activity outlined in Table 1 are essential for understanding the dynamics of India's transportation landscape.

Table 1 Accelerators of Road freight activity

Economic growth 	Rise in billion-ton kilometer (BTKM) is closely tied to economic expansion and globalization trends. Surge in demand for goods, increased production and distribution activities. More goods being transported over longer distances due to expanded supply chains
Urbanization 	Urbanization in India is accelerating, with 34% of the population living in cities as of 2018, with expected urbanization to reach 51% by end of 2040. Efficient logistics systems are increasingly needed to meet growing urban demand.
Infrastructure development 	Investments in road infrastructure have facilitated the growth of road freight transportation. 54,908 km of NH built in last 10 years, with 25 Greenfield Corridors under Bharatmala Pariyojana Better infrastructure has reduced transit times and costs, encouraging businesses to rely more on road freight for timely and efficient delivery of goods.
e-Commerce 	Rapid growth of e-commerce is a major driver behind the surge in freight transportation. Growing preference for online shopping has increased consumer expectations for faster delivery times and wider product selection. Meeting these demands requires a robust logistics network, often relying heavily on road freight for last-mile delivery.
Supply Chain Complexity 	Global supply chains have become increasingly complex, with components and finished products being sourced from various locations. This complexity requires extensive transportation networks to move raw materials, components, and finished goods between suppliers, manufacturers, and consumers, contributing to higher billion-ton kilometers (BTKM).
Energy Prices and Environmental Concerns 	Fluctuations in energy prices influence transportation choices within the freight sector. Lower fuel prices make road transport more cost-effective compared to rail or maritime transport. Growing environmental concerns and the need to reduce carbon emissions are driving demand for efficient, eco-friendly transportation solutions.

The Indian trucking industry operates under a distinct set of conditions that differentiate it from its global counterparts as shown in Figure 3. These unique operational and functional characteristics are shaped by a combination of economic factors, infrastructure challenges, regulatory environments, and cultural practices. Understanding these nuances is crucial for developing effective strategies tailored to the Indian context.

¹ Data analysis from Vahan Dashboard by Ministry of Road Transport and Highways (Government of India)

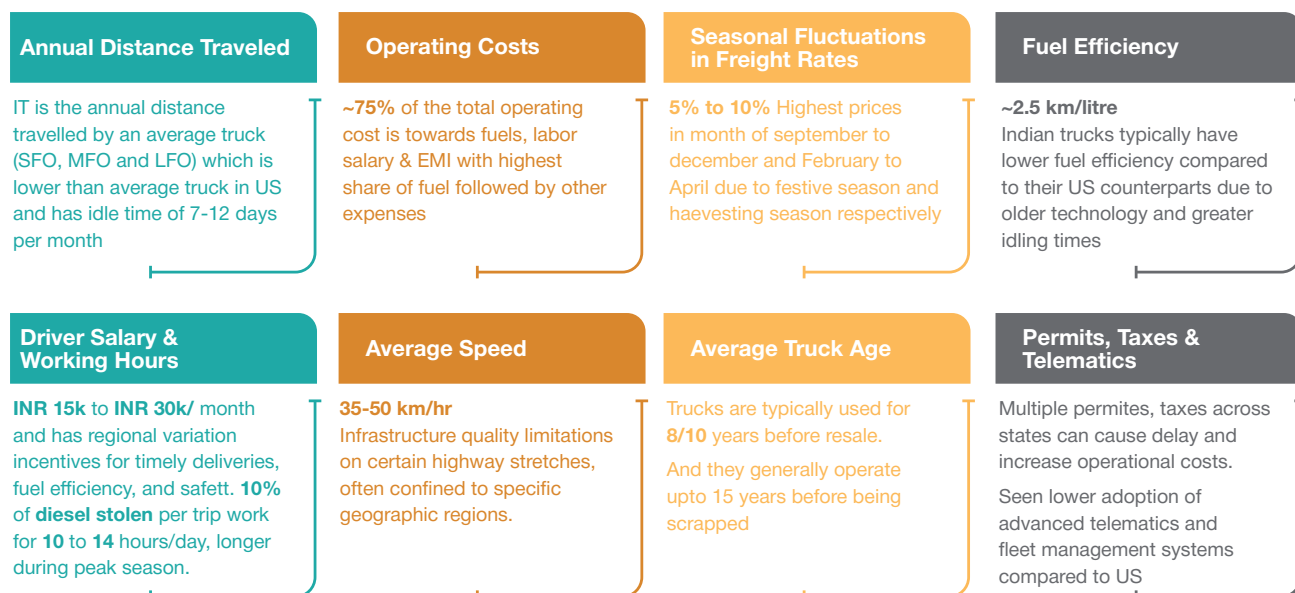


Figure 3 Operational and Functional Characteristics unique in Indian Trucking Industry²

There are about 6.7 million trucks (> 3.5 tonnes gross vehicle weight, GVW) plying on Indian roads and highways as of 2024³ which can be categorized based on multiple criteria to understand the Indian trucking landscape. This chapter delves into the extensive analysis of how trucks are categorized and segmented within the Indian industry. It provides a comprehensive exploration of the various criteria and factors that serve as the foundation for classifying and dividing trucks in this specific market. The chapter goes on to provide in-depth information on truck segmentation, key stakeholders, the policy and regulatory structure of the trucking industry, sales trends, and other critical aspects. This comprehensive analysis aims to offer a detailed understanding of the various elements that shape the Indian trucking landscape, helping stakeholders make informed decisions.

TRUCK SEGMENTATION

Trucks in India are primarily categorized by their permissible gross vehicle weight (GVW). Additional classification can be done based on fuel type (diesel, CNG, LNG, electric, LPG), as shown in Figure 4.

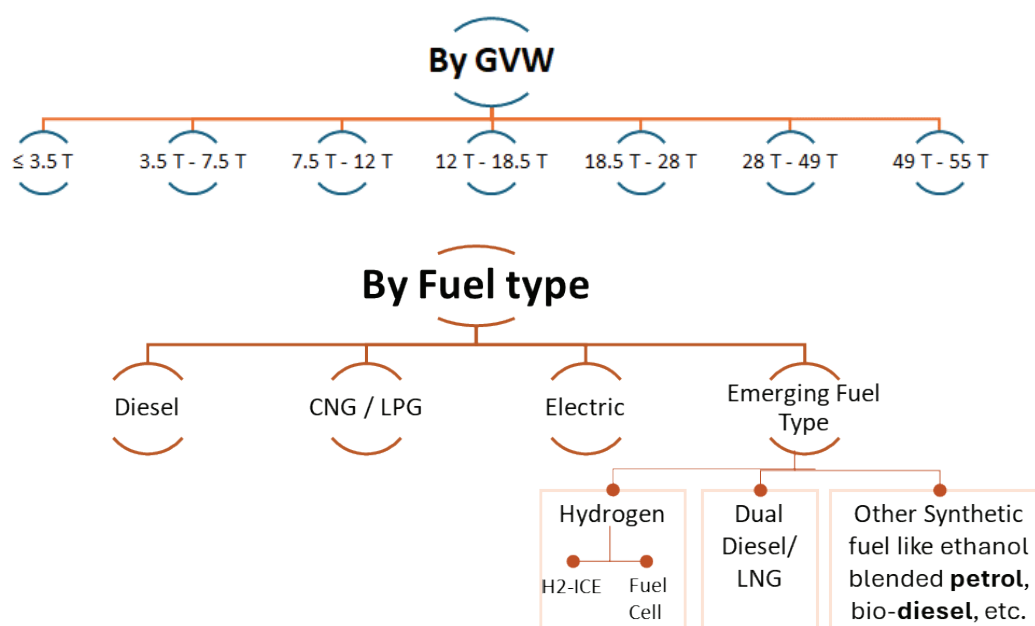


Figure 4 Classification of Trucks

- Indicative data interpreted from Consultation with Rhenus Logistics, JSW, CoEZET-IITM, August 2024 (Refer 10: Annexure Stakeholder Consultation Summary) and Secondary research from Early Market Outlook Report – Electrification of MHDT in India, CG & pManifold, 2021
- Data analysis from Vahan Dashboard by MoRTH (Govt. of India) till May '24



GVW BASED

The Ministry of Road Transport and Highways (MoRTH) has established a classification of trucks based on permissible gross vehicle weight (GVW) that is used for homologation in India, as presented in Table 2.

Table 2 **GVW Based Truck Classification**

GVW Range [T]	Category	Range Pre-fixes	Segment as per Regulation ⁴	Segment as per Industry
GVW ≤ 3.5	N1	N1A	LGV	SCV
3.5 < GVW ≤ 7.5	N2	N2A	MGV	LDT
7.5 < GVW ≤ 12		N2B		IDT
12 < GVW ≤ 18.5	N3 2-Axle Rigid	N3A	HGV	MDT
18.5 < GVW ≤ 28	N3 Multi-Axle Rigid	N3B		
28 < GVW ≤ 49		N3C		HDT
30 < GVW ≤ 55	N3 Tractor	N3D		HDT-TT

For our project execution, we will consider the industry nomenclature of medium and heavy-duty trucks (M&HDTs), which includes vehicles greater than 3.5 tonnes, as shown in Table 2.

Historic market trends for goods-carrying vehicles show the following distribution:

- Small commercial vehicles (SCVs) or light goods vehicles, with gross vehicle weight (GVW) ≤ 3.5 tonnes, account for 60-70% of annual units sold
- Medium and heavy-duty trucks (M&HDTs) or heavy goods vehicles, with GVW > 12 tonnes, comprise approximately 25-35% of annual sales
- Light and intermediate-duty trucks (L&IDTs) or medium goods vehicles, with GVW between 3.5 and 12 tonnes, represent approximately 5% of annual sales

⁴ MoRTH Regulation, 2021

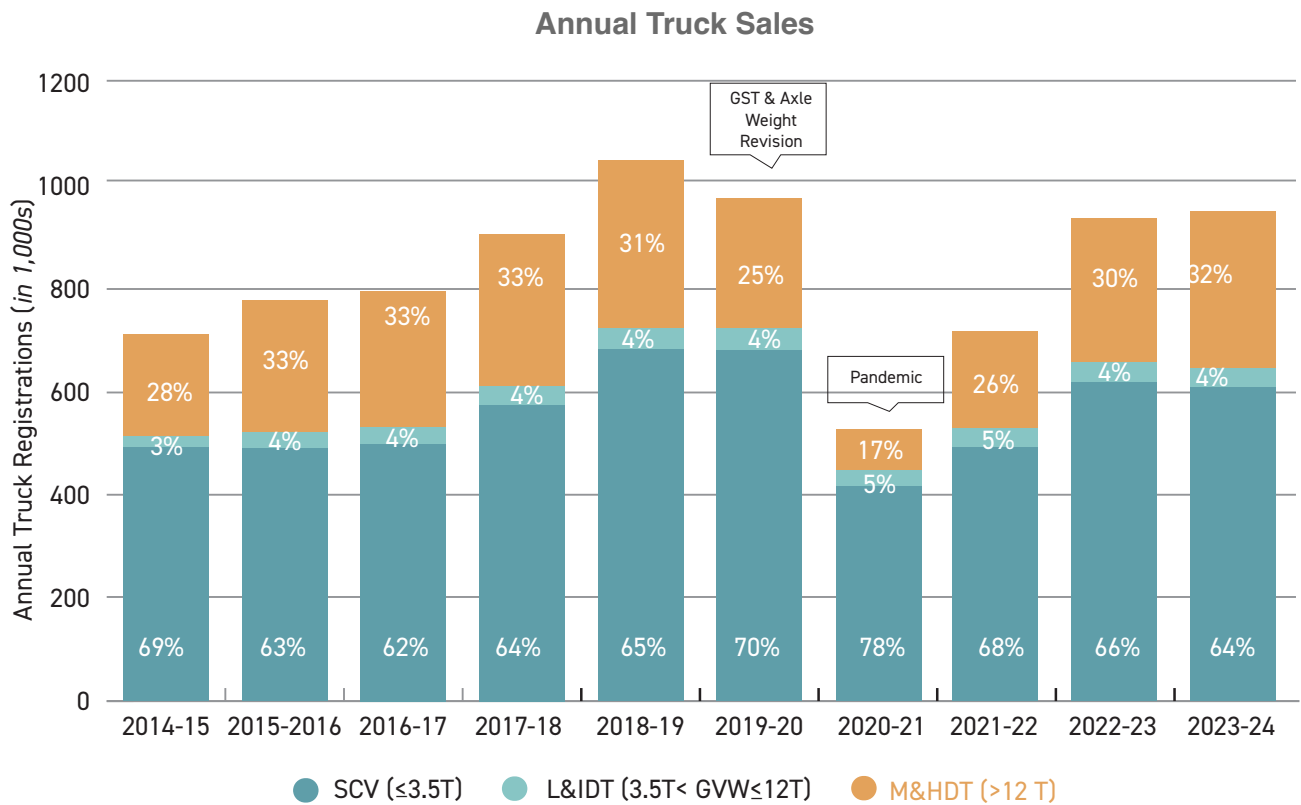


Figure 5 Year-wise Annual Truck Sales⁵

Two significant events—the rationalization of the Goods and Services Tax (GST) in 2017 and the revision of permissible Gross Vehicle Weight (GVW) in 2019, followed by the pandemic in 2020—had a negative impact on goods vehicle sales. However, the goods vehicle market has been showing signs of recovery since 2021, as illustrated in Figure 5. This recovery is particularly driven by increasing demands from the e-commerce and perishable produce sectors, which are anticipated to remain key growth drivers over the next 5-10 years.

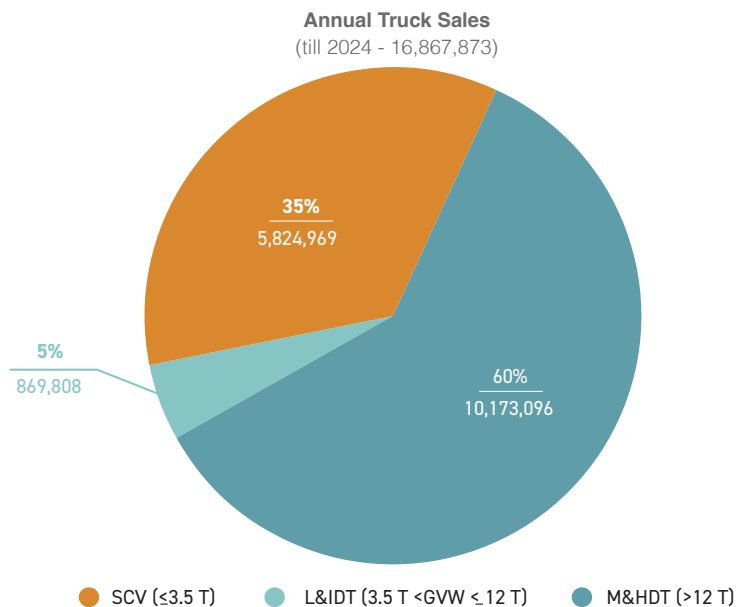


Figure 6 On-road Truck Stock (till 2024)⁶

Among these, the rigid truck in the 7.5-12 tonnes GVW category leads the M&HDT segment with 24.0% market share, as depicted in Figure 7. The 18.5-25 tonnes GVW rigid segment follows with 20% market share. Overall, rigid trucks constitute over 89% of M&HDT sales.

⁵ Data analysis from Vahan Dashboard by MoRTH (2014-24)

⁶ Data analysis from Vahan Dashboard by MoRTH (2014-24)

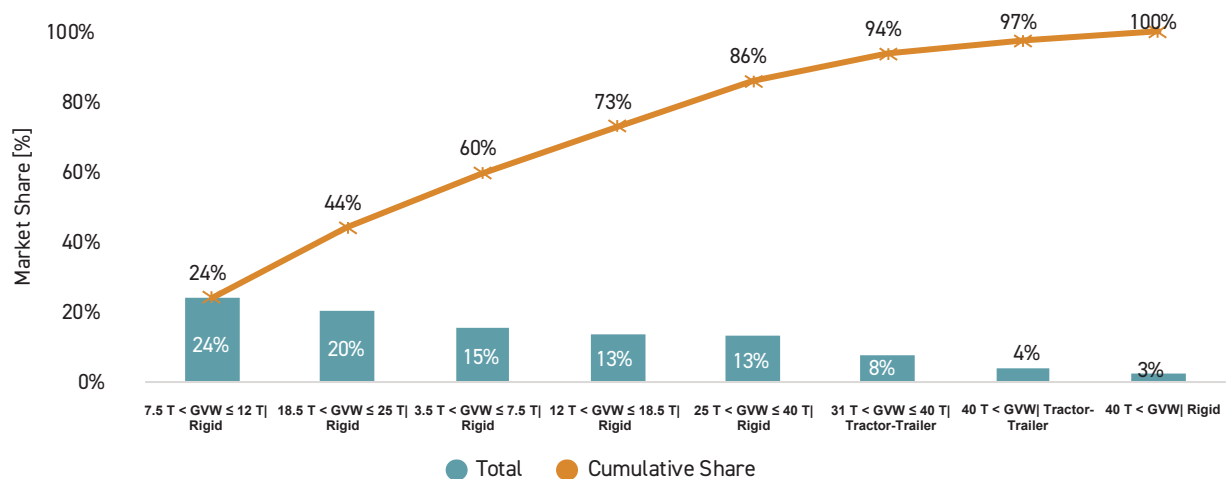


Figure 7 M&HDT in India – Segment wise Analysis (2019-20)7

APPLICATION BASED

Trucking plays a pivotal role in the primary movement across key economic sectors contributing to GDP: agriculture, mining, construction, manufacturing, and specialized applications. Each sector has unique transportation requirements:

➤ Agriculture

- **Applications:** Includes the transportation of foodgrains, edible oil, milk, vegetables, and fruits
- **Truck Segment:** Predominantly handled by IDTs and MDTs
- **Growth Outlook:** Expected to grow significantly due to increasing population and consumption

➤ Mining

- **Applications:** Involves the transportation of coal, iron ore, limestone, and bauxite
- **Truck Segment:** HDTs are primarily used
- **Growth Outlook:** Likely to grow with increased industrial activity and urbanization

➤ Construction

- **Applications:** Includes cement & clinker, iron and steel, sand and gravel, ready-mix concrete (RMC), and bricks and tiles
- **Truck Segment:** Mostly handled by HDTs
- **Growth Outlook:** Expected to see continued growth due to infrastructure development and urbanization

➤ Manufacturing

- **Applications:** Involves the transportation of petroleum products, chemicals, machinery and equipment, textiles, and automotive parts
- **Truck Segment:** Handled by MDTs and HDTs
- **Growth Outlook:** Anticipated to grow with industrial expansion and increased manufacturing activities

➤ Specialized Applications

- **Applications:** Includes temperature-controlled goods, hazardous materials, bulk liquids, and bulk solids
- **Truck Segment:** MDTs and HDTs are used based on specific requirements
- **Growth Outlook:** Likely to grow with advancements in logistics and increased demand for specialized transportation

These broad components are further classified into two main categories based on their volume and weight characteristics:

- **Bulk Commodities:** Goods with a high weight-to-volume ratio that are transported in large quantities without packaging, often in loose form.



- **Non-Bulk Commodities:** Goods with low weight-to-volume ratio that are transported in packaged form, typically using containers or pallets.

Figure 8 Application based Classification⁸

The segment-wise distribution of applications shown in Table 3 indicates that market load, e-commerce, FMCG, and vegetables & fruits applications are dominant in MDTs. HDTs are primarily used for bulk transport of steel, cement, petroleum products, and minerals (primarily coal on short hauls). Although not a rule, M&HDTs are typically used for long-haul transport. Some short-haul applications of M&HDTs include mineral handling at mines, mineral transport to plants (usually built in proximity to mines with long hauls being done by trains), and construction material.

Table 3 Application-wise Truck Segment mix⁹

Market Share (% of truck share)	Application	L&IDT (3.5 < GVW < 12T)	MDT (12 < GVW < 28T)	HDT - Rigid (> 28T)	HDT TT (> 28T)
30	Market Load & FMCG	52%	35%	8%	4%
15%	e-Commerce	41%	48%	5%	7%
15%	Vegetables & Fruits	62%	33%	4%	2%
8%	Steel	0%	14%	42%	45%
6%	Coal & Iron Ore	0%	44%	38%	19%
6%	LPG	21%	37%	17%	26%
6%	Cement & Clinker	32%	18%	30%	21%
3%	Fish	74%	26%	0%	0%
3%	Petroleum	0%	59%	34%	7%
3%	Water Tanker	59%	34%	4%	4%
3%	Edible Oil	0%	81%	13%	6%
3%	Garbage	55%	0%	45%	0%

⁸ Early Market Outlook Report – Electrification of MHTD in India, CG & pManifold, 2021

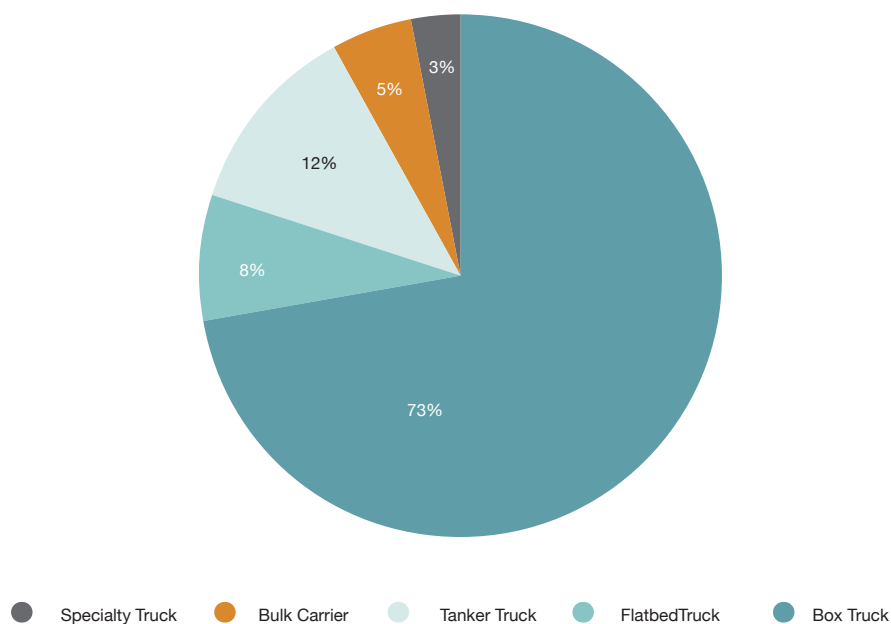
⁹ Indicative data interpreted from Industry Assessment & Roadmap for Zero-emission Medium- and heavy-duty Trucks in India, pManifold supported by CALSTART, 2022

BODY TYPE BASED

In the trucking industry, vehicles are classified by body type based on their specific design and the nature of the cargo they are intended to transport. This classification ensures that each type of truck is optimized for its particular application, offering efficiency, safety, and versatility. Table 4 shows the detailed classification of trucks by body type.

Table 4 **Truck Classification - By Body Type**

Truck Type	Description	Applications	Features
Box Trucks 	Also known as enclosed trucks or van trucks, featuring an enclosed cargo area that provides protection from weather and theft	General Goods: Ideal for transporting goods that need to be kept dry and secure, such as electronics, furniture, and retail products FMCG (Fast-Moving Consumer Goods): Often used for the distribution of goods to retail stores e-commerce: Widely used for last-mile delivery in e-Commerce logistics	Enclosed cargo area with lockable doors Varying sizes to accommodate different cargo volumes Often equipped with loading ramps or lift gates for easy loading and unloading
Flatbed Trucks 	Features an open platform with no sides or roof, ideal for transporting heavy and oversized loads not requiring enclosure	Construction Materials: Transporting building materials like lumber, steel beams, and concrete pipes Machinery and Equipment: Moving heavy machinery and industrial equipment Agricultural Products: Hauling farm equipment and large bales of hay	Open platform for easy loading and unloading from any side Can accommodate oversized and irregularly shaped loads Often equipped with tie-down points to secure cargo
Tanker Trucks 	Designed for transporting liquids or gases in bulk, featuring specialized tanks for safe and secure transport	Petroleum Products: Transport of gasoline, diesel, and other fuels Chemicals: Transport of industrial chemicals and hazardous materials Food and Beverage: Transport of milk, edible oils, and beverages Gas Transport: Transport of LPG and LNG	Specialized tanks with safety features for leak and spill prevention Temperature control systems on select models Compliance with hazardous materials transport regulations
Bulk Carrier Trucks 	Designed for transporting large quantities of loose, non-liquid materials, with hopper or container configurations	Agricultural Products: Transport of grain, seeds, and animal feed Construction Materials: Transport of sand, gravel, and cement Mining Products: Transport of coal, iron ore, and minerals	Efficient loading/unloading hopper systems Hydraulic tilting cargo bed mechanisms Optimized for high-volume bulk material handling
Specialty Trucks 	Designed for specific applications requiring unique configurations and capabilities, customized for industry requirements	Garbage Trucks: Collecting and transporting waste to disposal sites Refrigerated Trucks: Temperature-controlled perishable goods Concrete Mixers: Mixing and transporting ready-mix concrete to construction sites Auto Transporters: Hauling multiple vehicles to dealerships or customers	Custom configurations to meet specific needs Specialized equipment such as refrigeration units, compactors, or mixers Compliance with industry-specific regulations and standards



Estimated percentage distribution of trucks by body type on Indian roads is given in Figure 9.

Figure 9 Estimated percentage distribution of Trucks - By Body Type¹⁰

FUEL TYPE BASED

M&HDT segment employs a diverse range of fuels, including diesel, CNG, LNG, LPG, diesel-hybrid, bio-CNG, electric, and hydrogen. Currently, diesel dominates the commercial vehicle fleet, accounting for 98.4%, followed by CNG at 1.3%, petrol at 0.3%, and others, as shown in Figure 10. However, this pattern is expected to shift in coming years with the rise of alternative fuels including LNG, LPG, electric, hydrogen, and hybrid technologies. By operating e-trucks and fuel cell electric trucks (FCETs) on renewable electricity, India has the potential to achieve zero-emission trucking, which would help reduce the country's energy import bills.¹¹

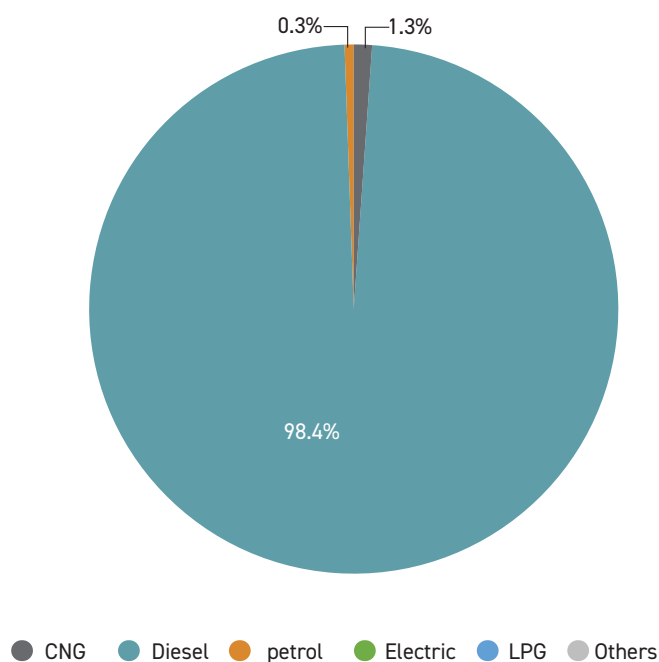


Figure 10 Commercial vehicle On-road fleet- By fuel type¹²

¹⁰ Indicative data interpreted from Industry Assessment & Roadmap for Zero-emission Medium- and heavy-duty Trucks in India, pManifold supported by CALSTART, 2022

¹¹ Technical roadmap for Deployment of Zero-emission trucking In India, March 2023

¹² Data analysis from Vahan Dashboard by MoRTH (Govt. of India) till May 2024

INDUSTRY STRUCTURE

The trucking value chain consists of multiple actors: demand-side logistics companies and demand aggregators; supply-side OEMs, charger and battery manufacturers; support service providers such as truck body builders, component suppliers, and fuel suppliers; and government and regulatory bodies. The key stakeholders among all market actors are illustrated in Figure 11.

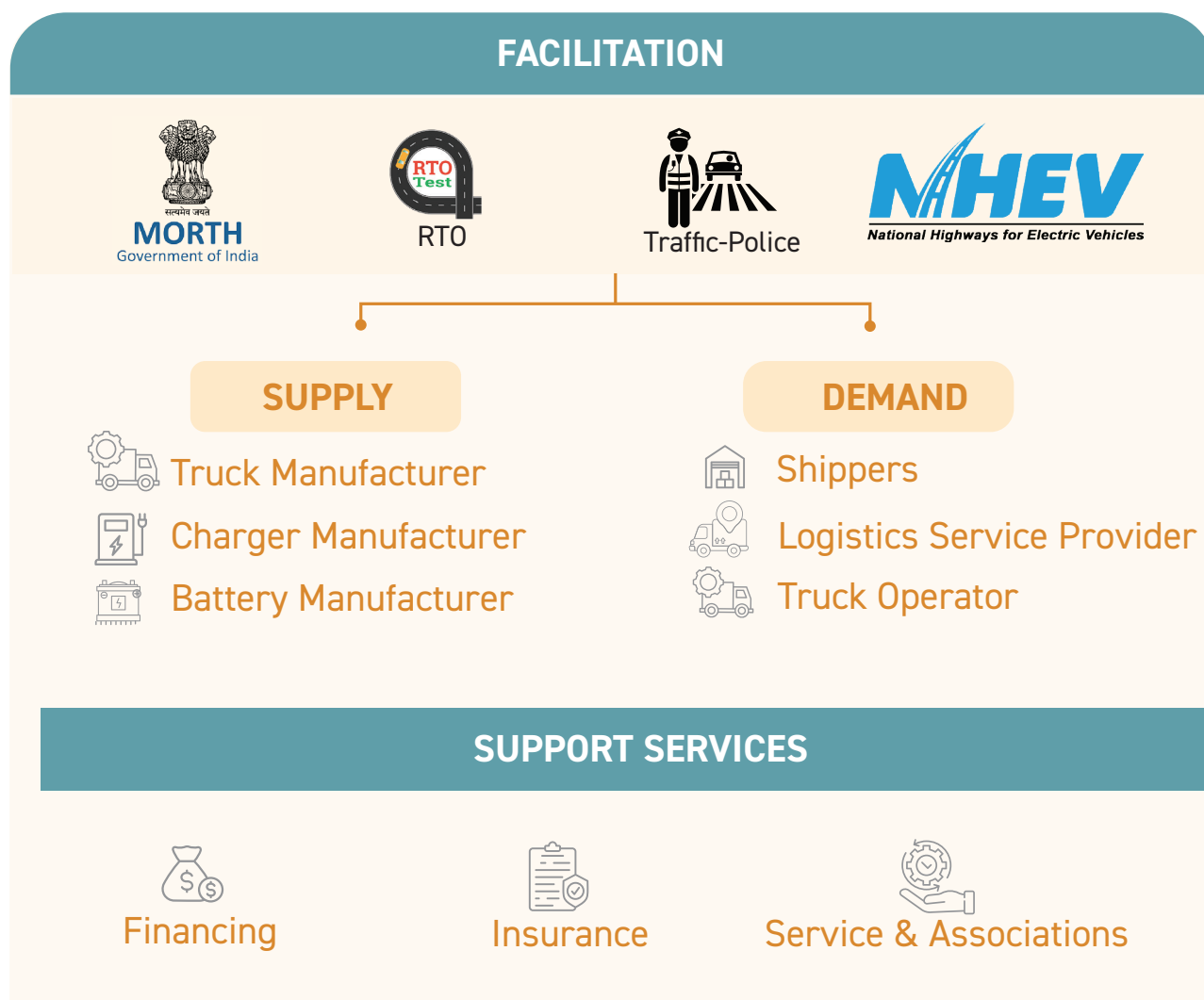


Figure 11 Structure of Trucking Industry¹³

➤ Demand

- **Shippers:** Shippers who generate demand for trucks include, Goods manufacturers, construction contractors and e-commerce companies
- **Logistic Service Providers:** Large, organized players with extensive fleets for specific applications
- **Truck Operators:** Individual driver-owners and small to medium fleet operators

➤ Supply

- **Truck Manufacturers (OEMs):** Indian and multinational truck manufacturers and assemblers.
- **Charging Manufacturers:** Providers of charging infrastructure for e-trucks.
- **Charging infrastructure and Equipment providers:** Plan, install, and maintain infrastructure for zero-emission medium and heavy-duty trucks.
- **Battery Manufacturers:** Suppliers of e-truck batteries

¹³ An Overview of the Trucking Sector in India: Significance and Structure, G. Raghuram - IIMA, 2015

- **Truck Body Builders and Component Suppliers:** Customize cabins and load bodies, and supply major components like gearboxes, suspension systems, and brakes.

➤ Support Services

- **Financing:** Dominated by banks and non-banking finance companies providing truck purchase financing.
- **Insurance:** Growing trend of comprehensive coverage among individual truck buyers and larger fleets.
- **Service & Associations:** Maintenance and repair services, IT services for truck tracking, and other digitized support functions.
- **Associations:** Various associations providing support and lobbying for the trucking sector.

➤ Facilitation

- **Ministry of Road Transport and Highways (MoRTH):** Key regulatory and policy-making body for the trucking industry.
- **Regional Transport Offices (RTO):** Enforce regulations and standards set by MoRTH and other bodies.
- **NHforEV:** National Highway for Electric Vehicles initiative focusing on EV infrastructure development. This framework captures the roles and responsibilities of key actors in the truck ecosystem, encompassing demand, supply, support services, and facilitation.
- **e-FAST India (Electric Freight Accelerator for Sustainable Transport – India)¹⁴** is the country's first platform designed to facilitate collaboration between government stakeholders and private sector partners. This innovative platform brings together Original Equipment Manufacturers (OEMs), Logistic Service Providers (LSPs), financiers, producers, and Charge Point Operators (CPOs) to develop strategies and actions that support large-scale freight electrification.
- **Other forward-thinking business** models can help speed up the e-truck transition, such as:
 - **Battery Leasing** - The battery in an e-Truck accounts for 50-60% of the total cost of the vehicle. By separating the battery from the vehicle, the upfront cost can be significantly reduced, making the vehicle less capital-intensive. Under this model, the truck and the battery can be financed separately. The battery remains a liability for the OEM, and operators lease the battery from the OEM. This arrangement not only lowers the initial cost of the vehicle but also reduces maintenance charges associated with the battery, as the OEM is responsible for maintaining its condition.
 - **Truck as a Service Model** - OEMs can offer customers trucks at a fixed monthly cost, providing access to trucks, charging infrastructure, insurance, maintenance, and driver training. Additionally, a pay-per-mile leasing option can be implemented, where the leasing payment is calculated based on the truck's usage. This innovative business model ensures access to e-Trucks for small road operators who cannot guarantee demand and do not wish to commit to longer-term leases. Currently, companies like Volvo Trucks and Daimler are exploring the Truck as a Service model and pay-per-mile leasing methods, respectively.

These business models aim to make the transition to e-Trucks more financially viable and operationally efficient, thereby accelerating the adoption of e-Trucks in India.

DEMAND-SIDE TREND

Figure 12 provides a schematic insight of the remarkable characteristics of fleet landscape in India. The aim of this report is to additionally promote the need for future studies based on the some of the salient features of the Indian fleet landscape as follows:

¹⁴ e-Truck Market in India, JMK, 2024

- **High concentration of Small Fleet Owners (SFOs):** Nearly 70% of truck buyers own no more than six trucks, accounting for about 30% of the on-road fleet. Another 23% of buyers own between six and twenty trucks, representing 38% of the fleet.
- **Skewed Fleet Trade:** The market is heavily skewed towards individual buyers, with more than half of these buyers purchasing fleets for personal use.
- **Fleet Lifecycle and Resale:** Most truck owners maintain a small fleet, using trucks for their first eight to ten years of life before reselling them. Typically, these trucks are in operation for up to 15 years before being scrapped. The Government of India (GoI) is working on limiting the maximum age of trucks to 15 years to control pollution and reduce road accidents. While there is some secondary use for trucks, it is currently limited to specific applications such as in-port container movement and raw material transport from quarries to road hubs.
- **Versatility and Adaptability:** Many truck operators prefer new-age trucks that offer versatility, allowing them to switch between various applications and adapt to market demand. However, only a fraction of these operators have fixed contracts.
- **Flexibility and customization:** About 20-25% of trucks are fully built with both cabin and load body, 40-45% are sold with only the cabin allowing for custom load bodies, and 30-35% are cowl trucks, offering maximum customization with only the chassis and engine provided.

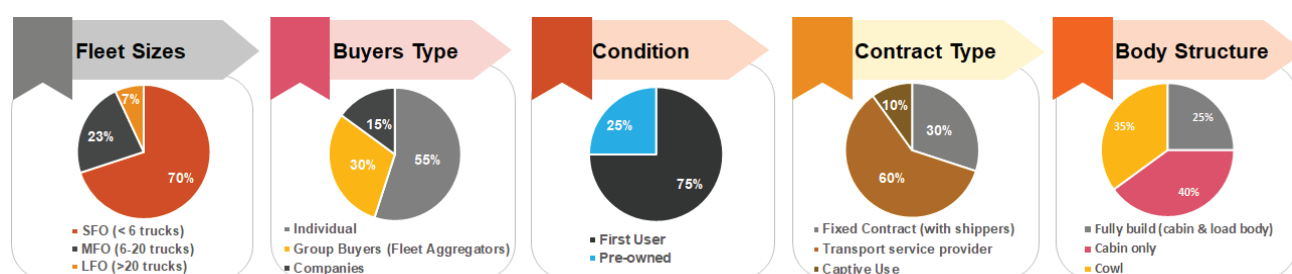


Figure 12 Indian Fleet Characteristics¹⁵

SUPPLY-SIDE TREND

The supply side of the Indian truck market is highly consolidated. The top manufacturers of medium and heavy-duty trucks (M&HDT) are Tata Motors, Ashok Leyland, VECV-Eicher, Mahindra & Mahindra, and SML Isuzu, accounting for more than 95% of the market. Tata Motors and Ashok Leyland together consistently maintain a market coverage of more than 70%, as shown in Figure 13. This consolidation presents an opportunity for the large OEMs to experiment and develop new technology as financing and investment in R&D is not a barrier for them.

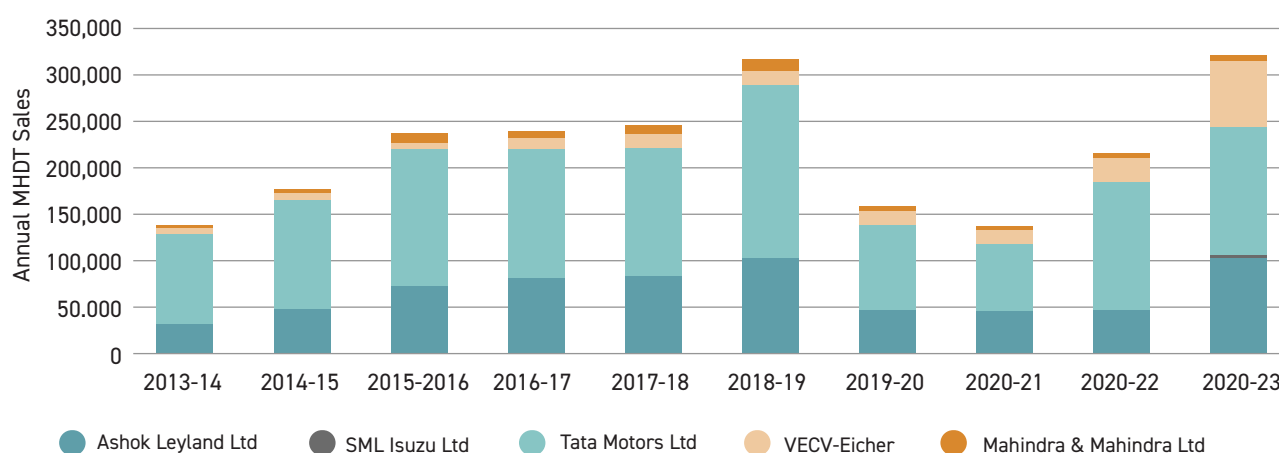


Figure 13 Market share of M&HDT by OEMs¹⁶

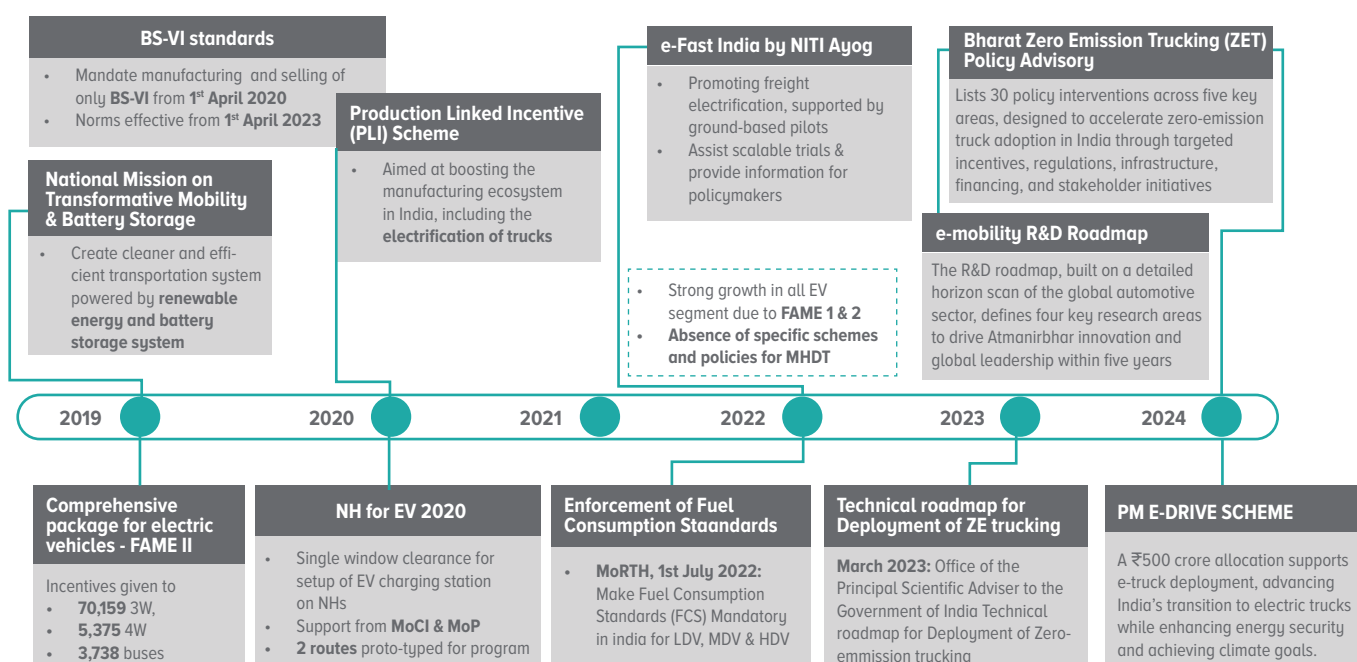
¹⁵ Indicative data interpreted from Primary consultation with Logistics Player (Rhenus Logistics & TruckSuidha), JSW, and COE-ZET, August 2024 (Refer 10: Annexure Stakeholder Consultation Summary); Validated with Secondary data from Early Market Outlook Report, CG, 2022

¹⁶ Data analysis from Vahan Dashboard by MoRTH (Govt. of India) till May 2023

POLICY & REGULATORY STRUCTURE

India has taken significant steps to ensure a more sustainable and efficient transportation system. The National Mission on Transformative Mobility and Battery Storage is a key initiative to help India transition to electric vehicles and renewable energy sources. The Ethanol Blending and Biodiesel Programs are helping reduce the country's dependence on fossil fuels. Several other crucial measures include the BS-VI standards, comprehensive package for EVs, fleet modernization program, and enforcement of fuel consumption standards. Additionally, e-FAST India and NHforEV 2020 are ambitious projects supporting the creation of a clean and sustainable energy system. These policy actions, as shown in Figure 14, form the framework for India's transition to a greener transportation system.

Figure 14 India's actions on Trucking Industry Decarbonization¹⁷



Apart from initiatives such as the Faster Adoption and Manufacturing of Electric Vehicles (FAME) scheme, the government has actively supported the development of a robust manufacturing ecosystem for EVs and their components. The goal is to boost local value creation and generate employment in the EV manufacturing sector. Under FAME-II, vehicle manufacturers must meet localization criteria outlined in the Phased Manufacturing Program, which mandates that 50% of vehicle components be sourced locally in India to qualify for demand incentives.

On the supply side, the government has utilized its **Production Linked Incentive (PLI)** scheme for Automobile and Auto Components Industry. The Auto PLI scheme has attracted proposed investments totaling INR 67,690 crore (USD 8.1 billion), surpassing the target of INR 42,500 crore (USD 5 billion) set for 2022-2027. An additional investment of INR 27,000 crore (USD 3.2 billion) is anticipated under the Advanced Chemistry Cell (ACC) battery PLI scheme, aimed at establishing a manufacturing capacity of 50 gigawatt hours of ACC and 5 GWh of specialized ACC.¹⁸

India's national and state-level EV policies have introduced various fiscal and non-fiscal incentives to promote manufacturing and adoption of EVs and charging infrastructure. These policies have accelerated EV market growth and enhanced energy security, focusing primarily on two-wheelers, three-wheelers, four-wheelers, and buses. While M&HDT electrification is not explicitly mentioned, these policies provide a framework for expanding current programs or developing initiatives to support zero-emission truck (ZET) manufacturing and adoption across India.

To support ZET deployment, Office of the Principal Scientific Adviser to the Government of India has provided a **Technical Roadmap for the Deployment of Zero-Emission Trucking in India**. The government-appointed Consultative Group on e-Mobility (CGeM) has determined priority subjects and regions for implementation. The roadmap outlines these key technical milestones and urgent initiatives:

¹⁷ Data compilation from various sources – BEE-EV Yatra, OMI Dashboard and Industry updates

¹⁸ Year-End- Review of Ministry of Heavy Industries – 2022, PIB

- Develop mechanisms for gathering, analyzing, and reporting field data from operational trucks nationwide
- Accelerate product development and scale up ZET deployment through rapid adoption of national standards for vital technologies
- Design tools for successful pilot deployment, tracking, and continuous improvement
- Identify and revise regulatory requirements while developing a future emission reduction roadmap

OPPORTUNITIES FOR TRANSITIONING THE INDIAN FREIGHT ECOSYSTEM TOWARDS ELECTRIC

The adoption of ZETs in India is driven by several key factors, including stringent government regulations on emissions, increasing environmental awareness, rising fossil fuel costs, corporate commitments, and supportive policies. Government initiatives and subsidies promoting green transportation, combined with growing corporate social responsibility (CSR) mandates among businesses, further fuel the demand for ZETs. This section will explore the opportunities for this transition in detail, providing insights into how these factors shape the market for ZETs as shown in Table 5.

Table 5: Opportunity for ZET Transition

Demand Driver	Details
 Emissions and Net-zero	2% 10% 47% M&HDT make up around only 2% of the road vehicle fleet yet they perform about 10% of road vehicle kilometres travelled (VKT). In total, M&HDT account for 47% of all road transport emissions in India. The result is a disproportionate amount of GHG emissions produced by the road freight sector, as shown in the figure above¹⁹. Widespread adoption of ZETs could significantly mitigate these emissions. By 2050, ZET adoption could reduce annual trucking carbon emissions by 46%, contributing to a substantial decrease in the nation's GHG emissions. This transition could result in cumulative CO₂ savings of 2.8-3.8 gigatons through 2050, which is comparable to or even exceeds India's current economy-wide annual GHG emissions.²⁰
	90% Small and family businesses make up almost 98% of all trucking operators 70% and 70% own less than 6 trucks Not well known, less than 0.5% of all fleet operators have more than 100 Trucks in their fleets <6 100 Diesel is one of the most significant costs for a trucking business - with fuel representing around 50% - 60% of operator costs.²¹ Trucking operators, especially smaller operators, have significant difficulty passing increases in the volatile price of diesel on to clients. Here, ZET adoption can dramatically lower associated fuel costs by up to 46% over the vehicle's lifetime, reducing the burden of the volatility of fuel prices while providing lower maintenance costs.²²
 Economic Opportunity	

¹⁹ The Potential to Electrify Freight Transportation in India, CSTEP, 2022

²⁰ Transforming Trucking in India, Pathways to Zero-Emission Truck Deployment, NITI Aayog, RMI, September 2022

²¹ Integrated Research and Action for Development (IRADe)

²² Transforming Trucking in India, Pathways to Zero-Emission Truck Deployment, NITI Aayog, RMI, September 2022

Demand Driver	Details
 e-Truck Model Availability	Availability and continuous development of these e-Truck models underscore the potential for a substantial shift towards e-Freight transport in India. Details of Current suppliers & New entrants in e-Truck is given in <i>Section 4.2 Current Suppliers & New Entrants in e-truck</i>.
 Supportive policies	Indian government has been proactive in implementing supportive policies to accelerate the adoption of e-Trucks. These policies span from infrastructure development to regulatory frameworks, aimed at creating a conducive environment for e-Trucks. Key initiatives include corridor identification, new Corporate Average Fuel Economy (CAFE) norms, and other supportive measures like e-FAST India Launch, FAME Scheme, and GST Reduction.
 Health	With supportive policies, ZETs can achieve an 85% sales penetration by 2050. With cost competitiveness and technology maturity, nearly 9 in 10 trucks sold in 2050 can be ZETs. ²³
 Fuel Security	It is stated that widespread ZET adoption could reduce cumulative trucking particulate matter (PM) and nitrogen oxides (NOx) pollution by approximately 40% by 2050, leading to a significant improvement in air quality across India. ²⁴ Henceforth, e-Trucks have significant potential to reduce vehicle noise and improve urban air quality in our communities. It will also improve conditions for truck drivers, through lower noise and vibrations.
 Opportunity to become global manufacturing hub for ZETs	Today, road freight accounts for more than 25% of oil import expenditures—and is expected to grow over 4x by 2050. ZET adoption has a potential to eliminate a cumulative total of 838 billion litres of diesel consumption by 2050, which would reduce oil expenditures by ₹116 lakh crore through 2050. ²⁵
 Planned e-truck Pilots, initiatives and Commitments by Corporates	A robust domestic ZET market can transform India into a global green hub for battery manufacturing. ZETs would be a significant source of demand for domestically produced batteries (up to 4,000 gigawatt-hours [GWh] cumulative through 2050) ²⁶, supporting and underpinning the National Energy Storage Mission and providing the impetus for the nation to become a low-cost and low-carbon manufacturing hub.
	Various pilot initiatives, Commitments by Corporates and planned projects also presenting a significant opportunity for e-Truck adoption in India. Leading companies are leveraging their supply chain expertise to develop and deploy e-Trucks for logistics and goods transportation. Notable collaborations include Volvo Eicher's partnership with Amazon to introduce up to 1,000 e-Trucks, Adani Group's order of 400 e-Trucks from BYD, and JSW Cement's pilot with plans to expand to 500 e-Trucks. Additionally, new players such as Tresa Motors and Pepper Motion are driving innovation and competition, further shaping India's e-Truck ecosystem. Similarly, e-Commerce companies and retail brands are increasingly committing to include EVs in their fleet as part of their sustainability initiatives. Details are elaborated in <i>Section 5.2 e-Truck Technology and Product Roadmap</i>

²³ Transforming Trucking in India, Pathways to Zero-Emission Truck Deployment, NITI Aayog, RMI, September 2022

²⁴ Transforming Trucking in India, Pathways to Zero-Emission Truck Deployment, NITI Aayog, RMI, September 2022

²⁵ Transforming Trucking in India, Pathways to Zero-Emission Truck Deployment, NITI Aayog, RMI, September 2022

²⁶ Transforming Trucking in India, NITI Ayog, Sep 2022

Key takeaways:

1

Key drivers of road freight activity include economic growth, urbanization, infrastructure development, e-commerce, and supply chain complexity.

2

The fragmented nature of the Indian truck industry creates challenges such as high cost of financing, high incidence of taxes, low productivity, and lack of wayside amenities.

3

The Indian trucking industry has unique operational and functional characteristics and is categorized based on GVW, fuel type, application, and body structure.

4

The market is dominated by small fleet owners, with a high concentration of individual buyers, while the supply side is highly consolidated, with top manufacturers like Tata Motors and Ashok Leyland.

5

Opportunities for transitioning to e-Trucks include emissions reduction, economic benefits, and supportive policies.



**The domestic
sales of
commercial
vehicles have
demonstrated
a compound
annual growth
rate CAGR of
~12% from 2014
to 2024**

3. e-Truck Market Perspective Demand-side

This chapter delves into the demand side of the freight market with a focus on Zero-Emission Trucks (ZETs) in India. It aims to provide a comprehensive understanding of the market landscape, highlighting the primary drivers for ZET adoption, the challenges faced in their integration, and the usage characteristics of typical truck applications. Additionally, it examines the existing infrastructure, business models, and financing options that support the transition to zero-emission freight transport.

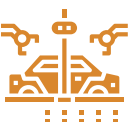
USAGE CHARACTERISTICS

Freight transport in India is highly fragmented, with various characteristics that can be used to categorize it. One of the primary ways to distinguish different types of freight movement is by considering the type of goods being transported and the distance they need to travel. This classification helps in understanding the specific requirements and challenges associated with each operation. By examining these factors, it becomes possible to develop targeted strategies and solutions to optimize transportation efficiency and effectiveness. Table 6 presents the usage characteristics of typical truck applications in India.

Table 6: Usage Characteristics of typical truck applications in India²⁷

Application	Payload Characteristics	Distance per trip (km)	Speed	Corporate / Government Influence	Overloading Propensity
 Agriculture	Market Load - Carries irregular shape of goods packages - Performs long-haul trip - Mixed density payload	500 – 600	Medium: 40-60 kmph	High	Moderate
	Vegetable & Fruits - Deteriorates over a short time - Mix payload, time sensitive transportation - Perishable & fragile	200 – 250	High: 50-60 kmph	Low	Low
	Fish - Decay if not kept insulated or frozen - Mix Payload - Perishable & fragile	200 – 250	High: 50-60 kmph	Low	Moderate
	Edible Oil - Mobile bulk container used to transport wholesale - Compliance with food safety, hygiene, and packaging regulations - May require temperature control measures	300 – 400	Medium: 45-55 kmph	Medium	Low
	Fertilizer* - Requires protection from moisture and environmental factors - High-density materials - Seasonal transportation	Information not found			

²⁷ Early Market Outlook Report – Electrification of MHTD in India, CG & pManifold, 2021

Application	Payload Characteristics	Distance per trip (km)	Speed	Corporate / Government Influence	Overloading Propensity
 Mining	Coal & Minerals	100 – 120	Low: 20-25 kmph	Medium	Low
	Iron Ore				
 Construction	Cement & Clinker	150 – 170	Low: 20-30 kmph	Low	Low
	Iron & Steel	300 – 350	Low: 20-30 kmph	Medium	High
	Water Tanker	100 – 120	Low: 20-35 kmph	Low	High
	RMC*	Information not found			
 Manufacturing	Container*	Information not found			
	Automotive*	Information not found			
	FMCG	500 – 600	Medium: 40-60 kmph	High	Moderate
	e-Commerce	500 – 600	Medium: 40-60 kmph	High	Low
	Pharma*	Information not found			
 Specialized Application	Garbage	100 – 150	Low: 20-30 kmph	Low	Low
	Petroleum	180 – 200	Medium: 45-55 kmph	High	Low
	LPG	200 – 250	Medium: 45-60 kmph	High	High

* Excluded from further assessment because no data was found

➤ The usage characteristics of typical truck applications in India are analyzed in Chapter 7, “ZET Adoption Opportunities: Segment and Use Case View,” to determine electrification favorability as follows:

➤ **Distance per Trip (km):**

- **Technical Feasibility:** Determines if current e-truck models can meet the required range
- **Operational Certainty:** Aids in planning efficient charging infrastructure and logistics
- **Scalability:** Assesses the potential for expanding e-truck fleets across varying distances and operational scales without compromising performance or cost-efficiency

➤ **Speed:**

- **Technical Feasibility:** Influences battery consumption and vehicle performance, and charging needs.
- **Operational Certainty:** Helps design e-trucks for real-world conditions, considering varying speeds across different routes.

➤ **Corporate**

- **Scope 3 Emission Reduction Potential:** Assesses long-term emission reductions aligned with corporate sustainability goals.
- **Scalability:** Sectors with strong corporate and government backing have well-established regulatory frameworks and resources, facilitating broader adoption of e-trucks with conducive use cases for early electrification and scaled adoption
- **Economic Case:** Analyzes a specific set of freight use cases with cost parity and potential savings (refer to Chapter 7 on TCO).

➤ **Government Influence:**

- **Economic Impact:** Government policies, incentives, and subsidies can significantly reduce initial costs and improve the feasibility of e-truck adoption
- **Social Impact:** High influence can drive policy changes and public-private partnerships, accelerating the transition to e-trucks

➤ **Overloading Propensity:**

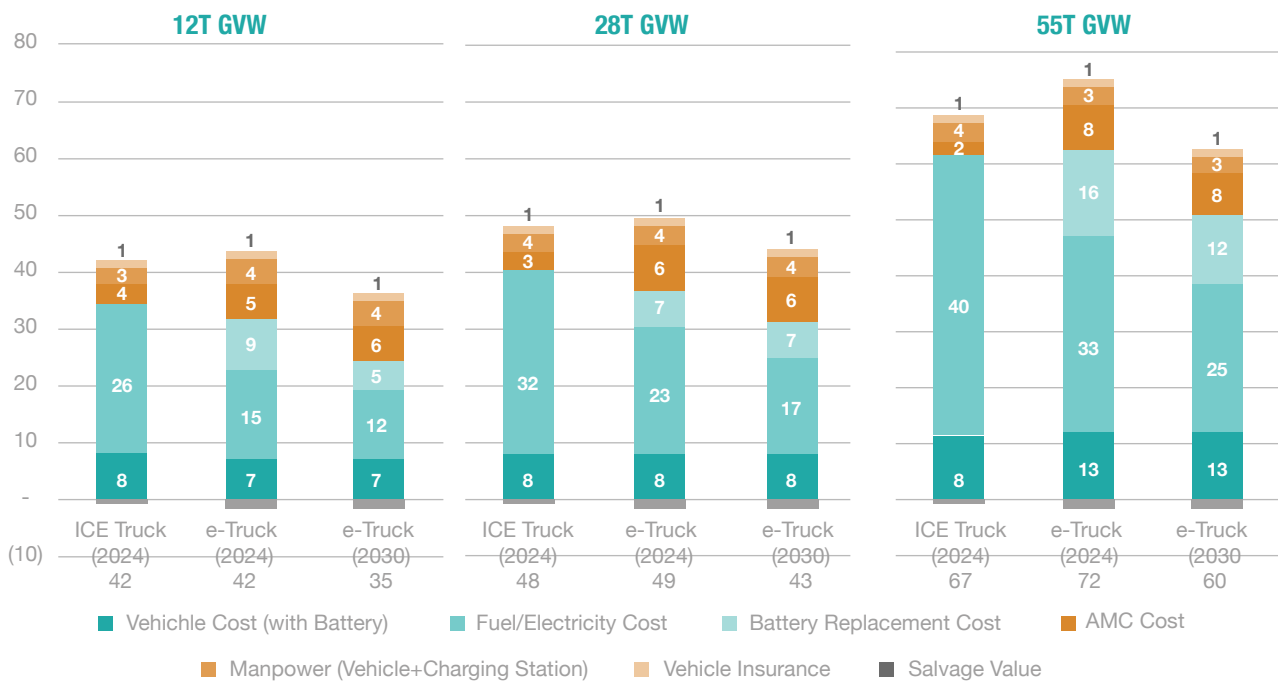
- **Technical Feasibility:** Affects vehicle performance and battery life, and maintenance needs.
- **Operational Certainty:** Ensures reliable and safe operation under real-world conditions, minimizing risk of breakdowns or inefficiencies.

Understanding these characteristics helps in identifying the most feasible and impactful segments for electrification, ensuring that the transition to e-trucks is both practical and effective.

TOTAL COST OF OPERATIONS CHARACTERISTICS

Total Cost of Operations (TCO) is a key metric used to evaluate the financial viability of vehicle ownership and operation over its lifetime. For medium- and heavy-duty trucks (M&HDTs), TCO includes various cost components such as initial purchase price, fuel or energy costs, maintenance expenses, insurance, financing, and residual value. When comparing electric (e-M&HDTs) and internal combustion engine (ICE) trucks, TCO plays a crucial role in assessing the economic feasibility of transitioning to electric vehicles.

The estimated TCO analysis for e-M&HDTs compared to ICE trucks reveals that, as of 2024, e-M&HDTs have a slightly higher TCO. Specifically, the 55T GVW segment shows a more significant cost difference compared to its ICE counterpart than the 12T GVW and 28T GVW segments, which exhibit only slight differences. This analysis highlights the varying degrees of TCO parity across different GVW categories, indicating that while smaller e-M&HDTs are approaching cost parity with ICE trucks, larger e-M&HDTs still face notable financial gaps, primarily due to higher initial purchase and battery costs.



Chapter 7 will present a detailed breakdown of Total Cost of Operations (TCO) by application, analyzing cost components across different use cases

BUSINESS & FINANCING MODELS

The financing landscape for diesel trucks in India is well-established, catering to a wide range of fleet operators, from large logistics companies to small individual operators. As trucks serve as a primary means of livelihood, approximately 98% of purchases are made through borrowed funds. The financing is primarily distributed across three sources: Non-Banking Finance Companies (80%), Banks (15%), and other financiers (3%). Lending decisions are based on factors such as scale of operations, financing needs, and credit profiles. Figure 15 illustrates the distribution of financing across different operator segments, reflecting the industry's diverse nature and varying needs.

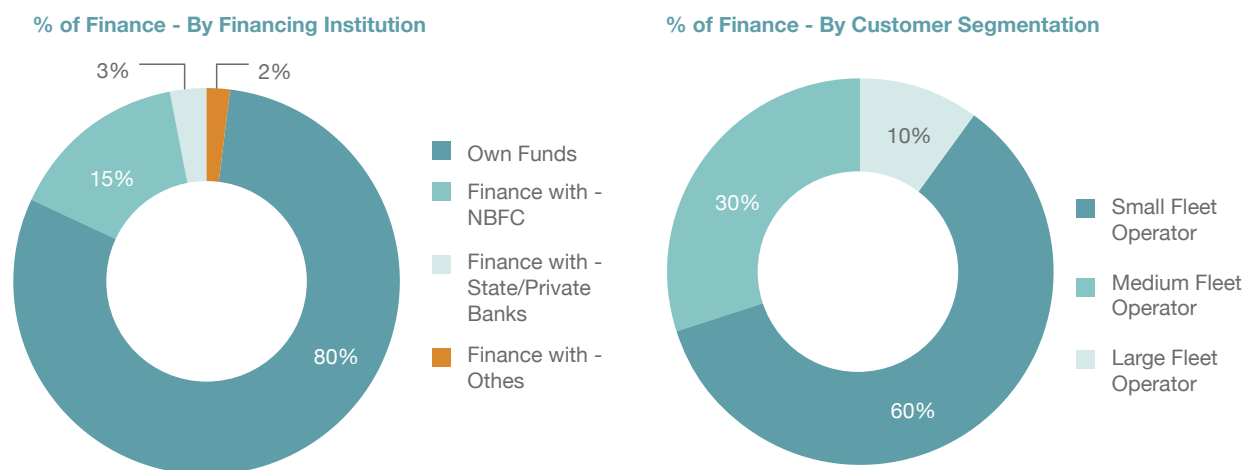


Figure 15 Financing landscape for diesel trucks²⁸

In the Indian trucking industry, the majority of trucks are owned outright by their operators, while a smaller percentage are acquired through leasing arrangements. Here's a brief overview of the ownership and leasing dynamics:

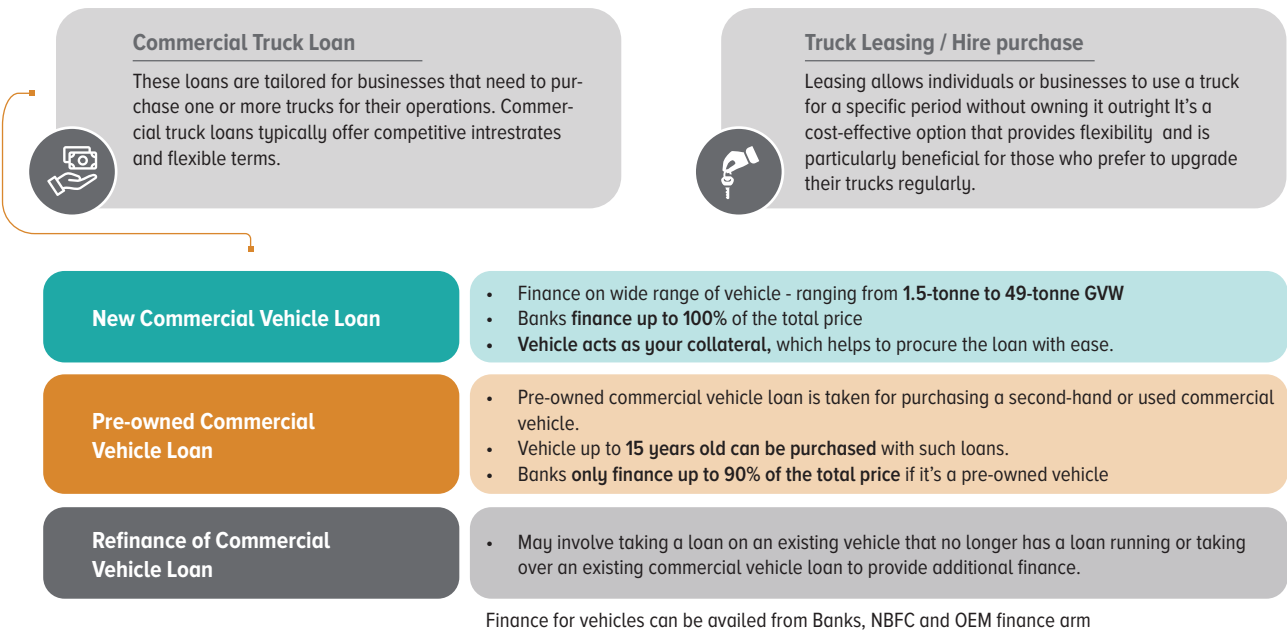
Owned Trucks: Approximately 70-80% of diesel trucks in India are owned outright by their operators. Truck owners typically secure loans from banks or Non-Banking Financial Companies (NBFCs) to finance their purchases. These loans often have tenures ranging from 5 to 7 years, with interest rates between 10% and 14% per annum. Owning

²⁸ Indicative data interpreted from Primary consultation with Sundaram Finance, August 2024 (Refer 10: Annexure Stakeholder Consultation Summary); and Stakeholder input received at Mumbai and Chennai Workshop organized by SFC (Refer 10: Annexure Workshop Summary)

trucks provides operators with full control over their assets and allows them to customize their vehicles to meet specific operational needs.

Leased Trucks: Around 20-30% of diesel trucks in India are acquired through leasing agreements. Leasing is an attractive option for fleet operators who prefer lower upfront costs and flexible terms. The typical lease duration ranges from 3 to 5 years. Leasing agreements often include maintenance and service packages, reducing the operational burden on the lessee. Interest rates for leasing may be slightly higher than loan interest rates, reflecting the additional services and flexibility provided by leasing companies.

AVAILABLE FINANCING OPTIONS FOR ICE TRUCKS²⁹



Sundaram Finance, Tata Capital, Mahindra Finance, and HDFC Bank are key players in India's truck financing market, serving both Small Fleet Operators (SFOs) and Large Fleet Operators (LFOs). When considering truck financing, operators must meet specific criteria to qualify for loans or leases. These criteria help lenders mitigate risks while ensuring borrowers' repayment capability. The key parameters for financing trucks are:

Table 7 Criteria for Truck Financing³⁰

Criteria	Parameters	SFOs	LFOs
Credit worthiness	Source of income	Salary proof, Bank statements, Income tax returns	
	Business financials	Income tax assessment	
		Satisfactory track record with existing banks	Balance Sheets & Annual income
		UDYAM registration certificate (MSME)	
	Credit score	Must be above 700	
	Business type	Establishment year	Stability of Company & Trade License
	Work Experience	2 years of experience in the transportation sector	
Asset details		Details of vehicle for which loan applied	
Down payment		15% margin on the on-road price	

²⁹ Primary consultation carried out with Sundaram Finance, August 2024 (Refer 10: Annexure Stakeholder Consultation Summary); and Stakeholder input received at Mumbai and Chennai Workshop organized by SFC (Refer 10: Annexure Workshop Summary)

³⁰ Creditworthiness - Lenders will assess credit history and credit score to determine the ability to repay the loan.

Source of income - Lenders request proof of income, such as bank statements or tax returns to assure reliable source of income for EMI

Business Financials - Financial statements, including income statements & balance sheets, may be evaluated to assess ability to repay loan

Down Payment - The amount of the down payment can influence eligibility and terms

Business Type - Established businesses with a proven track record may have an easier time securing financing.

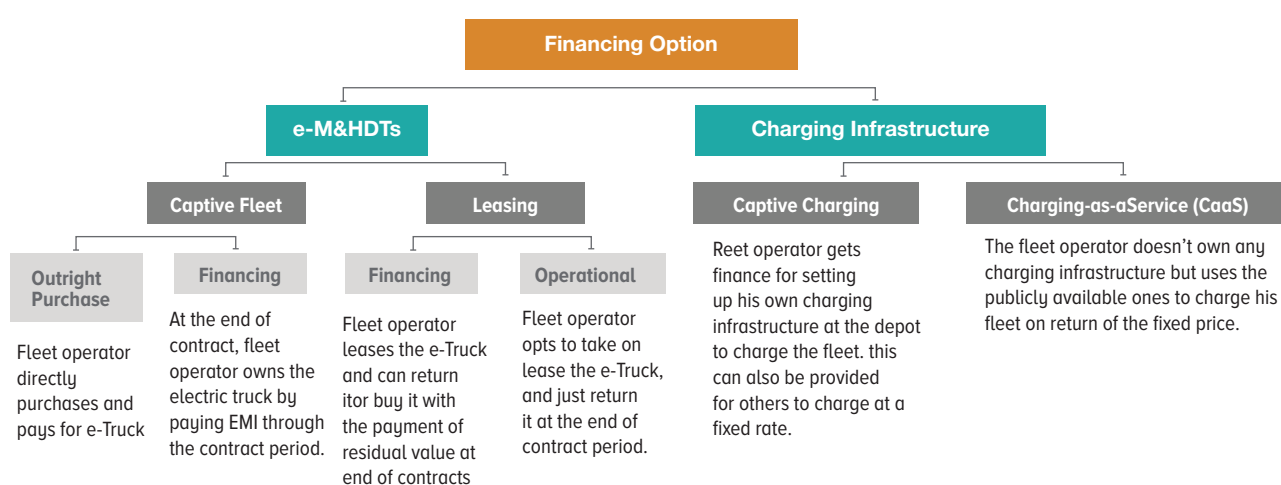
Asset details - information about the truck with intend to finance, including its make, model, year, and purchase price.

The financing section highlights various options available for acquiring e-trucks, including commercial truck loans, new and pre-owned vehicle loans, refinancing, and leasing. These options offer flexibility in terms of interest rates, loan amounts, and collateral requirements. However, Small Fleet Operators (SFOs) face significant challenges in accessing these financing options. They often encounter stricter criteria and limited financing percentages, especially for pre-owned vehicles, making it harder for them to secure necessary funds compared to Large Fleet Operators (LFOs). This disparity underscores the need for tailored financial solutions and government support to make e-truck adoption more accessible and financially viable for SFOs. As the industry transitions towards sustainability, financing institutions are developing specialized options for zero-emission trucks, often with more favorable terms and incentives to promote their adoption.

FINANCING OPTIONS FOR E-TRUCKS

There can be different financing options for procuring the e-truck fleet and setting up the charging infrastructure as shown in Figure 16. These are:

Figure 16 **Financing Options for e-Trucks**



These models highlight how innovative financing strategies can support the widespread adoption of ZETs by managing risks and providing flexible, cost-effective solutions for operators as shown in Table 8. Details are provided in **10**:

Annexure - Business & Financing Model.

Table 8 **Financing Strategy Levers and Potential models**

Large Fleet Operator	
Direct Investment	Large companies can invest directly to ensure control and reliability.
Green Bonds and Loans	Can issue green bonds or avail green loans designed for environmental-friendly investments.
Public-Private Partnerships (PPPs)	To leverage government support and incentives for infrastructure development.
Captive Financing	Setting up their own financing arms to offer loans and leases to their customers.
Small players/ Individuals	
Leasing	Opting for leasing e-Trucks to avoid the high upfront costs and mitigate the risk of obsolescence.
Government Grants and Incentives	Avail government schemes designed to support small businesses in adopting EVs.
Crowdfunding	Raising funds through crowdfunding platforms to finance the transition to e-Trucks.
Cooperative Buying	Forming cooperatives to pool resources and negotiate better terms with manufacturers.
Third-Party Financing	Partnering with banks or non-banking financial companies (NBFCs) that specialize in EV financing.
Innovative financing models applicable to any scale:	
Pay-Per-Use	Paying for the e-Trucks based on usage, which can help manage cash flow and align costs with revenue.
Transport-as-a-Service (TaaS)	Subscribing to a service that provides e-Trucks, maintenance, and charging for a regular fee.

DEMAND-SIDE CHALLENGES & OPPORTUNITIES

This section elaborates the challenges faced by the truck buyers in adopting BETs.³¹ Details are provided in *Annexure 10: Technological, Financial and Operational Challenges & Opportunities for ZET Transition*.

Challenges	Key Parameter	Opportunities
Battery Electric Trucks (BETs) cost two to three times more than equivalent Internal Combustion Engine (ICE) trucks. Consequently, with the same financing rates and tenure, the Equated Monthly Installments (EMI) would also be two to three times higher. Unless the operating cost advantages of BETs significantly offset this difference, their Total Cost of Ownership (TCO) remains unfavorable. This high upfront cost represents a significant barrier to BET adoption.	Purchase Cost	Develop strategies to reduce the high entry costs of BETs, possibly through subsidies or incentives.
Although some financiers offer full financing for BETs, they typically charge higher rates and require substantial security deposits ³² . This stems from the higher perceived risks associated with an emerging technology. Battery-related failures and safety concerns further affect the risk assessment of BETs. Additionally, financing institutions evaluate the borrower's income stability through long-term contracts and require guarantors with strong creditworthiness to assess loan default risk.	Financing	Create tailored financial products that address the higher perceived risks and security deposit requirements.
If a BET requires charging beyond its overnight charge, it disrupts the on-road schedule and reduces truck productivity. Additional operational challenges include reduced payload and volumetric capacity, as battery packs are heavier and bulkier than equivalent fuel tanks. These limitations can result in a poor 'Truck Replacement Factor' (TRF) - the number of BETs needed to match the productivity of one ICE truck. This increased vehicle requirement further compounds the already higher purchase cost of BETs.	Operations	Innovate in operational practices to minimize productivity losses due to charging and payload capacity issues.
Trucks require high-power chargers even for slow charging. A 180-kWh battery pack typically requires a 120-kW charger. Most power distribution companies (DISCOMs) require dedicated energy infrastructure (high-tension cables, distribution transformers, civil works, etc.) for power requirements above 25-50 kW. Thus, setting up a private charging point represents a significant additional expense beyond the BET cost. Unless the charging point is shared by multiple trucks, its cost significantly impacts the Total Cost of Ownership (TCO). Many truck operators in India maintain small fleets (see Figure 12), making it prohibitively expensive to install private charging points, particularly for their initial BET purchases. Therefore, access to public charging infrastructure becomes critical for these operators to adopt BETs.	Access to charging	Invest in shared public charging points to alleviate the high costs of private installations.
Truck manufacturers have begun introducing BET models, primarily in three weight categories: 14T, 19T, and 55T. These models fall into two segments: Rigid trucks (12T < GVW ≤ 25T) with approximately 25% market share in 2023, and Tractor-Trailers (GVW > 18.5T) with approximately 15% market share in 2023, as shown in Figure 7. While these segments collectively represent 40% of the market, the current BET models may not align with early adopter requirements.	Availability of BET models	Encourage manufacturers to diversify BET models to meet the specific needs of early adopters.

³¹ Stakeholder input received at Mumbai and Chennai Workshop organized by SFC (Refer 10: Annexure Workshop Summary)

³² Primary consultation carried out with Sundaram Finance, August 2024 (Refer 10: Annexure Stakeholder Consultation Summary)

Key takeaways:

1

Freight transport in India is highly fragmented, categorized by the type of goods and travel distance. Key applications include agriculture, mining, construction, manufacturing, and specialized applications, each with unique payload characteristics, distances, speeds, and overloading propensities.

2

The financing landscape for diesel trucks is well-established, with most purchases financed through Non-Banking Finance Companies (80%), Banks (15%), and other financiers (3%). Ownership dynamics show that 70-80% of trucks are owned outright, while 20-30% are leased. Small players can opt for leasing, government grants, crowdfunding, cooperative buying, and third-party financing. Innovative models like Pay-Per-Use and Transport-as-a-Service (TaaS) offer flexible, cost-effective solutions.

3

Demand-Side Challenges and Opportunities:

- **Purchase Cost:** BETs are significantly more expensive than ICE trucks, posing a high entry barrier. Strategies to reduce costs through subsidies or incentives are needed.
- **Financing:** Higher perceived risks and security deposit requirements make financing challenging. Tailored financial products can address these issues.
- **Operations:** Charging requirements and reduced payload capacity can affect productivity. Innovations in operational practices are necessary to minimize these impacts.
- **Access to Charging:** High costs of private charging installations necessitate investment in shared public charging points.
- **Availability of BET Models:** Encouraging manufacturers to diversify BET models to meet specific needs of early adopters is crucial.

4. e-Truck Market

Perspective: Supply-side

This chapter provides an in-depth analysis of the supply side of the freight technology market, focusing on the current trends and challenges associated with ZETs. It aims to offer a comprehensive overview of the landscape from the perspective of suppliers, including current suppliers and new entrants, supply side policies, key challenges for e-Truck OEMs, key technology trends, and the potential for technology transfer.

ALTERNATE TECHNOLOGY TRENDS

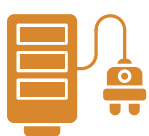
The trajectory of alternate technology in the freight sector is evolving through distinct phases, each marked by varying levels of technological maturity and infrastructure development as shown in Figure 19.



Present State: Currently, the technology is at an evolving stage, facing numerous unknowns and challenges. The sector still relies heavily on legacy diesel engines and natural gas-powered vehicles. Many solutions are in their nascent stages, with significant obstacles remaining in terms of efficiency, cost, and infrastructure development.



Mid-Term State: In the mid-term, we anticipate a landscape of optimized solutions with growing infrastructure support. This period will see diversified fuel choices, including advanced diesel technologies, hybrids, and battery electric vehicles (BEVs). Technological innovation and maturity will be evident, with empirical data replacing estimates and learning curves leading to more efficient and reliable solutions.



Long-Term State: Looking further into the future, the technology will reach a state of fast charging capabilities, widespread hydrogen availability, and long-life, low-cost batteries. These advancements will result in acceptable weight and cost parameters for e-trucks. Hydrogen fuel cells derived from clean energy sources will become commonplace, significantly reducing emissions and operational costs.

This progression from an immature state to a technologically advanced and optimized ecosystem will drive the transition toward a more sustainable and efficient freight transportation sector.

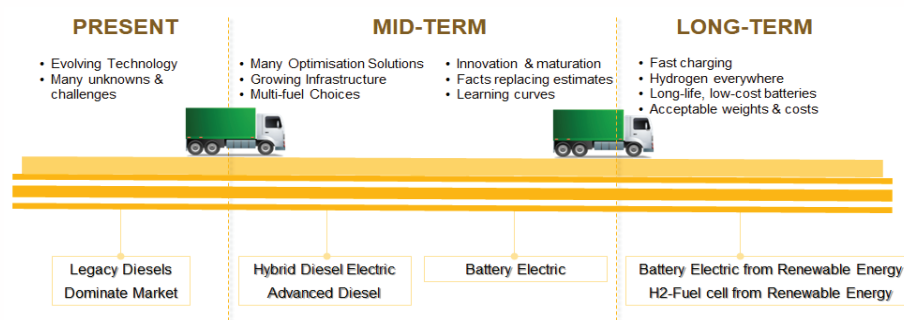


Figure 17 Alternate Technology Trends and Anticipated Advancements

By 2030, the technological landscape for ZETs is expected to be significantly more advanced and mature as shown in Table 9.

Table 9 Estimate of Technology Readiness³³

	SUSTAINABILITY			FLEET OPERATIONAL		INFRASTRUCTURE	INTEGRATION CHALLENGES	MATURITY
	ZEV	Well-to-Wheel	NOx/PM	Range	Route Flexibility			
DIESEL								
ICE RENEWABLE*								
NATURAL GAS								
HYDROGEN ICE								
BATTERY ELECTRIC								
H2- FUEL CELL								

*ICE Renewable = Renewable Natural Gas, Renewable Diesel, Renewable Propane, etc.

 = UNFAVORABLE  = FAVORABLE

The technology readiness assessment in the above table projects the expected development of each powertrain technology. It illustrates the major attributes and trade-offs among various solutions. This assessment evaluates key attributes—fleet operational range, route flexibility, infrastructure, integration challenges, and maturity—to guide fleet adoption decisions. Diesel scores highest across most categories due to its established reliability and infrastructure, making it the most adaptable for diverse routes and long distances. Alternative fuels like natural gas and hydrogen show moderate readiness, indicating potential but requiring significant infrastructure investment. Battery electric vehicles, while promising, face challenges due to limited range and nascent charging infrastructure, necessitating further development. This analysis provides a strategic framework for fleets to evaluate both the current capabilities and future potential of each powertrain option against their operational needs and long-term goals.

CURRENT SUPPLIERS & NEW ENTRANTS IN E-TRUCK

As technology readiness for e-trucks advances toward 2030, supply-side dynamics are evolving rapidly. The market is witnessing a wave of new entrants alongside established suppliers, all vying to capture the growing demand for sustainable freight solutions. Established players like Tata and Ashok Leyland are developing various e-truck prototypes optimized for India's road conditions and hauling demands.

In the light-duty segment, Tata has launched the Ace EV, which has become a popular logistics choice for brands like Amazon and Flipkart. The models currently in domestic production in India, as shown in Table 10, include the Tata Ultra T.7 Electric (MDT), Ashok Leyland Boss Truck, and Rhino 5536 IPLT (HDT) by Infraprime Logistics (IPLT). Several top OEMs have developed e-trucks that have successfully cleared the prototyping phase and will soon enter mass production.

³³ The Messy Middle: A Time For Action, Pg. no. 24, 2023

Table 10 Available e-M&HDT models or will likely be available in India over the next 18-24 months³⁴

	OEM/Model	Technology	GVW	Battery Size	Range	Format	Remarks
LAUNCHED	IPLT – Rhino ³⁵ 5536 (6 x 4)	BEV	55 T	265 kWh	185 km under standard condition. One side load, One side empty	Tractor Truck	Variant 1: 6 x 4, 38 T Cargo carrying capacity Variant 2: 4 x 2, 40 T Cargo carrying capacity
	BYD – Q1 ³⁶	BEV	40 T	255 kWh	200 kms	Tractor Truck	
	Olectra - Meghatron 6 x 4 ³⁷	BEV	28 T	350 kWh	150 kms to 200 kms	Tipper Truck	
	Ashok Leyland - Boss ³⁸	BEV	14 T	201 kWh	230 km per Charge	Tractor Truck	
	TATA Motors Prima E.28K ³⁹	BEV	28 T	453 kWh	150 kms to 200 kms	Tipper Truck	TATA Motors is eager to work with progressive customers and develop customized Zero emission solutions, to closely match the duty cycle requirements.
	TATA Motors Prima E.55S ⁴⁰	FCEV	55 T	Fuel Stack – 220 kW to 270 kW Battery – 22 kW to 34 kW	350 kms to 500 kms	Tractor Truck	
DEMONSTRATION	Ashok Leyland	BEV	19T	94 kWh – 284 kWh	100 kms to 300 kms	Haulage	Customizations available in terms of loading span, day cabin, sleeper cabin, AC, telematics, air suspension, ABS, FOTA, ADAS, etc.
	Ashok Leyland	BEV	55T	200 kWh – 400 kWh	80 kms to 160 kms	Tractor with three axle trailer	
	Ashok Leyland	H2-ICE	41T	Not Applicable	400 kms	Multi-axle Haulage	
	Ashok Leyland	FCEV	28T	55 kWh	300 kms to 350 kms	Multi-axle Haulage	
	Ashok Leyland	FCEV	28T - 49T	55 kWh	300 kms to 350 kms	Haulage	
	Ashok Leyland	FCEV	40T - 55T	55 kWh	300 kms to 350 kms	Tractor	
	Volvo Eicher Pro 3015	BEV	55T	Not Disclosed	Not Disclosed	Tractor Truck	

India's e-freight vehicle manufacturing sector is burgeoning, with numerous players operating across 20 states, as illustrated in Figure 20. Delhi, Bengaluru, and Hyderabad have emerged as pivotal hubs in this dynamic sector, with high concentrations of key supply-side players

³⁴ TATA Motors, Ashok Leyland and IPLT have confirmed their upcoming products, data on other OEMs is based on public information. This data is indicative. In addition to the above, Kalyani Powertrain has a retrofit solution in ZET

³⁵ IPLT, RHINO 5536, last accessed July 22, 2022

³⁶ Battery Electric Terminal Tractor, BYD, 2017, last accessed July 22, 2022

³⁷ Investors Earnings call Presentation, Olectra, March 2023, last accessed July 22, 2022

³⁸ Ashok Leyland commences delivery of Electric Trucks at Bharat Mobility Global Expo, 2024

³⁹ Tata Prima E.28K, last accessed July 22, 2022

⁴⁰ Tata Prima E.55S, last accessed July 22, 2022



Figure 18 Electric Commercial Vehicle Manufacturing Location⁴¹

In these fast-developing manufacturing hubs, companies are not only manufacturing e-freight vehicles but also driving innovation and competition in the market. The presence of diverse manufacturers underscores a robust ecosystem, fostering technological advancements and competitive pricing strategies. This diversification across geographical locations reflects the broadening scope and decentralized growth of India's e-freight vehicle industry.

Compared to developed markets, the Indian e-Truck market is still in its nascent stages, with limited model availability and evolving infrastructure as shown in Table 11. In developed countries, a wider range of e-Truck models with varying specifications is available, catering to different segments of the transportation industry. These models are often supported by advanced charging infrastructure and favorable government policies, promoting faster adoption. In contrast, India's e-Truck market is gradually expanding, with a few models introduced in recent years, primarily focusing on specific use cases and urban logistics.

⁴¹ Decarbonizing India's Road Freight, WRI, 2022

Table 11 Comparison of e-Truck Market: India vs. Developed Markets (China)⁴²

Country	Model	Battery capacity	Range	GVW	Payload	First Available year
India	BYD – Q1	255 kWh	200 km	40 T	31.8 T	2019
China	BYD – Q3	355 kWh	160 km	26 T	15 T	2021
	BYD – T7	177 kWh	230 km	11.8 T	7 T	2021
	BYD – T8 Clean	222 kWh	280 km	11.8 T	6.5 T	2021
	BYD – T8 General	217 kWh	210 km	18 T	10.5 T	2021
	BYD – T9 Clean	348 kWh	300 km	18 T	10.5 T	2021
	BYD – T18 General	255 kWh	245 km	18 T	10.5 T	2021
	BYD – T31	444 kWh	190 km	31 T	19 T	2021

KEY DIFFERENCES



Model Variety: Developed markets, such as China, offer a broader range of e-truck models catering to different GVW categories and payload capacities. In contrast, India's market is more limited, focusing on a few specific models.



Battery Capacity and Range: E-trucks in developed markets feature battery capacities and ranges comparable to Indian models, generally offering moderate ranges suitable for urban and regional logistics.⁴³



Adoption and Infrastructure: Developed markets benefit from well-established charging infrastructure and supportive government policies, accelerating e-truck adoption. India is gradually building its infrastructure and policy framework to support e-mobility growths.

TECHNOLOGICAL CAPABILITIES FOR PRODUCTION

India is rapidly advancing its capabilities in e-truck production, leveraging technological innovations across the supply chain. However, supply chain localization and e-truck demand are not linearly correlated. The supply chain localization depends on three major aspects that must coexist: conducive government policies, financial capacity of auto component manufacturers, and access to raw materials. While government policy (PMP) has provided ample push for local manufacturing and some auto-component manufacturers have sufficient capital for investment, India lacks the raw materials needed for manufacturing key EV components that represent a high share of the EV value chain. Table 12 shows key e-truck components and their potential for localization by 2030.

Table 12 2030 Localization potential of e-Truck components

Component	(% cost contribution)	Current localization	Localization potential by 2030	Rationale
Battery Cell	50-60%	Very Low	Low	Unavailability of core raw materials like lithium. Battery R&D is capital intensive. Rapid evolution of battery technology. Cost competitiveness of Chinese Li-ion batteries.
Chassis and Body	10-15%	High	Very High	No requirement for special raw materials or technology. Manufacturing know-how already exists locally.

⁴² Data Analysis from Zero-Emission Technology Inventory (ZETI) Tool, CALSTART

⁴³ Designing Electric Truck Incentives for India, UC Davis, 2024

Component	(% cost contribution)	Current localization	Localization potential by 2030	Rationale
BMS and TMS	10-12%	Moderate	Very High	Primarily require software. India is known for development and export of software.
Motor	10-12%	Very Low	Moderate	Unavailability of rare earth magnets such as Neodymium. China's dominance in rare earth magnets poses geopolitical risks in sourcing raw materials.
Power Electronics	8-10%	Very Low	Very High	No major challenges except for capital required for R&D and infrastructure setup.
Others (HVAC, Control units, etc)	-	Moderate	Very High	Indian manufacturers have experience and know-how. Already manufacturing similar systems; minor adaptation required for EVs.

INFRASTRUCTURE ASSESSMENT

The implementation of ZETs requires robust support infrastructure to mitigate range anxiety and ensure operational reliability. An integrated strategy combining slow- and fast-charging infrastructure is crucial for widespread adoption. Infrastructure is particularly critical in developing economies like India to scale up ZET adoption.

Chargers are typically classified by power output but can also be categorized by location, enabling charging during operational hours (mid-shift) or outside them (off-shift). This includes warehouse charging (overnight at operator facilities) and destination charging (during loading and unloading at distribution centers, as well as public charging at

rest areas, ports, or parking spaces)⁴⁴. ZETs generally require higher-capacity chargers, even for off-shift cycles, due to the larger average battery size of Medium/Heavy/Commercial Vehicles (M/H/CVs).

The total number of Public Electric Vehicle Charging Stations (EVCS) in India has surged by 1,650% from June 2020 to June 2024. Currently, 16,344 Public Charging Stations (PCS) are distributed across various states in India, as shown in Figure 19. These PCS include 27,471 charging points, comprising both fast and slow charging options. Karnataka leads with 5,130 PCS, followed by Maharashtra (3,083) and Delhi (1,886). The state-wise distribution is shown in Figure 19. Eighty-two Charge Point Operators (CPOs), including both Public Sector Units (PSUs) and private entities, manage these stations. Fast chargers constitute approximately 40% of India's charging points, with over 10,756 fast charging points out of the total 27,471.⁴⁵

Current charging infrastructure guidelines

Figure 19: PCS in India



⁴⁴ Mathieu et al., 2020 Mathieu et al., 2020

⁴⁵ Electrifying India's Roads, Jul 2024, PIB

⁴⁶ Electrifying India's Roads, Jul 2024, PIB

in India mandate one PCS per 100 km on highways, requiring at least two public chargers with power outputs exceeding 100 kW. However, these guidelines primarily target e-4W and buses. To support ZET deployment, India may need recharging pools with combined power capacity of at least 2 MW and individual charger ratings of at least 200 kW⁴⁷ along highways. While some innovative fleets have implemented these advanced chargers and charging models, e-M&HDT charging infrastructure has not received the same attention as LDT infrastructure. The scarcity of charging options remains a significant barrier to widespread e-M&HDT adoption. Historically, government support has focused on LDT charging, as e-LDTs were first to enter the market. Retailers, workplaces, and municipalities have also prioritized light-duty charger installation due to their primary interaction with e-LDTs.

The challenges for e-M&HDT charging are compounded by limited physical accessibility to most public EV chargers. These chargers are typically located in parking lots designed exclusively for light-duty EVs, excluding most M&HDTs from the expanding public charging network. Furthermore, the lack of standardized charging port locations for e-M&HDTs complicates charging facility layout design. The substantial capital investment required for high-power chargers (750 kW and above), essential for opportunity charging, presents another significant barrier to ZET adoption in long-haul operations. Governments, utilities, and other stakeholders have recognized the growing e-M&HDT market and are expected to address this infrastructure gap.

To address this challenge, India plans to develop **5,500 kilometers of highways** into e-highways **across 12 states**, including the installation of charging infrastructure⁴⁸. Assessing the techno-economic feasibility of this transition is essential. Initiatives like C40 Cities in India (Mumbai, Ahmedabad, Delhi NCT, Chennai, Bengaluru) and The Climate Pledge's 'Laneshift' aim to provide insights through demonstration projects and an EV highway roadmap. As shown in Figure 16, the final corridors identified will support accelerated deployment of zero-emission freight vehicles in India by electrifying corridors originating from four C40 cities: Delhi, Mumbai, Pune, and Bengaluru.

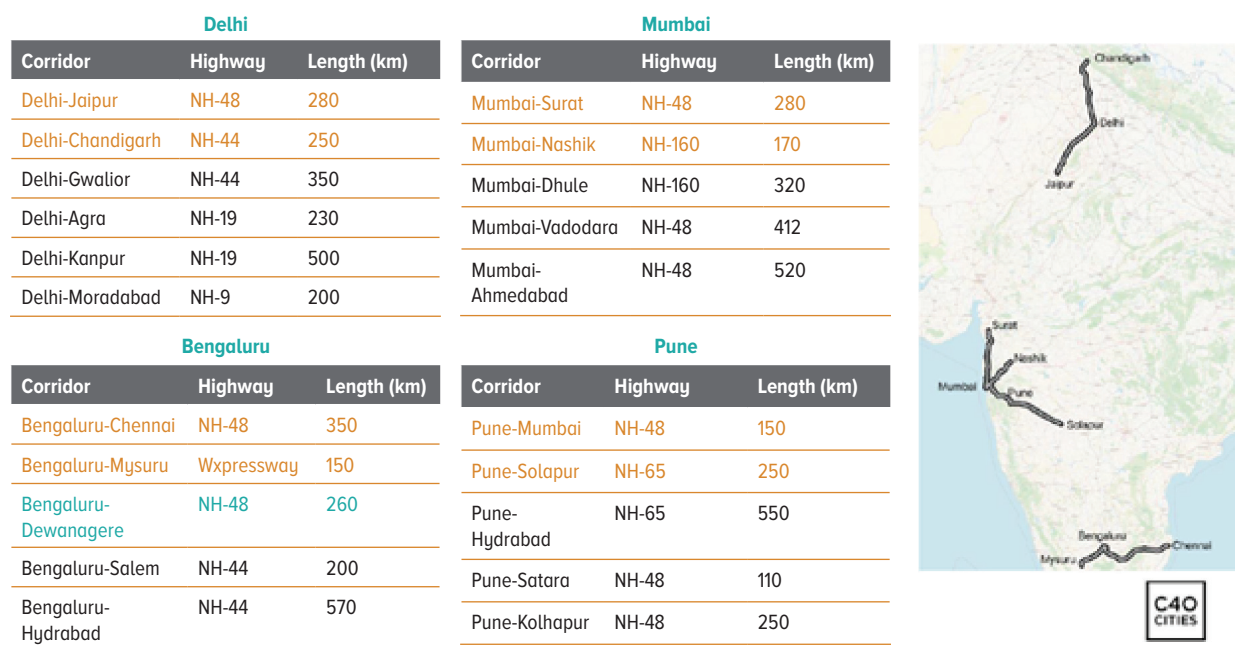


Figure 20 Corridors identified by C40 ⁴⁹

ANTICIPATED TECHNOLOGY ADVANCEMENT IN E-TRUCK

The future of e-Trucks is marked by several anticipated technological advancements aimed at enhancing their efficiency, performance, and adoption. Here are the key areas of innovation:

- **Battery Technology:** Significant progress in lithium-ion batteries has increased energy density, enabling longer ranges per charge. Research is focused on improving battery durability, charging efficiency, and reducing charging times. These advancements address critical concerns about electric vehicle (EV) performance and practicality.

⁴⁷ A Pathway to Zero-Emission Trucking in India, ITF, 2024

⁴⁸ NHforEV Update

⁴⁹ C40 Analysis on EV Highways Identification

- **Battery Swapping:** Battery swapping technology is gaining traction, particularly in China⁵⁰. In Japan, Mitsubishi Fuso Truck and Bus Corporation has signed an agreement with Ample Inc. to begin collaborating on a battery swapping technology pilot project for e-trucks.⁵¹ This method allows quick replacement of depleted batteries with fully charged ones, minimizing downtime. Reports indicate significant growth in battery-swapping e-HDT adoption, with expectations of continued rapid expansion.
- **Electric Drivetrains and Powertrains:** Innovations in electric drivetrains and powertrain systems are enhancing e-trucks' capability to handle heavy loads efficiently. High-torque electric motors and regenerative braking systems, which capture energy during deceleration, contribute to improved overall efficiency and performance.
- **Smart Technologies and Connectivity:** Integration of smart technologies, such as advanced telematics, is revolutionizing e-truck operational management. Real-time insights into vehicle performance, battery status, and charging infrastructure allow fleet operators to optimize route planning, monitor energy consumption, and schedule maintenance with precision.
- **Retrofitting:** Retrofitting existing trucks with electric systems offers a cost-effective solution to reduce emissions without purchasing new vehicles. This approach is economically favorable and supports sustainability goals. However, obtaining homologation and certification for retrofitted trucks remains a challenge.
- **Charging Infrastructure:**
 - **Overhead Catenary Charging:** Overhead catenary charging enables trucks to charge while driving via an overhead contact line. Pilot projects in Europe and North America demonstrate its potential, though it remains in early development stages.⁵²
 - **Wireless In-Road Charging:** Wireless charging systems embedded in roads transfer electricity to vehicles during operation. This technology, being tested in pilot programs in Sweden and the United States, promises seamless and continuous charging capabilities.⁵³
- **Fuel Transition Potential:** Meeting long-haul trucking demands with current battery technology remains challenging. As a result, alternatives like Fuel Cell Electric Trucks (FCETs) are being explored to provide extended travel ranges with minimal downtime, addressing Battery Electric Truck (BET) limitations.

As adoption of e-Trucks accelerates, OEMs are continuously innovating to introduce advanced technologies and new models. The following Table 13 outlines the key technological features and Innovation in Truck Technology Features by OEMs.

Table 13 Innovation in Truck Technology Features by OEMs

OEM	Year of Entry	Tech Features
Tata	2020	Collaboration on battery technology and Advanced Driver Assistance System (ADAS) features
Ashok Leyland	2024	Advanced Driver Assistance Systems (ADAS): A two-camera system that warns drivers of dangerous situations (such as tailgating and distracted driving) through voice alerts
IPL Tech	2019	Vehicle Telematics, Fast charging (90 mins to 100% charge), range of 185 km (single charge under standard test conditions).
Olectra	2022	Integrated Vehicle Tracking System via IoT, Smart sensors: Electricity leakage sensors, battery temperature sensors, power train regeneration, etc.

These advancements highlight the dynamic and innovative landscape of e-Trucks, paving the way for a more sustainable and efficient future in transportation.

⁵⁰ <https://www.chinadaily.com.cn/a/202301/18/WS63c74916a31057c47ebaa452.html>

⁵¹ <https://www.mitsubishi-fuso.com/en/news-main/press-release/2023/07/26/mitsubishi-fuso-and-ample-to-partner-on-battery-swapping-technology-for-electric-trucks/>

⁵² <https://theicct.org/wp-content/uploads/2022/12/charging-infrastructure-trucks-zeva-dec22.pdf>

⁵³ <https://theicct.org/wp-content/uploads/2022/12/charging-infrastructure-trucks-zeva-dec22.pdf>

SUPPLY-SIDE CHALLENGES & OPPORTUNITIES

This section elaborates the challenges faced by the truck manufacturers in production of BETs⁵⁴. Details are provided in *Annexure 10: Technological, Financial and Operational Challenges & Opportunities for ZET Transition*.

Challenges	Key Parameter	Opportunities
Unlike LDTs, M&HDTs are typically produced to meet specific demand rather than in large quantities. This limited production volume leads to higher component and material costs due to smaller order sizes. The resulting higher costs, combined with low production volumes, may reduce fleet operators' incentive to adopt M&HDTs	Limited Demand and Economies of Scale	Government incentives and collaboration with fleet operators are essential to boost market demand, achieve economies of scale, and optimize production efficiency, ultimately reducing costs associated with small-batch manufacturing
Indian OEMs operate with EBITDA margins typically below 10%, while their US and European counterparts achieve 12-15%. This financial constraint limits Indian OEMs' ability to invest significantly in advanced fuel technologies. ⁵⁵	Constraints on Indian Truck OEM Profit Margins	Financial support and R&D subsidies are crucial to help Indian truck OEMs invest in advanced fuel technologies without financial strain, particularly given their typically low EBITDA margins of under 10%.
Availability and cost of key raw materials like lithium, cobalt, nickel, and manganese can fluctuate, affecting the consistency and cost-effectiveness of producing standardized battery packs with specific chemistry.	Material Supply Variability	Developing alternative materials and recycling programs can stabilize the supply chain for key raw materials like lithium, cobalt, nickel, and manganese. Establishing industry standards for battery packs can streamline production and reduce costs.
Technological capabilities or production processes keep varying from manufacturer to manufacturer. Standardizing battery packs requires alignment in manufacturing techniques, which can be difficult given the diverse approaches and technologies used across the industry.	Manufacturing Capabilities	Investment in advanced manufacturing technologies and training programs, along with partnerships with global battery manufacturers, can enhance local manufacturing capabilities and ensure adherence to required standards.
Battery technology advancement creates risks of technology obsolescence before the investment recovery period. Today's batteries are denser, thus allowing for longer ranges in a smaller battery (Liimatainen et al. 2019). Each improvement, however, forces the manufacturer to purchase new equipment as well as reconfigure its approach to installing the battery in the vehicle, thereby increasing the cost of assembly. <i>Annexure: Key comparison of Lithium-ion chemistries preferred in BET</i>	Battery Technology Obsolescence	Government grants for upgrading manufacturing facilities and adopting new technologies, along with incentives for early adopters, can help manufacturers keep up with rapidly changing battery technology and reduce per-unit costs.

⁵⁴ Stakeholder input received at Mumbai and Chennai Workshop organized by SFC (Refer 10: Annexure Workshop Summary)

⁵⁵ https://www.nrdcindia.org/pdf/NRDC_%20Heavy_Trucking.pdf

Challenges	Key Parameter	Opportunities
Building e-truck is challenging due to the heterogeneous use cases they serve (Birky et al. 2017; Smith et al. 2019). For instance, while refrigerated trucks and delivery box trucks may look similar, their driving patterns differ significantly, affecting the battery requirements for each. Refrigerated trucks driven on highways have distinct operational characteristics compared to delivery trucks that navigate urban environments, including their ability to leverage regenerative braking. ⁵⁶	Diverse Vehicle Use Cases	Customizable battery solutions and focused R&D efforts are needed to optimize battery performance for various e-truck use cases, such as refrigerated trucks and delivery box trucks, ensuring efficient operation in different environments.
Companies with proprietary battery technologies may be reluctant to share their innovations as part of a standardization effort.	Intellectual Property Concerns	Legal frameworks are necessary to protect proprietary technologies while promoting standardization, encouraging companies to share innovations without losing their competitive edge.
The adoption of electric trucks (e-trucks) in India faces several critical challenges that hinder widespread acceptance. A significant barrier is the limited availability of e-truck models suited to diverse use cases in India, particularly in long-haul and heavy-duty segments. The technology maturity of electric trucks is another concern, as battery efficiency, range, and charging infrastructure are not yet optimized for the demanding Indian logistics environment. High upfront costs of e-trucks, driven by expensive battery technologies, further deter fleet operators, who are accustomed to cost-sensitive decision-making. Additionally, the readiness for zero-emission truck (ZET) adoption in India is low due to inadequate charging networks, lack of policy incentives tailored to the trucking sector, and limited awareness about the long-term operational benefits. Together, these factors create a complex ecosystem of barriers that slow the transition to sustainable freight in India.	Technology Readiness & Path Ahead	Supply-side mandates can serve as a transformative pathway for accelerating e-truck adoption in India. A phased introduction of these mandates, alongside well-structured incentive programs like production-linked incentives (PLIs), can accelerate the industry's transition to zero-emission trucks (ZETs). Supply mandates provide a structured and predictable framework for emission reductions, aligning with both national and international decarbonization targets. However, successful implementation requires careful consideration of India's unique resources—energy capacity, economic landscape, and manufacturing capabilities—to avoid overburdening original equipment manufacturers (OEMs). Incentivization measures, including PLIs, subsidies, tax benefits, and credit systems, can motivate stakeholders across the value chain to adopt greener practices and enhance domestic e-truck component manufacturing. By combining mandates with support mechanisms, India can foster a collaborative ecosystem that drives sustainable freight solutions while maintaining industrial competitiveness.

⁵⁶ <https://www.rff.org/publications/reports/medium-and-heavy-duty-vehicle-electrification-challenges-policy-solutions-and-open-research-questions/>

Key takeaways:

1

The freight sector's technology is evolving through distinct phases:

- Present State: Reliance on diesel and natural gas vehicles, with nascent solutions facing efficiency, cost, and infrastructure challenges
- Mid-Term State: Optimized solutions with diversified fuels, including hybrids and BEVs, supported by growing infrastructure
- Long-Term State: Advanced technologies featuring fast charging, hydrogen fuel cells, and long-life batteries, leading to reduced emissions and operational costs

2

The market is rapidly evolving with established players like Tata and Ashok Leyland developing e-truck prototypes. New entrants are driving innovation and competition. Current production models include the Tata Ultra T.7 Electric, Ashok Leyland Boss Truck, and Rhino 5536 IPLT, with several others advancing through the prototyping phase.

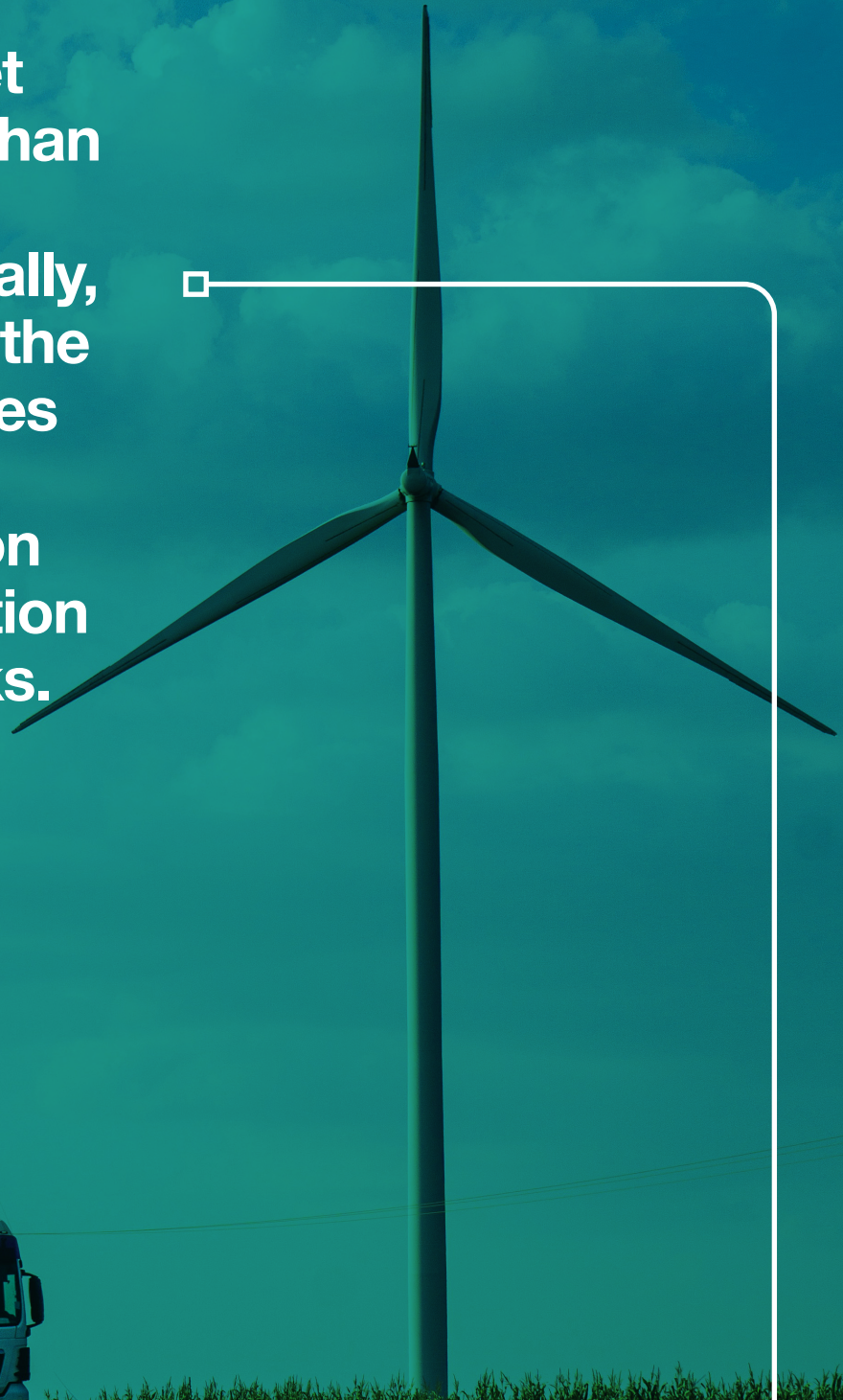
3

India is advancing in e-Truck production, leveraging technological innovations. However, supply chain localization depends on government policies, financial strength, and raw material access. Key components like battery cells have low localization potential due to raw material unavailability, while chassis and body have high potential.

4

Innovations in battery technology, battery swapping, electric drivetrains, smart technologies, and retrofitting are expected to enhance e-Truck efficiency and performance. Charging technologies like overhead catenary and wireless in-road charging are being tested, promising seamless charging solutions.

the market saw less than 250 units sold annually, reflecting the early stages of market penetration and adoption of e-Trucks.



The e-truck ecosystem in India is rapidly evolving as the nation pushes towards greener and more sustainable transportation solutions. This chapter provides an in-depth analysis of the current state and future prospects of the e-truck market, covering market dynamics, technological advancements, policy environment, infrastructure, and stakeholder engagement.

E-TRUCK ADOPTION IN INDIA

The annual e-truck sales in India have shown stagnant growth from 2014 to 2023, with a substantial surge projected in 2024. Between 2014 and 2023, the market saw less than 250 units sold annually, reflecting the early stages of market penetration and adoption of e-Trucks. However, in 2024, the sales are expected to see a significant jump, with more than 200 units sold as shown in Figure 21. This dramatic increase highlights a turning point in the e-Truck market, driven by enhanced government policies, improved technology, availability of e-Truck models in the market, and growing environmental awareness among consumers and businesses.

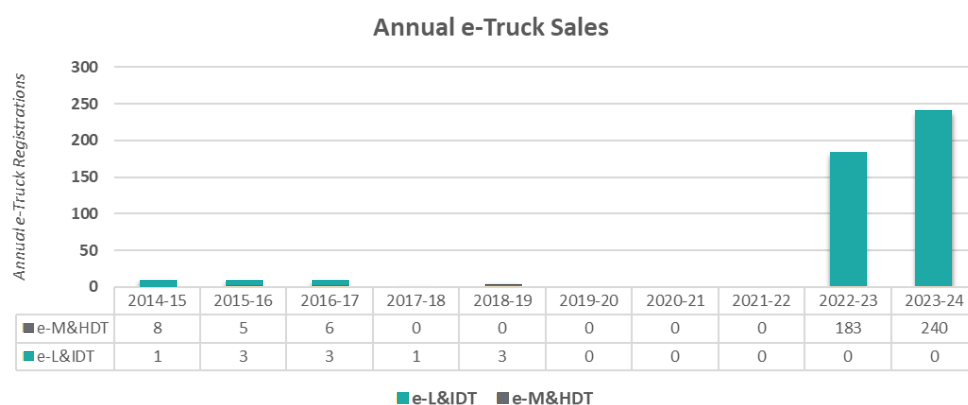


Figure 21 Annual e-Truck Sales⁵⁷

By 2024, over 450 e-trucks had been sold in India, reflecting a growing acceptance and adoption of EVs in the freight sector. The distribution of these vehicles highlights the following trends in the market:

Light & Intermediate Duty Trucks (L&IDT) represent just 2.5% of the total e-truck stock. This lower penetration could be attributed to the current stage of technological and infrastructural development, which is more favorable for smaller vehicles.

Medium & Heavy-Duty Trucks (M&HDT) make up 97.5% of the e-truck stock and are gradually gaining traction. These vehicles are essential for long-haul freight and heavy-duty applications. The relatively higher cost and infrastructural requirements for charging and maintenance are potential barriers to their widespread adoption. However, as the market evolves, M&HDT are expected to play a crucial role in the sustainable transformation of India's freight industry.

E-TRUCK TECHNOLOGY AND PRODUCT ROADMAP

The e-truck ecosystem in India is evolving rapidly with numerous pilot initiatives, planned projects, key partnerships, and announcements by new players. These developments highlight the country's commitment to electrifying its freight sector and reducing its carbon footprint.

⁵⁷ Data analysis from Vahan Dashboard by MoRTH

PILOT INITIATIVES & PLANNED PROJECTS

Many companies are supporting the electrification transition, focusing on M&HDT. Large OEMs are leveraging their extensive supply chain knowledge and industry experience to develop new technologies. Key partnerships are emerging between demand-side companies and top OEMs for the delivery of e-trucks to transport goods and logistics across the country, as illustrated in Table 14.

Table 14 Pilot initiatives & Planned projects

Company	Project Details
Volvo Eicher Commercial Vehicles (VECV)	Developing light e-Trucks in collaboration with Amazon. Aim to introduce up to 1,000 e-Trucks over five years (2023)
Adani Group	Ordered 400 e-Trucks from BYD for port operations at Ennore, Katupalli, Hazira, and Mundra (2023)
JSW Cement	Initiated a pilot with 5 e-trucks from Murugappa Group (Infraprime Logistics Tech Electric) and plans to expand to 50 e-trucks by the end of 2024, further scaling to 500 (2023)
Ultratech	Partnered with Murugappa Group (IPLTech Electric) to purchase 5 e-trucks for transporting clinker, planning to deploy 500 e-Trucks by June 2025 (2024) Partnered with Greenline to deploy 1,000 LNG trucks by June 2025 (2024)
Maersk	To deploy more than 500 EVs in 26 cities covering first-, middle- and last-mile distribution across India by end of 2024 (2023)
Flipkart	Set a target to replace 100% of its delivery fleet by March 2030 (2020)
IKEA	Planning to electrify 100% of its delivery fleet in India by 2025 (2022)
Tata Steel	Contracted for 27 e-trucks for transporting finished steel rolls in India (2021)
JK Lakshmi Cement	Collaborated with SwitchLabs to deploy e-HDT (one of its kind operation in India), intending to reduce ~100 Ton of CO2 emission per Truck per year (2024)

KEY PARTNERSHIPS AND ANNOUNCEMENTS BY NEW PLAYERS

Several new players are entering the e-truck market, bringing innovation and driving competition. Their partnerships and projects are critical in shaping the future of the e-truck ecosystem in India as shown in Table 15.

Table 15 Key Partnerships and Announcements by New Players

Organization	Date of Announcement	Description
Triton Electric Vehicle Pvt. Ltd.	June 2021	Triton Electric Vehicle will invest INR 2,100 crore in Telangana to produce EVs, including semi-trucks
Pune Municipal Corporation and Eka Mobility	June 2023	Purchased 10 electric tipper trucks for garbage collection.
TI Clean Mobility	August 2023	Entered the electric small commercial vehicle (e-SCV) category. Plans to roll out trucks from a new facility in Manesar by April 2024.
Tresa Motors	October 2023	Investing INR 500 crore to start commercial production of e-Trucks by 2026.
Hindustan Zinc and Inland EV Green Services Pvt Ltd	November 2023	Deploying 10 e-Trucks for inter-operations transport.
Pepper Motion	December 2023	Laying the foundation for an EV bus and truck manufacturing unit in Andhra Pradesh.
Wardwizard Innovations & Mobility and Triton EV	December 2023	Partnering to manufacture battery-operated trucks in India and UAE.
BillionElectric	June 2023	Emerging e-mobility platform for electric light and medium commercial vehicles, backed by partnerships with various EV OEMs, secures USD 10 million in seed funding

Organization	Date of Announcement	Description
Daimler India Commercial Vehicle	April 2024	Plans to launch the all-electric e-Canter in India within the next 6 to 12 months

India's e-Truck ecosystem is set for rapid growth and transformation, driven by robust partnerships, innovative pilot projects, and a strong focus on sustainable and alternative fuel technologies.

E-TRUCK ADOPTION SCENARIOS AND ITS IMPACT

Three policy scenarios have been developed based on different ZET penetration levels, energy intensity improvement rates, electricity grid CO2 emission intensity levels, and FCET adoption. Table 16 briefly describes each scenario, which we examine in detail below.

Table 16 **Summary of ZET Projection Scenarios**⁵⁸

Scenario	Brief Description	Energy Intensity Improvement	ZET Penetration	Electricity Grid	Hydrogen	Additional Policy Assumption
Zero ZET Penetration	Reference scenario, no new policies assumed after 2021	No improvement	Zero	BAU grid <i>(IEA STEPS projected to 2070)</i>	No FCETs	
India 2070 Net-Zero	Focuses on ZET penetration required to meet India's 2070 Net-Zero target	Ambitious energy intensity improvement of ~40% in diesel trucks	100% ZET sales by 2050	Ambitious decarbonized grid	Green hydrogen	Scrappage of vehicles causing residual emissions in 2070, all of which are at least 20 years old
Ambitious	Most aggressive decarbonization scenario	Ambitious energy intensity improvement of ~40% in diesel trucks	100% ZET sales by 2045	Ambitious decarbonized grid	Green hydrogen	Scrappage of 15-year old diesel trucks and avoid-and-shift in VKT by improvements in freight logistics

Table 17 presents the ZET sales shares, broken down by BETs and FCETs, assumed in the Zero ZET Penetration, India 2070 Net-Zero, and Ambitious scenarios.

Table 17 **ZET Sales in Zero ZET Penetration, India Net-Zero 2070, and Ambitious Scenario**⁵⁹

Year	Zero ZET Penetration			India Net-Zero 2070				Ambitious		
	BET Sales	FCET Sales	Cumulative CO2 Emissions	BET Sales	FCET Sales	Mitigated Emission wrt Zero ZET Penetration – With BAU Grid + Grey H ₂	Mitigated Emissions wrt Zero ZET Penetration – With Decarbonised Grid + Green H ₂	BET Sale	FCET Sale	Mitigated Emissions wrt Zero ZET Penetration
2020	0%	0%	180	0%	0%	0	0	0%	0%	0
2025	0%	0%	190	0%	0%	10	14	2%	1%	20
2030	0%	0%	210	2%	1%	32	35	24%	6%	55
2035	0%	0%	240	20%	5%	65	70	48%	12%	115
2040	0%	0%	275	40%	10%	115	130	72%	18%	215
2045	0%	0%	300	60%	15%	150	188	80%	20%	270

⁵⁸ Assessing the scale of zero-emission truck deployment required for meeting India's net-zero goal, ICCT, 2024

⁵⁹ Assessing the scale of zero-emission truck deployment required for meeting India's net-zero goal, ICCT, 2024

Zero ZET Penetration				India Net-Zero 2070				Ambitious		
Year	BET Sales	FCET Sales	Cumulative CO2 Emissions	BET Sales	FCET Sales	Mitigated Emission wrt Zero ZET Penetration – With BAU Grid + Grey H ₂	Mitigated Emissions wrt Zero ZET Penetration – With Decarbonised Grid + Green H ₂	BET Sale	FCET Sale	Mitigated Emissions wrt Zero ZET Penetration
2050	0%	0%	350	80%	20%	220	265	80%	20%	325
2055	0%	0%	375	80%	20%	265	325	80%	20%	353
2060	0%	0%	400	80%	20%	296	373	80%	20%	380
2065	0%	0%	425	80%	20%	323	400	80%	20%	407
2070	0%	0%	475	80%	20%	374	450	80%	20%	460

Note: Green cells represent 100% ZET sales share in the given years. All CO₂ Emissions value provided in MMT

WELL-TO-WHEEL CO2 EMISSIONS

Well-to-wheel (WTW) CO₂ emissions will change with variations in ZET penetration rates, relative shares of BETs and FCETs in future ZET deployment, relative shares of grey or green hydrogen used to fuel FCETs, and grid carbon intensity levels. Figure 22 illustrates CO₂ emissions from the formulated ZET projection scenarios. The Alternate Net-Zero 2070 scenario with BAU grid and grey hydrogen results in a 76% reduction by 2070, while the Net-Zero 2070 and Ambitious scenarios result in a 96% reduction by 2070.

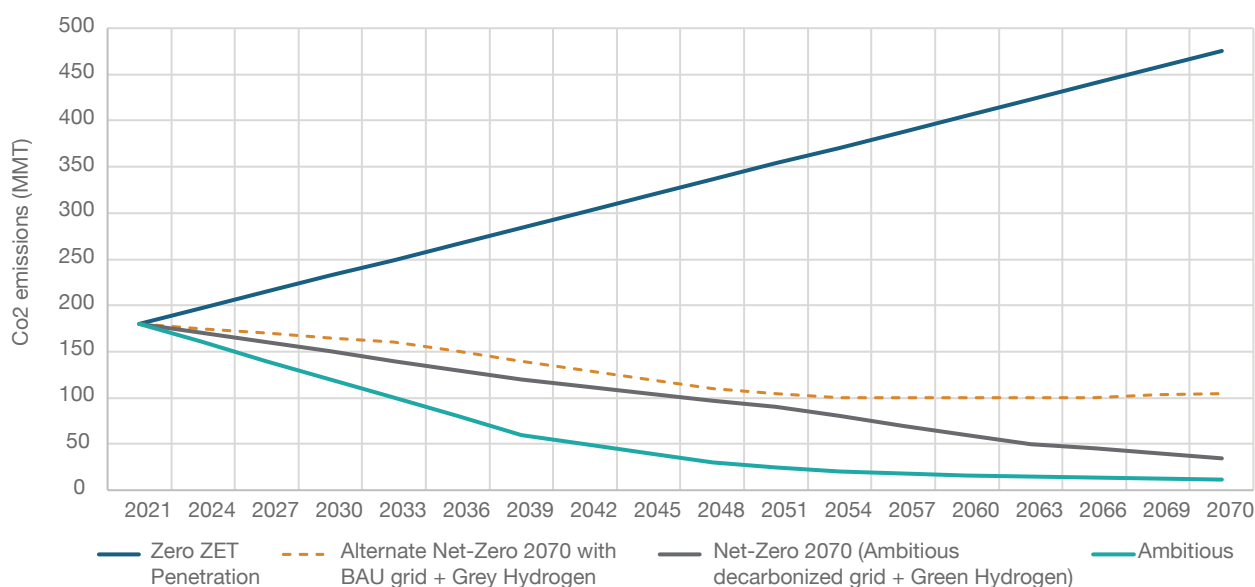


Figure 22 Annual WTW CO₂ emissions by Scenarios

To align with the 2070 net-zero target, India would need to achieve 100% ZET for new sales by no later than 2050. However, to align with a global pathway to limit the rise in temperature below 2 °C, ZET sales would need to be further accelerated to reach 30% by 2030 and 100% by 2045.

Using the on-road medium and heavy-duty truck share, their typical annual mileage accumulation and fuel consumption, the annual CO₂ emissions share of each application has been estimated, as represented in Figure 23. The manufacturing and agricultural sectors account for more than 50% of CO₂ emissions and therefore could be prioritized for electrification.

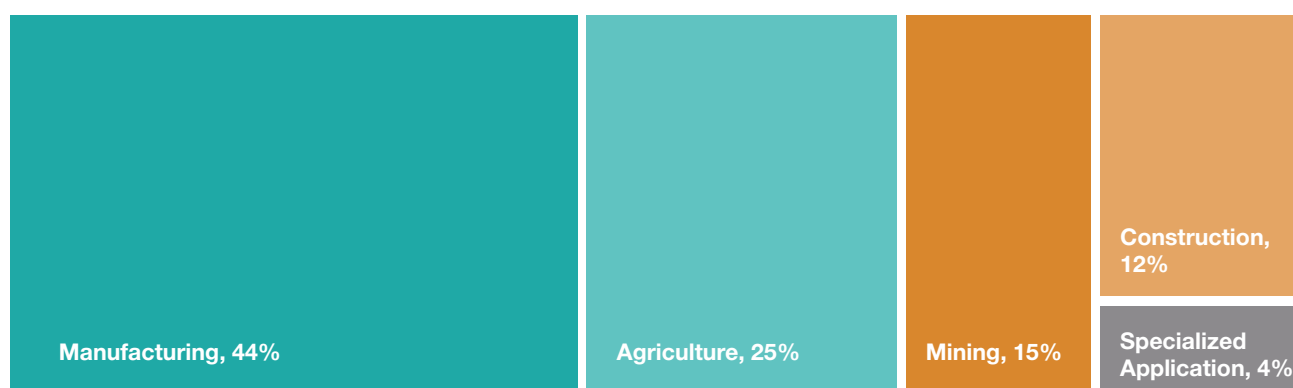


Figure 23 CO2 emission share of M&HDT – By Application⁶⁰

E-TRUCK ADOPTION BARRIER IN INDIA

ZET sales have been limited so far. The adoption of ZETs has been low because of barriers such as high upfront costs, limited vehicular models, range anxiety, limited policy support, and others. At present, EVs in the freight segment are used mainly for last-mile deliveries associated with e-commerce and hyperlocal deliveries – food, groceries, and other items. Figure 24 presents the key challenges with ZET adoption for logistics:

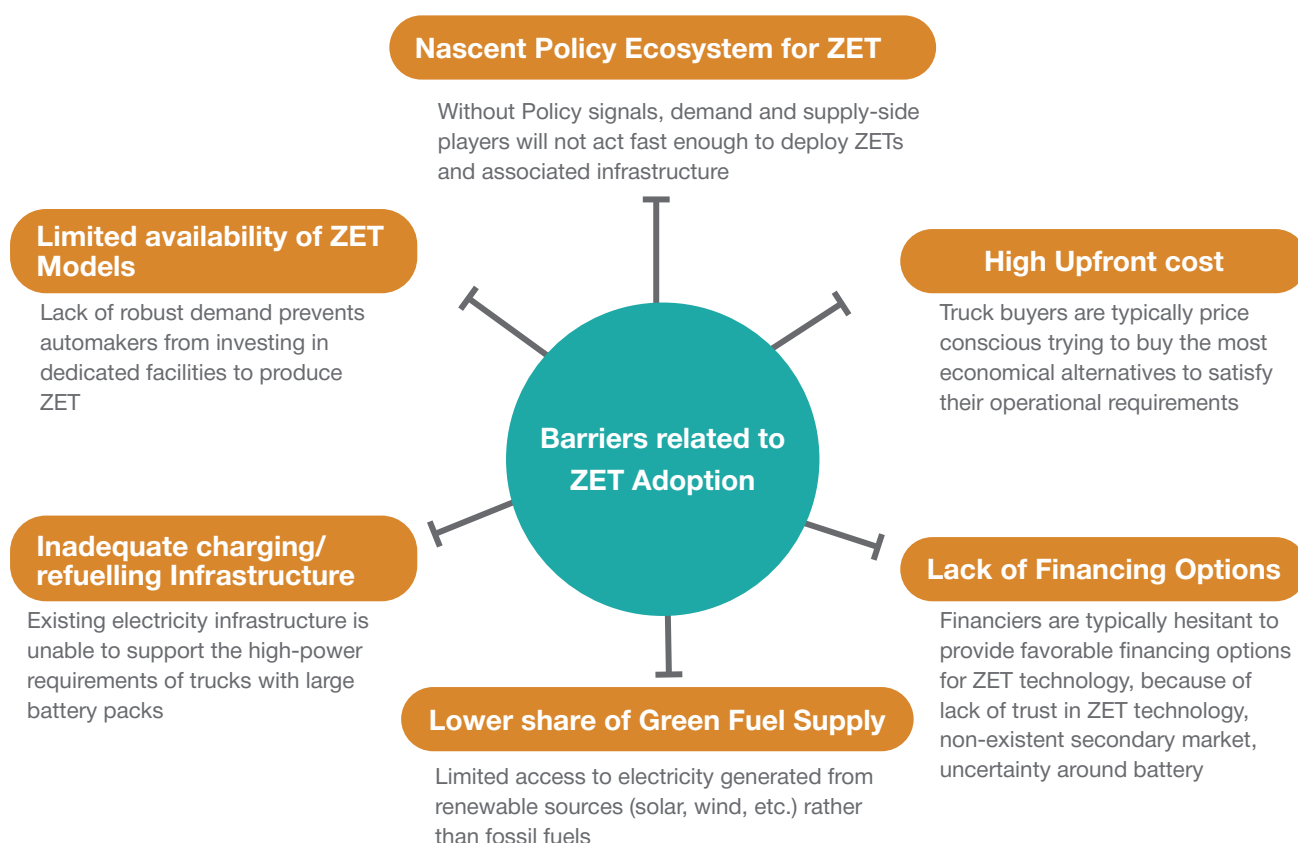


Figure 24 Challenges for adoption of ZETs

Although the transition to ZETs may present challenges, India can draw valuable lessons from other countries which have successfully shifted towards ZETs. *Chapter 6: Global Benchmarking of e-Truck Adoption* of the report highlights these lessons.

⁶⁰ Data interpreted from Early Market Outlook Report, Climate Group, 2022

Key takeaways:

1

The e-truck market in India has shown stagnant growth from 2014 to 2023, with less than 250 units sold annually. However, a significant surge is projected for 2025 with over 500 units expected to be sold, marking a turning point driven by enhanced government policies, improved technology, and growing environmental awareness.

2

The e-truck ecosystem is rapidly evolving with numerous pilot initiatives and planned projects. Key partnerships between OEMs and demand-side companies are emerging to support the electrification transition. Notable projects include Volvo Eicher's collaboration with Amazon, Adani Group's order from BYD, and JSW Cement's pilot with Murugappa Group, among others.

3

Key barriers to ZET adoption include high upfront costs, limited vehicle models, range anxiety, and limited policy support. Current EV usage in the freight segment is mainly for last-mile deliveries.

6. Global Benchmarking of e-Truck Adoption

As various countries and regions strive to achieve goals to reduce greenhouse gas emissions, improve air quality, and promote sustainable transportation, they have implemented a range of innovative practices and policies to support the adoption and integration of e-trucks into their transportation systems.

This section explores the best practices for e-truck adoption across the United States, Europe, and China—three leading regions in this field. The majority of e-Truck registrations and sales are concentrated in these three regions. Out of 54,000 e-trucks sold worldwide in 2023, China holds the majority of sales (~70%), amounting to 38,200, followed by Europe and the US, as shown in Figure 26.⁶¹ In Europe, e-truck sales nearly tripled in 2023, surpassing 10,000 units and accounting for over 1.5% of total sales. Similarly, the United States experienced a threefold increase in e-Truck sales, though the total reached only 1,200 units, making up less than 0.1% of total truck sales.

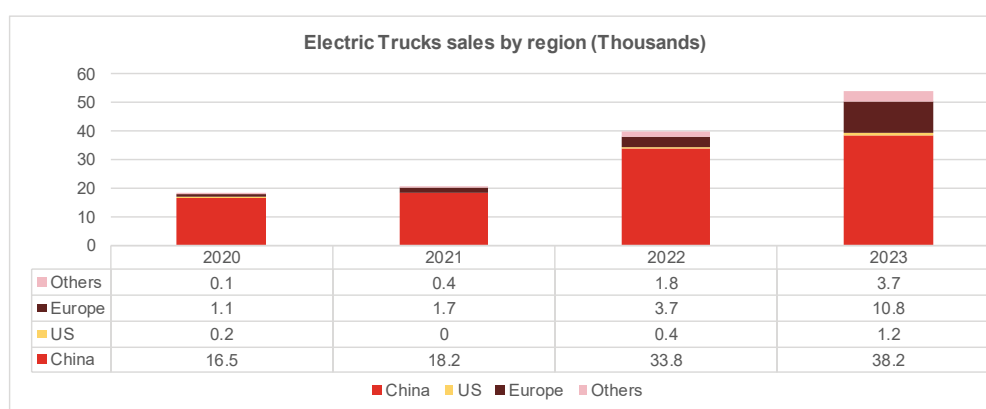


Figure 25 e-Trucks sales by region in 2023 (Thousands)

These regions are at the forefront of introducing various initiatives to boost the adoption of e-trucks. In the United States, efforts have been made to utilize demonstration projects to pinpoint truck segments suitable for electrification. In June 2023, the North American Council for Freight Efficiency, in collaboration with the Rocky Mountain Institute, initiated Run on Less – Electric DEPOT. This initiative involved deploying nearly 300 e-trucks of different sizes at various depots to collect telemetry data. The goal was to identify scenarios where e-trucks are already practical and to determine where challenges still exist. Similarly, the UK Government is committing USD 250 million to the Zero Emission HGV and Infrastructure Programme to conduct real-world trials of ZET. This initiative will roll out 370 trucks and establish nearly 60 refueling and electric charging stations.

A scenario-based approach can be used to explore the outlook for e-mobility, based on recent market trends, policy drivers, and technology developments. The projections in the Stated Policies Scenario (STEPS) and the Announced Pledges Scenario (APS) take into account historical data up to the end of 2023, as well as stated policies and ambitions as of March 2024. The Net Zero Emissions by 2050 Scenario (NZE Scenario) aligns with the 2023 update to the IEA Net Zero Roadmap and the World Energy Outlook 2023.

The Stated Policies Scenario (STEPS) incorporates existing policies and measures, along with firm policy ambitions and objectives that have been enacted by governments globally. It encompasses current policies, regulations, and investments related to EVs, as well as market trends based on anticipated impacts of technological advancements, announced deployments, and plans from industry stakeholders. The Announced Pledges Scenario (APS) assumes that all announced ambitions and targets set by governments worldwide are fully achieved on schedule. Concerning electromobility, it incorporates all recent major announcements of

⁶¹ <https://www.iea.org/reports/global-ev-outlook-2024/trends-in-electric-heavy-duty-vehicles>

electrification targets and long-term net zero emissions commitments, as well as other pledges, regardless of whether these have been formalized in legislation or updated Nationally Determined Contributions. The Net Zero Emissions by 2050 Scenario (NZE Scenario) is a prescriptive pathway outlining a feasible yet challenging route for the global energy sector to achieve net zero CO₂ emissions by 2050.

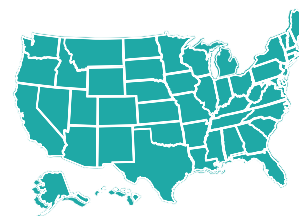
Recent emissions standards in the United States and the European Union are expected to bolster e-HDV adoption in the coming years. In the Stated Policies Scenario (STEPS), sales are projected to increase more than 30-fold by 2035, starting from around 54,000 units in 2023. Consequently, over 20% of medium- and heavy-duty truck sales are anticipated to be electric by 2035.

At COP28, six additional countries joined the Global Memorandum of Understanding on Zero-Emission Medium- and Heavy-Duty Vehicles (Global MOU), bringing the total to 33 nations committed to achieving 100% zero-emission sales by 2040 and 30% by 2030. Collectively, these countries currently account for nearly 25% of the global medium- and heavy-duty truck market. This commitment is expected to push the global e-truck sales share in the Announced Pledges Scenario (APS) to nearly 30% by 2035.

In the Net Zero Emissions by 2050 Scenario (NZE Scenario), e-truck sales are projected to exceed 55% of total M&HDT sales by 2035.⁶² By examining their approaches, we can gain valuable insights into the strategies that have proven effective. These insights can serve as a guide for India looking to enhance its own e-truck initiatives and contribute to a more sustainable future.

USA

The trucking industry is crucial to the U.S. economy, serving as the backbone of logistics and transportation. It supports commerce by moving nearly three-quarters of the nation's freight and employs approximately 8.4 million people, generating over \$940 billion in annual revenue.⁶³



The truck stock is primarily comprised of three segments, with heavy-duty trucks being the most prevalent, totaling approximately 5.1 million vehicles. Following heavy-duty trucks are cargo vans and medium-duty trucks, with around 3.7 million and 3.6 million vehicles, respectively. Together, these three segments constitute about 97% of all truck registrations in the U.S.⁶⁴ In U.S. convention, Class 4-6 trucks are considered medium-duty trucks with a GVW ranging from 10,001 to 26,000 pounds (4,536-11,793 kg), whereas Class 7-8 are considered heavy-duty trucks with a GVW more than 26,001 pounds (11,794 kg).⁶⁵

At present, more than 160 models of zero-emission trucks are available from more than 40 OEMs in the U.S. These ZET trucks include various categories of vehicles like cargo vans, medium-duty step vans, medium-duty trucks, heavy-duty trucks, refuse trucks, and yard tractors. As of June 2023, more than 17,500 ZETs were present on U.S. roads. Out of 17,500+ ZETs, medium-duty and heavy-duty trucks numbered 442 and 867, respectively.⁶⁶ The ZET market share out of total stocks of trucks for medium-duty and heavy-duty comes to 0.01% and 0.02%, respectively. The U.S. aims to achieve 30% zero-emission truck sales in 2030 and 100% in 2040.⁶⁷

Table 18 Learnings from the case study of USA

S.No	Parameters ⁶⁸	Best Practices
1	Increased Model availability from OEMs	The number of available models in medium-duty and heavy-duty trucks increased from ~60 to ~160 from more than 40 OEMs in a span of 3 years (2021-2024)

⁶² <https://www.iea.org/reports/global-ev-outlook-2024/trends-in-heavy-electric-vehicles>

⁶³ https://calstart.org/wp-content/uploads/2024/01/ZIO-ZET-2024_010924_Final.pdf

⁶⁴ https://calstart.org/wp-content/uploads/2024/01/ZIO-ZET-2024_010924_Final.pdf

⁶⁵ <https://www.badgertruck.com/heavy-truck-information/truck-classification/#:~:text=In%20the%20U.S.%2C%20trucks%20are,8%20are%20considered%20heavy%2Dduty.>

⁶⁶ https://calstart.org/wp-content/uploads/2024/01/ZIO-ZET-2024_010924_Final.pdf

⁶⁷ <https://theicct.org/biden-electric-trucks-nov22/>

⁶⁸ https://calstart.org/wp-content/uploads/2024/01/ZIO-ZET-2024_010924_Final.pdf

S.No	Parameters ⁶⁸	Best Practices
2	Policy Initiatives	- Advanced Clean Trucks (ACT) - This rule requires truck manufacturers to sell an increasing number of ZETs as a percentage of their overall truck sales. California, along with 7 other states, had adopted ACT as of June 2023⁶⁹ - Advanced Clean Fleets (ACF) – This regulation requires large fleets with operations to deploy an increasing number of ZETs as a proportion of their overall fleet. California adopted this in April 2023. This regulation targets 1,690,000 ZEVs in the California fleet by 2050⁷⁰
3	Fiscal Incentives for ZETs	- At the national level, the Inflation Reduction Act authorized commercial clean vehicle credit helps cover the incremental cost of ZETs by providing a credit of up to \$40,000 per truck⁷¹ - At the state level, various incentive programs have been deployed to accelerate the adoption of ZETs, along with funding for charging or refueling infrastructure. Fifteen medium- and heavy-duty truck incentives are available across 10 states
4	Robust battery supply chains	- To decrease battery prices and ensure a smooth supply chain, OEMs are forming partnerships. Accelerate by Cummins, Daimler Truck, and PACCAR announced a joint venture to advance battery cell production in the U.S. - Inflation Reduction Act funded subsidies for new U.S. battery manufacturing are available via the Advanced Manufacturing Production Credit. These credits offer \$35 per kWh of capacity for battery cells and \$10 per kWh for battery packs
5	Focus on Charging Infrastructure	- ZET OEMs are investing in public charging. Volvo and Pilot Company announced a partnership to deploy truck charging at select locations. - Volvo also partnered with Volvo Financial Services, Volvo Technology of America, Shell Recharge Solutions, and others to develop a publicly accessible ZET charging network connecting several of California's largest metropolitan areas - Daimler Trucks North America partnered with NextEra Energy Resources and BlackRock to launch Greenlane, a \$650 million JV to operate a U.S. nationwide high-performance ZE public charging network for MHD battery EVs - Numerous electric utility companies offer incentives/rebates to support electric transportation charging through their "make-ready" program. For example, Alabama Power (a company in the Southern United States which provides electricity to 1.4 million customers in the southern two-thirds of Alabama) provides a rebate of a minimum of \$5,000 for a 20kW charging port and a maximum rebate of \$20,000 for a 150 kW DC fast charger⁷²
6	Increased support for small fleets	- To support small fleet owners in the ZET transition, governments have created special fleet assistance programs like Cal Fleet Advisor and Mass Fleet Advisor to provide technical assistance, including education on vehicles, refueling, and regulations, which will guide small owners to correct resources - Incentives are also available for small fleets. California's Clean Truck and Bus Voucher Incentive Project has a special program known as Innovative Small E-Fleet (ISEF) program, which allows fleets with fewer than 20 trucks to access flexible financing, lease, rental, and packaged Trucks as a Service options that include enhanced incentives

69 <https://ww2.arb.ca.gov/our-work/programs/advanced-clean-trucks>

70 <https://ww2.arb.ca.gov/our-work/programs/advanced-clean-fleets/about>

71 <https://www.irs.gov/credits-deductions/commercial-clean-vehicle-credit>

72 <https://www.alabamapower.com/business/business-customers-and-services/electric-transportation-business-programs/make-ready-program.html#:~:text=Alabama%20Power's%20Make%20Ready%20Program,electric%20chargers%20at%20their%20facilities.>

S.No	Parameters ⁶⁸	Best Practices
7	As-a-service model	- Truck-as-a-Service: Volvo Trucks North America and Volvo Financial Services have launched “Volvo on Demand,” introducing the Truck-as-a-Service (TaaS) model. It features 25 Class 8 Volvo VNR e-trucks and offers flexible leasing starting at 12 months. The program includes Volvo Trucks’ Gold Contract, optional bundled insurance, route planning, charging solutions guidance, and incentives consultation. - Fleet-as-a-service (FaaS): Private companies like Zeem⁷³ and Einride⁷⁴ offers FaaS providing all-inclusive and comprehensive solutions for fleet management and transportation needs
8	Equity and Accessibility Initiatives	- Targeted Funding for Disadvantaged Communities: California’s Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP) allocates specific funds for trucks operating in disadvantaged communities, ensuring these areas benefit from cleaner air and reduced emissions. - Environmental Justice Considerations: Programs like HVIP prioritize equity by supporting ZET adoption in communities disproportionately affected by pollution. This aligns with broader state goals to improve public health and environmental outcomes in underserved areas. - Community Engagement and Support: Initiatives may include community consultation and partnerships with local organizations to ensure that the deployment of zero-emission technologies meets the needs of disadvantaged populations and supports local economic development.

EUROPE

In Europe, e-truck sales amounted to more than 10,000, which is approximately 3 times that of the previous year 2022. European OEMs offer the largest proportion of heavy-duty trucks, accounting for over 20% of all models. This dominance has enabled European OEMs, especially the Volvo group (which encompasses the Mack, Renault, and Dongfeng (joint venture) truck brands), to secure a substantial share of the heavy-duty e-truck market in both Europe and North America. Additionally, European OEMs manufacture a considerable number of specialized vehicles like refuse trucks, which represent about 10% of all models. These niche vehicles, similar to medium-duty trucks, are already cost-competitive with their internal combustion engine (ICE) counterparts.⁷⁵



Table 19 **Learnings from the case study of Europe**

S.No	Parameters	Best Practices
1	Fiscal Incentives for ZETs	- Various members of EU including Austria, Belgium, Croatia among others offer monetary rebates/incentives for M&HDT⁷⁶ - Tax benefits are also offered to push for adoption of e-trucks and related infrastructure which includes reduction in VAT for electricity consumption, reducing depreciation period for charging stations from 10 years to 5 years as well as accelerated depreciation for EVs, no registration tax on e-trucks⁷⁷

⁷³ <https://www.zeemsolutions.com/>

⁷⁴ <https://einride.tech/>

⁷⁵ <https://www.iea.org/reports/global-ev-outlook-2024/trends-in-heavy-electric-vehicles>

⁷⁶ https://www.acea.auto/files/Zero-emission-commercial-vehicles-Tax-benefits-purchase-incentives_2024.pdf

⁷⁷ https://www.acea.auto/files/Zero-emission-commercial-vehicles-Tax-benefits-purchase-incentives_2024.pdf

S.No	Parameters	Best Practices
2	Aggregating demand for ZETs	Fleet Electrification coalition (FEC) was launched by Smart Freight Centre and Calstart which aims to speed up large-scale e-truck deployment by leveraging the power of demand aggregation to capitalize on a single high-value order to obtain vehicle unit discounts and other offers from OEMs. This launch was underpinned by the announcement of the signaling for demand for more than 60,000 battery-e-HDT in the United States and Europe by 2030⁷⁸
3	As-a-service model	- Truck-as-a-service (TaaS): NEoT Green Mobility has partnered with Volta Trucks to develop customer funding solutions, with an ambition to finance up to 2,000 trucks from 2023. The funding will enable Volta Trucks to offer customers a wide range of financing solutions for the all-electric Volta Zero through the company's TaaS offering ⁷⁹ - Scania and Sennder establish JUNA, a joint venture to drive large-scale e-truck adoption introduced a pay-per-use model that provides transport companies with access to e-truck solutions and guaranteed capacity⁸⁰ - Fleet-as-a-service (FaaS): Private companies like Zeem and Einride offer FaaS providing all-inclusive and comprehensive solutions for fleet management and transportation needs
4	Focus on Charging Infrastructure	European commission allocated €1 billion for recharging and refuelling points under the Connecting Europe Facility (CEF) in which support will be provided for establishing charging stations for EVs and for megawatt recharging stations for heavy-duty vehicles⁸¹

CHINA

For years, China has led the world in the production and adoption of zero-emission heavy-duty vehicles (ZE-HDVs). China remains the largest market for e-trucks, representing 70% of global sales in 2023. However, the share decreased from 85% in 2022 to 70% in 2023. Chinese OEMs are currently the leading producers of battery e-HDV models, totaling 430, with a strong emphasis on buses designed for urban public transport, which constitute nearly 40% of all models.



Chinese OEMs have introduced approximately 40 new models each for medium-duty and heavy-duty trucks, expanding the variety and applications in the market. The number of new truck models has continued to rise, facilitating broader electrification. A substantial number of models is now available across segments in China. The top 5 OEMs in the truck segment include —Dongfeng, Geely, Foton, SAIC, and Sany.

⁷⁸ <https://www.smartfreightcentre.org/en/about-sfc/news/smart-freight-centre-leading-global-companies-unite-to-propel-electric-truck/>

⁷⁹ <https://www.neotcapital.com/en/ngm-has-partnered-with-volta-trucks-at-the-forefront-of-the-all-electric-trucks-industry-to-develop-a-turnkey-truck-as-a-service-solution-in-order-to-accelerate-the-decarbonation-of-logistics-fleet/>

⁸⁰ <https://www.scania.com/group/en/home/newsroom/press-releases/press-release-detail-page.html/4675185-scania-and-sennder-establish-juna--a-joint-venture-to-drive-large-scale-electric-truck-adoption-and->

⁸¹ https://transport.ec.europa.eu/news-events/news/commission-makes-eu1bn-available-recharging-and-refuelling-points-under-connecting-europe-facility-2024-02-29_en

Table 20 Learnings from the case study of China

S.No	Current Trends	Description
1	Battery Swapping	The share of swap-capable vehicles in China's e-truck sales has been increasing. In 2022, 49.5% of the e-trucks sold in China were swap capable. These swap-capable e-trucks are mainly used for short-haul applications at ports, mining sites and in urban logistics. They are typically equipped with a 141 kWh or 282 kWh battery and have a typical one-way trip length of less than 100 km⁸²
2	Fiscal Incentives	Purchase subsidies for e-trucks which included a maximum subsidy of 28,000 yuan per vehicle for e-trucks. However, these subsidies were valid till end of 2022. New EVs purchased by 31st December 2025 are exempted and new EVs bought between 1 January 2026 and 31 December 2027 have purchase tax reduced by half⁸³
3	Policy Initiatives	- Cities in China like Shanghai offer free license plates for EVs⁸⁴ - Cities such as Shenzhen, Dongguan, Hangzhou among others only allow e-trucks to enter low emission zones and city centers where diesel trucks are banned from entering low emission zones⁸⁵

LEARNING & TAKEAWAYS

The global transition towards e-trucks is driven by the urgent need to reduce emissions, enhance energy efficiency, and achieve sustainable transportation solutions. By examining the best practices in the United States, Europe, and China, several critical insights and patterns emerge that can inform and inspire further adoption of e-trucks worldwide. This section synthesizes the key learnings from these regions, offering valuable lessons for policymakers, manufacturers, and stakeholders in the transportation industry.

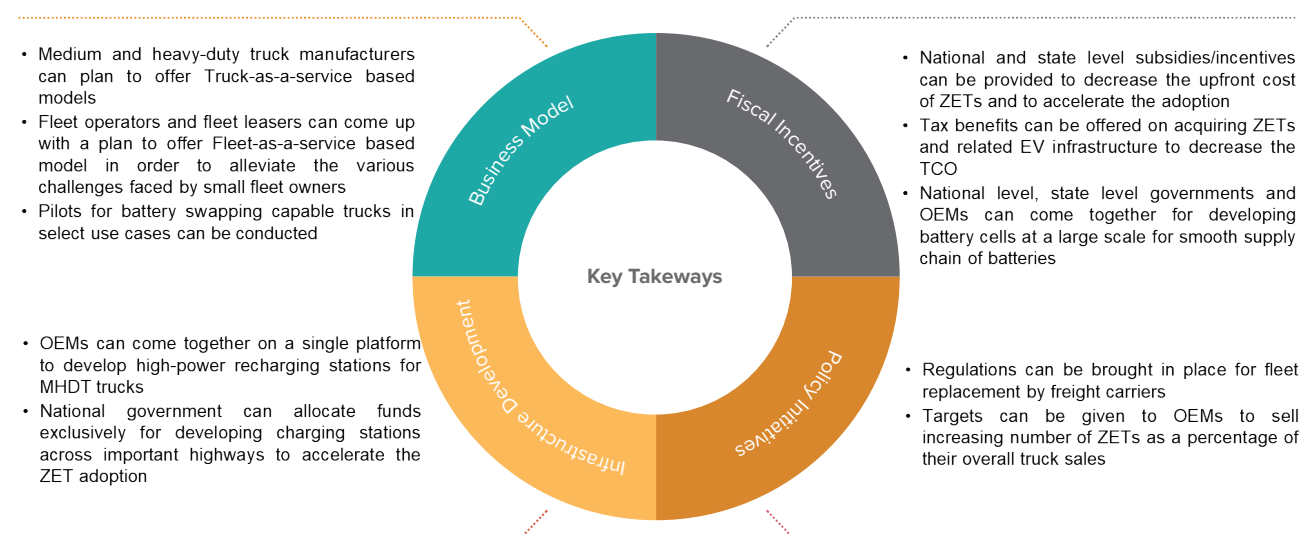


Figure 26: Key Takeaways from Global Case studies

⁸² <https://theicct.org/china-is-propelling-its-electric-truck-market-aug23/>

⁸³ <https://dialogue.earth/en/business/life-after-subsidies-for-chinas-evs/#:~:text=More%20than%20200%20billion%20yuan,support%20and%20subsidies%20have%20declined.>

⁸⁴ <https://cnevpost.com/2023/12/15/shanghai-to-continue-offering-free-license-plates-for-bevs-2024/>

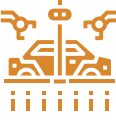
⁸⁵ <https://www.wri.org/insights/zero-emission-zones-lessons-cities>

7. ZET Adoption Opportunities: Segment and Use case View

The transition to EVs in the passenger segment has already begun, and it is expected that the early adoption of e-M&HDTs will also be driven by specific use cases. As elaborated in *Section 2.1 Truck Segmentation*, there is a wide range of use cases for trucks in India, each with its own unique functional and operational characteristics. For instance, urban parcel delivery trucks typically have shorter routes, fixed routes, reliable road terrains and lower payload capacity, which makes them ideal candidates for electrification. On the other hand, long-haul market load applications used for inter-city freight transport require a higher payload capacity and the ability to travel longer distances, which can be more challenging to achieve with current battery technology. Restating the usage characteristics of typical truck applications as shown in Table 21.

Table 21: Usage Characteristics of typical truck applications in India⁸⁶

Application		Payload Characteristics	Distance per trip (km)	Speed	Corporate / Government Influence	Overloading Propensity
 Agriculture	Market Load	- Carries irregular shape of goods packages - Performs long-haul trip - Mixed density payload	500 – 600	Medium: 40-60 kmph	High	Moderate
	Vegetable & Fruits	- Deteriorates over a short time - Mix payload, time sensitive transportation - Perishable & fragile	200 – 250	High: 50-60 kmph	Low	Low
	Fish	- Decay if not kept insulated or frozen - Mix Payload - Perishable & fragile	200 – 250	High: 50-60 kmph	Low	Moderate
	Edible Oil	- Mobile bulk container used to transport wholesale - Compliance with food safety, hygiene, and packaging regulations - May require temperature control measures	300 – 400	Medium: 45-55 kmph	Medium	Low
	Fertilizer*	- Requires protection from moisture and environmental factors - High-density materials - Seasonal transportation	Information not found			
	Coal & Minerals	Only used between mineral/quarry to bulk transportation centers	100 – 120	Low: 20-25 kmph	Medium	Low
 Mining	Iron Ore	Short haul trips				

Application		Payload Characteristics	Distance per trip (km)	Speed	Corporate / Government Influence	Overloading Propensity
 Construction	Cement & Clinker	- Only used between mineral/quarry to bulk transportation centers - Short haul trips	150 – 170	Low: 20-30 kmph	Low	Low
	Iron & Steel	- Generally medium to long haul trips - Carries steel rolls, plates, sections and finished products (less volume, more weight)	300 – 350	Low: 20-30 kmph	Medium	High
	Water Tanker	Permanently mounted tank for transporting water	100 – 120	Low: 20-35 kmph	Low	High
	RMC*	- Limited workable time - High-density material necessitates robust vehicles - Skilled drivers and advanced navigation	Information not found			
 Manufacturing	Container*	- Carries Mixed Cargo Types - High Density Payload - Have Standardized Dimensions	Information not found			
	Automotive*	- High Value load - Range from Varied Sizes and Weights - Requires Just-In-Time Delivery	Information not found			
	FMCG	- Mixed Density Payload - Regular Shape of Packages - Temperature Control	500 – 600	Medium: 40-60 kmph	High	Moderate
	e-Commerce	- Carries regular shape of goods packages - Performs long-haul trip - Mixed density payload	500 – 600	Medium: 40-60 kmph	High	Low
	Pharma*	- Requires specialized handling and transportation solutions to ensure the safety, efficacy, and compliance of the products - Perform medium-haul trip	Information not found			
 Specialized Application	Garbage	- Construction material/waste handling - Generally short haul trips	100 – 150	Low: 20-30 kmph	Low	Low
	Petroleum	- Designed specifically for transport petroleum products in bulk - Highly regulated, dangerous and hence no overloading - Unloaded trips are common on the return	180 – 200	Medium: 45-55 kmph	High	Low
	LPG	Transports goods from distributor to end-user (short and medium haul trips)	200 – 250	Medium: 45-60 kmph	High	High

* Excluded from further assessment because no data was found

Therefore, it will be important to adopt a phase-wise e-M&HDT adoption strategy, recognizing that not all truck segments can be electrified immediately. Instead, it is important to identify the truck applications that are most feasible now, focus immediate policy and investment efforts there, and develop a strategy for scaling technology over time to more challenging applications and segments

ELECTRIFICATION FAVORABILITY FRAMEWORK⁸⁷

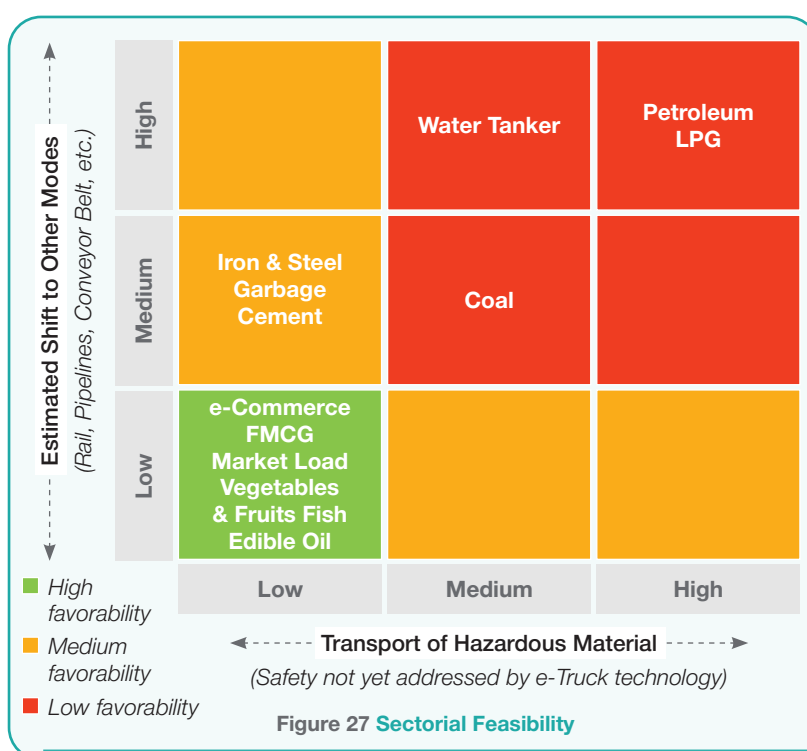
To successfully transition to e-M&HDTs in India, it is imperative to adopt a phase-wise strategy that prioritizes use cases based on various operational and functional characteristics. Given the nascent stage of e-trucks, we are required to shortlist the use cases that can be electrified in the near future. Hence, our approach involves first discounting infeasible use cases and then prioritizing the remaining ones. This approach enables fleet operators, policymakers, and other stakeholders to focus their resources and investments on areas with the most significant impact.

STEP 1: DISCOUNT INFEASIBLE USE CASE

In the transition to e-M&HDTs, certain use cases are infeasible due to their inherent requirements and the current limitations of EV technology. These use cases are characterized by their high potential to shift to other modes of transport (other than trucks) and/or involve the transportation of hazardous materials or face other significant constraints. Therefore, they are eliminated from consideration for truck electrification.

Petroleum and LPG: Eliminated due to high safety and regulatory constraints and potential for shift to pipelines.

Coal and Water Tankers⁸⁸: Estimated to experience a significant shift to other transport modes, such as rail, pipelines, and conveyor belts, which are more suitable for bulk and heavy cargo. Additionally, they involve medium levels of hazardous material transport.



By eliminating these infeasible use cases, we can focus on applications where the transition to e-M&HDTs is more practical and impactful. This targeted approach ensures that resources and efforts are directed towards use cases that are more likely to benefit from electrification, thereby facilitating a smoother and more effective transition.

STEP 2: PRIORITIZE FEASIBLE USE CASES

For the remaining use cases, to prioritize the applications with potential for high impact and commercial success for the electrification of freight in India, the following Electrification Favorability Framework has been developed. This framework, as shown in Table 21, systematically evaluates the readiness and potential benefits of electrification for each application, ensuring that resources are directed towards the most impactful and feasible applications.

⁸⁷ As stated in Chapter 3, Fertilizer, RMC, Container, Automotive and Pharma Trucking use case are excluded from further assessment *because no data was found*

⁸⁸ High Center of Gravity: Water tankers have a high center of gravity, making them more susceptible to tipping over, especially on sharp turns or uneven roads
 Sloshing Effect: The movement of water inside the tanker, known as the sloshing effect, destabilizes the vehicle. This is particularly problematic when the tanker is partially filled, as the water can move freely and shift the load, affecting balance and handling.
 Overloading: Water tankers often face overloading, which strains the braking system and suspension, making the vehicle harder to control and increasing the likelihood of accidents.

Table 22 e-M&HDT Transition Favorability Framework

Parameters		Description
Indicative Technical Feasibility	Technological Readiness	Evaluate the availability and maturity of EV technology for each segment. Some sectors may already have viable e-M&HDT options, while others may still be in the development phase.
	Infrastructure Requirements	Assess the existing infrastructure and the need for new charging stations, maintenance facilities, and other support systems.
Operational Certainty	Route Predictability	Segments with predictable routes and fixed schedules (like parcel/FMCG) are easier to electrify because charging can be planned more effectively.
	Range Requirements	Consider the daily range requirements of each segment. Sectors with shorter routes or more centralized operations may be more suitable for early electrification.
	Operational Flexibility	Evaluate the flexibility of schedules and operations in each segment. Segments with adaptable schedules can accommodate varying charging times and locations, enhancing the feasibility of EV integration.
Social Impact	Emission Reduction Potential	Prioritize segments that operate in densely populated areas, as reducing emissions in these regions can have significant public health benefits.
	Job Creation and Skill Development	Consider the potential for creating new jobs and the need for workforce training in maintaining and operating e-M&HDTs.
Scalability and Replicability	Pilot Projects	Identify segments which fall under the formal sector and where pilot projects can be easily scaled up and replicated in other regions or sectors.
	Partnership Opportunities	Look for opportunities to collaborate with industry stakeholders, technology providers, and local governments to support large-scale electrification efforts.

PARAMETER 1: INDICATIVE TECHNICAL FEASIBILITY

Using the e-M&HDT systems sized for technical feasibility, the commercial feasibility is assessed by comparing the total cost of operation per km for e-M&HDTs versus diesel vehicles. A few key assumptions are summarized in Table 22.

Table 22 Key assumptions for TCO analysis

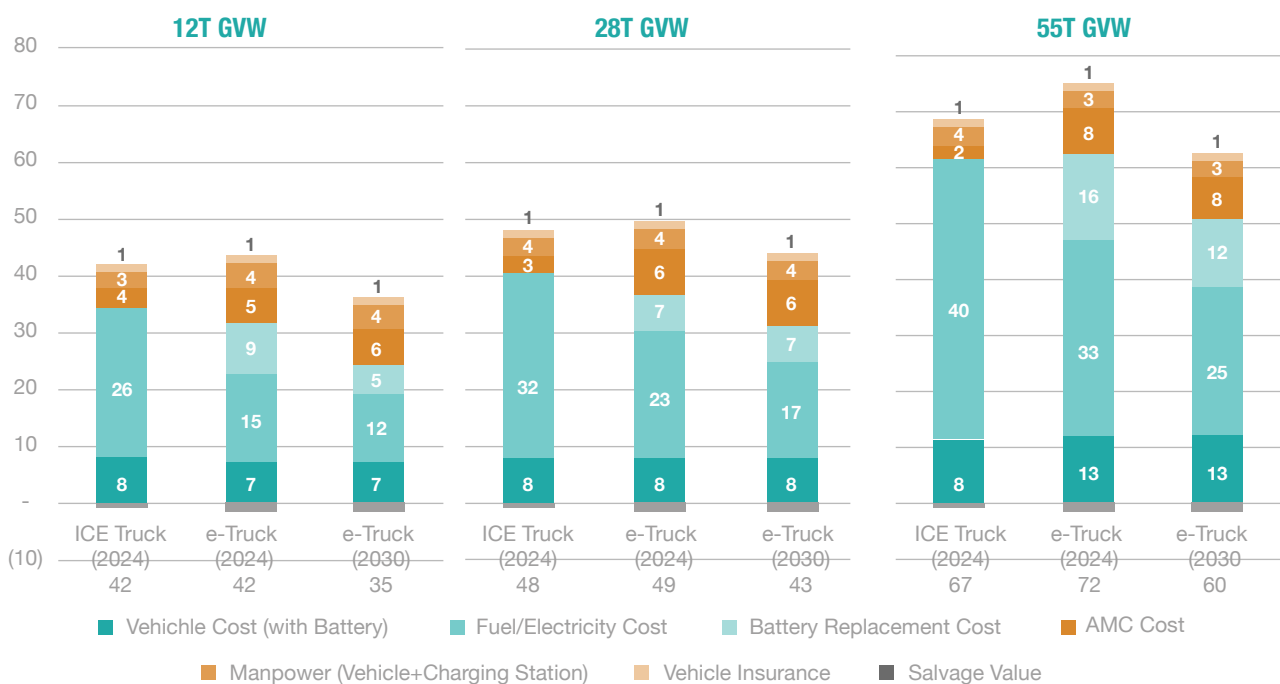
	Diesel			Electric		
	12 T	28 T	55 T	12 T	28 T	55 T
Model	Ashok Leyland Ecomet 1215 HE Truck star-rate 3.5	Tata Signa 2818.T	Ashok Leyland 5525 6x4	Ashok Leyland Boss 1218 EV Truck	Tata Prima E.28K Electric Tipper	IPL Tech Rhino 5536e
Period of Analysis [years]	15	15	15	15	15	15
Truck Purchase Cost / Ex-showroom price [₹100,000 INR]	24.5	30	44.5	26.1	33.1	66.75
Road Tax Component	RTO & Registration: 15% of Ex-showroom price Hypothecation & Number Plate: 2% of Ex-showroom price GST: 18% of Ex-showroom price for ICEV & 5% of Ex-showroom price for EV					
Battery Cost [INR/kWh]	-			2024: 16,000 INR/kWh ⁸⁹ 2030: 5,270 INR/kWh ⁹⁰		

89 Industry Consultation, 2024

90 BloombergNEF – Lithium-ion Battery Price Outlook

		Diesel			Electric		
		12 T	28 T	55 T	12 T	28 T	55 T
Fuel Cost [INR/L] & Charging-as-a-Service Cost [INR/kWh]		90			2024: 22 INR/kWh ⁹¹ 2030: 16.5 INR/kWh ⁹² (due to RE mix in Grid)		
Fuel Efficiencies [km/100 liters or km/100 kWh]		345	278	179	143	97	67
Maintenance Cost [INR/km]		3.00	3.50	3.50	6.00	8.00	8.00
Daily Distance Traveled [kms/day]	Vegetables, Fruits & Fish	250	-	-	250	-	-
	Garbage	250	-	-	250	-	-
	e-Commerce	400	-	-	400	-	-
	FMCG & Market Load	350	-	-	350	-	-
	Cement	-	400	-	-	400	-
	Edible Oil	-	350	-	-	350	-
	Iron & Steel	-	-	350	-	-	350
Insurance [% of truck cost]		2%	2%	2%	2%	2%	2%
Driver Cost [INR/month]		20,000			25,000		
Interest Rate (%)		10%			10%		
Vehicle Salvage Value (%)		10%			10%		
Battery Salvage Value (%)		-			20%		

The results are presented in Figure 27.



⁹¹ Article on - The Cost of Charging an Electric Car in India

⁹² Solar power cost will fall to Rs 1.9 per unit in India by 2030: TERI study

The estimated TCO analysis for e-M&HDTs compared to ICE trucks reveals that, as of 2024, e-M&HDTs have a slightly higher TCO. Specifically, the 55T GVW segment shows a more significant cost difference compared to its ICE counterpart than the 12T GVW and 28T GVW segments, which exhibit only slight differences. This analysis highlights the varying degrees of TCO parity across different GVW categories, indicating that while smaller e-M&HDTs are approaching cost parity with ICE trucks, larger e-M&HDTs still face notable financial gaps, primarily due to higher initial purchase and battery costs.



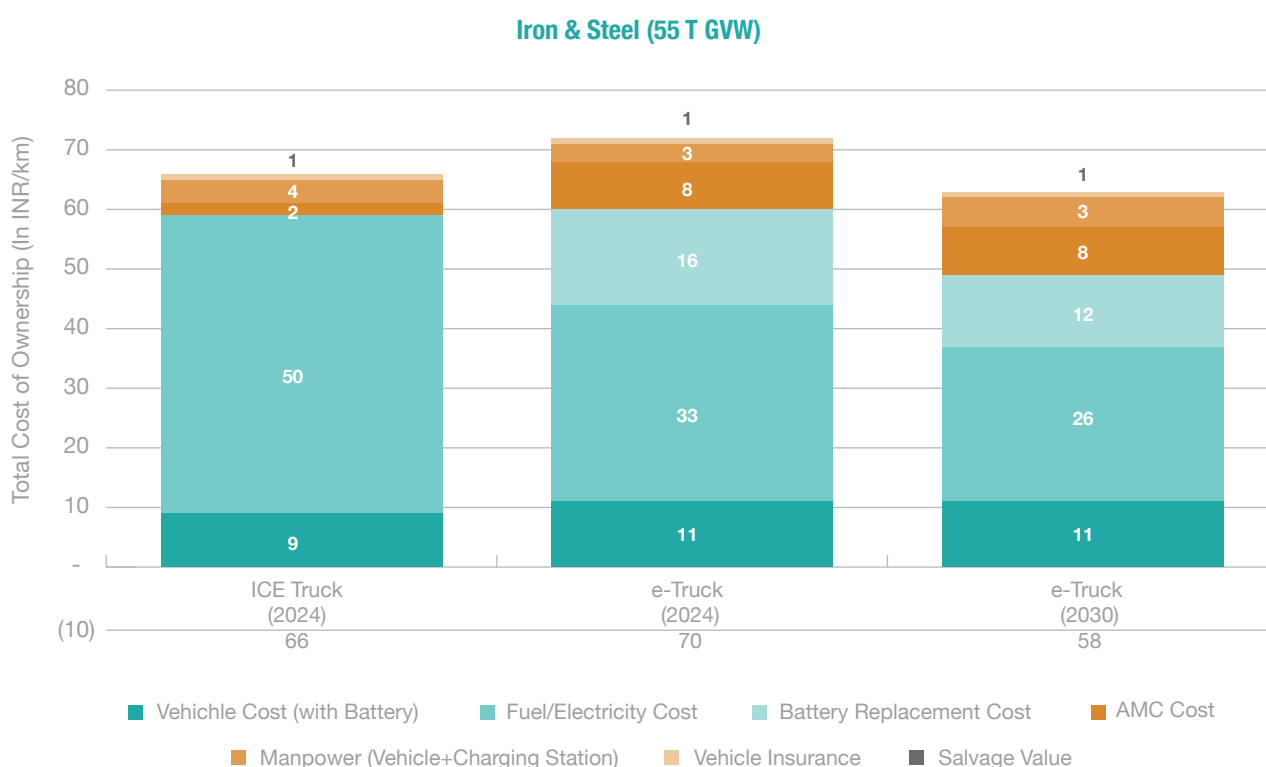


Figure 28 Indicative Technical Feasibility⁹³

The estimated TCO comparison between electric Medium & Heavy-Duty Trucks (e-M&HDTs) and conventional Internal Combustion Engine (ICE) trucks shows that all e-M&HDT segment-application combinations currently achieve TCO parity with diesel trucks in the M&HDT segment (including e-Commerce, FMCG, market, Edible Oil, and Iron & Steel trucks) due to their higher usage rates.

PARAMETER 2: OPERATIONAL CERTAINTY

Operational certainty is a critical factor in the successful adoption of e-M&HDTs. It refers to the predictability and stability of operational characteristics such as route regularity, schedule consistency, and range requirements. High operational certainty ensures that e-M&HDTs can be seamlessly integrated into existing logistics and transportation frameworks, minimizing disruptions and maximizing efficiency.

- E-commerce/FMCG and organized tanker applications (such as edible oil, milk, and garbage trucks) are suitable for short to medium routes due to their predictable schedules
- Market load segments show medium feasibility, as EV technology is viable but requires further development for heavier loads. Similarly, vegetables, fruits, and fish transportation demonstrate medium feasibility, benefiting from predictable schedules and shorter routes.
- In contrast, sectors with variable routes, such as water tankers and cement bag transportation, face more challenges and uncertainties, making them less suitable for immediate e-M&HDT adoption.

Overall, while some sectors are well-positioned for e-M&HDT adoption, others require significant technological advancements before widespread implementation.

PARAMETER 3: SOCIAL IMPACT

The adoption of e-M&HDTs has the potential to create significant positive social impacts, particularly in terms of reducing CO₂ emissions and mitigating climate change. A further detailed view of the data mentioned in Section 5.3, presented in Figure 28, highlights the segments with the highest potential for emission reductions. These segments

⁹³ Truck Segment with the maximum share is used for Application-based TCO analysis

include market load, parcel load, edible oil, milk, and coal applications, which collectively account for over 50% of CO2 emissions in the baseline year. Therefore, these high-emission segments have been prioritized for electrification, as targeting them will yield the most significant reductions in overall emissions.



Figure 29 CO2 emission share of M&HDT – By Application⁹⁴

PARAMETER 4: SCALABILITY AND REPLICABILITY

Scalability and replicability are critical parameters in the prioritization framework for e-M&HDT adoption. The assessment of these parameters involves several key factors, including regulatory frameworks, operational structures, and resource availability.

- Regulatory Frameworks and Corporate Influence:** Sectors with strong corporate and government backing, such as e-Commerce and FMCG, benefit from well-established regulatory frameworks and organized operational structures. This support facilitates broader e-M&HDT adoption by providing clear guidelines and predictable operational environments.
- Operational Challenges:** Sectors like cement and steel transport face more complex regulatory environments and logistical challenges. These sectors often handle high-density materials requiring specialized transport solutions. The variability in load types, routes, and heavy-duty vehicle requirements makes e-M&HDT integration more challenging.
- Resource Availability:** Sectors with high corporate and government influence typically have access to substantial resources, including funding, infrastructure, and technological support. This is less common in sectors like cement and steel, where the focus often remains on optimizing existing heavy-duty transport solutions rather than transitioning to new technologies.
- Pilot Project Success:** The e-Commerce and FMCG sectors have demonstrated successful pilot projects due to their organized nature and predictable logistics, enabling more effective scaling of these initiatives. In contrast, the cement and steel sectors have seen fewer successful pilot projects due to their inherent challenges.

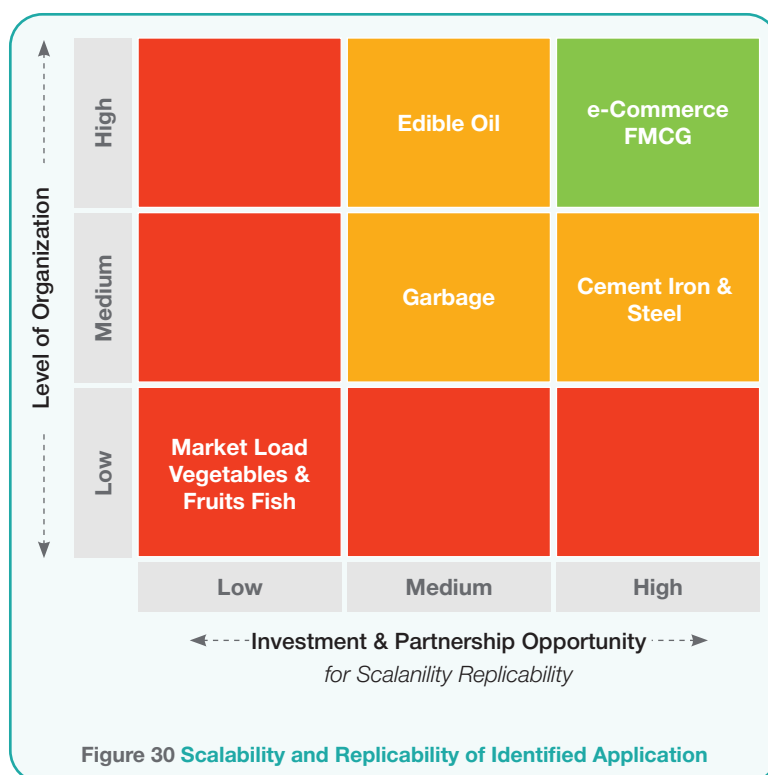


Figure 30 Scalability and Replicability of Identified Application

⁹⁴ Industry Assessment & Roadmap for Zero-emission Medium- and heavy-duty Trucks in India, pManifold supported by CALSTART, 2022

These factors inform the sectoral matrix for scalability and replicability of e-M&HDT adoption, as shown in Figure 29.

ELECTRIFICATION FAVORABILITY ANALYSIS

To successfully transition to e-M&HDTs in India, it is imperative to adopt a phase-wise strategy that prioritizes use cases based on electrification favorability framework elaborated above.

Short Term: which is approximately 1-2 years from now. This phase entails applications that are financially viable and have readily available e-M&HDT models. **Qualifying Criteria** for this phase is:

- **TCO Parity:** Focus on applications that already have TCO parity with diesel trucks or are very close to achieving it. Refer *Section 7.1 Parameter 1: Indicative Technical Feasibility* for more details
- **e-M&HDT Model Availability:** Target e-M&HDT models that are currently available in the market. Refer *Section 4.2 Current Suppliers & New Entrants in e-M&HDT* for more details

Focus is on low range/charge applications that utilize:

- **Trip Distance:** Shorter routes (200 – 300 kms) with fewer stops and minimal overload
- **Road Terrain:** Relatively flat roads which indicate less uphill/downhill run
- **Energy Management:** Fixed routes and schedules, repetitive and predictable charging times and duty cycles, charging while loading/unloading, all bring in a good level of certainty in energy consumption, and brings in end-to-end & enroute charging need
- **Technological Enablement:** Carryover powertrains from existing e-Buses, requiring small to medium-sized batteries for HDTs

Examples of suitable applications in this stage include parcel loads for intra-city transport, FMCG, e-Commerce, Pharma, and city garbage transport with Short-haul trip length, all of which possess definite functional and operational characteristics.

Medium Term: which is approximately 2-5 years from now. This phase focus on applications that falls under organized sector and possess the necessary resources to support the EV transition, ensuring a steady and scalable adoption of e-M&HDT. Refer *Section 7.1 Parameter 4: Scalability and Replicability* for more details. The following are key enablers for the successive electrification of e-M&HDT:

- **Trip Distance:** Medium-haul operations (300 - 500 kms) with minimal overload
- **Road Terrain:** Traversing variable terrains depending on fleet profile, road conditions, and route length
- **Energy Management:** Flexible routes and schedules; varying and unpredictable charging times, location; and duty cycles; all bring in uncertainty in energy consumption, and brings in end-to-end & enroute charging need
- **Technological Enablement:** High-speed charging infrastructure at intervals of approximately 50-100 km to support these vehicles

Key applications in this stage include medium-haul intercity operations for parcel loads, cement, Automotive truck, tankers for various liquids, on-road tippers, and perishable goods, container at port, among others.

Long Term: which is approximately 5+ years from now, introduces very high-range/charge applications, leveraging range-extender technologies like fuel cells to provide range extension off-highway in the absence of charging opportunities, and high-energy density batteries and/or quick recharge capability for long hauls. In this stage, the focus shifts to:

- **Trip Distance:** Long-distance routes or routes with frequent stops and heavy payload, providing fleet operators with greater route and payload flexibility
- **Road Terrain:** Hilly terrain and steep grades which indicate more uphill/downhill run
- **Energy Management:** Variable routes, payload, and harsh weather; all bring in uncertainty in energy consumption, and enroute charging need
- **Technological Enablement:** Batteries with higher energy density and/or quick recharge capability for long hauls and provision of range extension off-highway in the absence of charging opportunities

ELECTRIFICATION FAVORABILITY RESULT INTERPRETATION

The prioritized application that results from considering above framework are shown in Figure 30.



Figure 31 Electrification Favorability Analysis and Result Interpretation

Based on the analysis, top prioritized use cases for the electrification of M&HDTs are:

e-Commerce Truck: These sectors are likely to invest in e-M&HDTs due to their well-regulated industry frameworks, defined routes, and predictable schedules. Such structured operations facilitate planning around e-M&HDT range limitations, ensuring efficient vehicle operation within operational boundaries. The electrification of these sectors can achieve significant CO2 emissions reductions. While this environmental benefit and operational predictability make these sectors ideal for early e-M&HDT adoption, the industry's high sensitivity to Turnaround Time (TAT) presents a challenge. E-M&HDT usage could increase TAT unless restricted to short travels (<150 km). This limitation must be considered when planning e-M&HDT adoption in these sectors to maintain operational efficiency.



Garbage Truck: Garbage collection requires vehicles to operate on fixed routes over shorter distances. Operating in residential areas, conventional garbage trucks contribute to noise and air pollution. Electric garbage trucks offer significant advantages through quieter operation and zero tailpipe emissions, improving neighborhood air quality and reducing noise pollution. The government-authorized nature of these operations facilitates charging infrastructure implementation and route planning, making them ideal candidates for electrification.

Cement Truck: Cement trucks operate on short, fixed routes between batching plants and construction sites. These predictable, limited routes align well with e-M&HDT range capabilities, eliminating range anxiety concerns. Centralized operations enable strategic placement of charging infrastructure, allowing e-cement trucks to recharge during off-peak hours for next-day operations. As part of the formal sector, major companies like JSW and UltraTech have initiated e-cement truck pilots and are planning scale-up, encouraging broader adoption across the construction sector. This alignment ensures efficient and sustainable operation of electric cement trucks while contributing to emissions reduction and air quality improvement.



**Electrifying
M&HDT fleet
involves several
steps and
considerations
to ensure
commercial
viability and
operational
efficiency**



The adoption of e-M&HDT is influenced by a complex interplay of technological, operational, and financial factors. To facilitate this transition, it is crucial to develop robust business and value cases that can guide stakeholders in making informed decisions.

BUSINESS CASE HANDBOOK FOR E-M&HDT ADOPTION

Electrifying M&HDT fleet involves several steps and considerations to ensure commercial viability and operational efficiency. Here are some recommended approaches and steps to guide fleet managers through this transition as shown in Figure 31. Details of each step are given below:

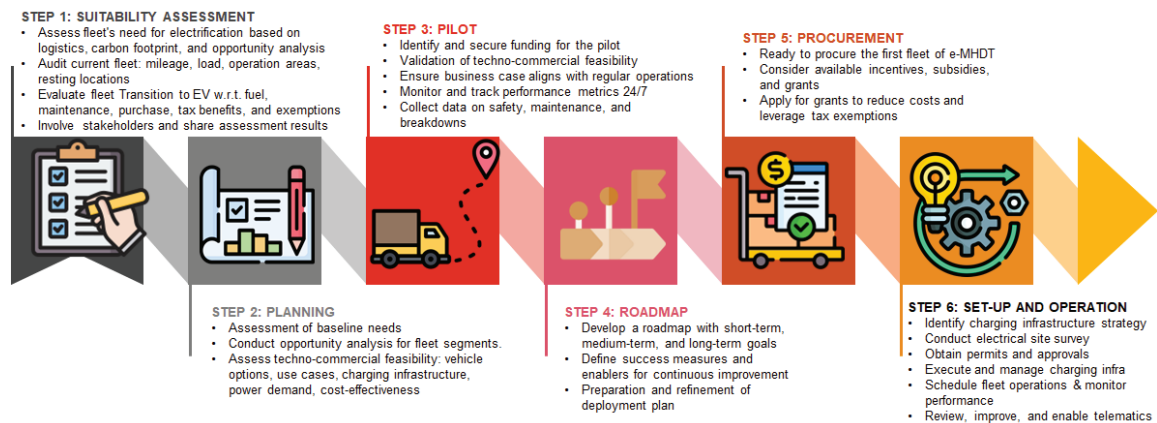


Figure 32 e-M&HDT Adoption Process

STEP 1: SUITABILITY ASSESSMENT

It is important to assess whether fleet needs electrification, based on factors such as logistics needs (operational characteristics and expenses, including fuel, maintenance, and tax benefits), carbon footprint, and opportunity analysis. Hence suitability assessment is done following below steps:

Sustainability Goals and Commitments: Begin by aligning the electrification plan with your company's sustainability goals and commitments towards reducing its carbon footprint. Consider any existing regulations or mandates related to electrification.

Audit Current Fleet's Workload

- Mileage per Trip/Day:** Assess the average distance covered in each trip and daily mileage to understand the usage intensity.
- Load Requirements:** Determine the load capacity needed for your operations.
- Areas of Operation:** Identify the geographic locations where your fleet operates.
- Resting Locations:** Pinpoint where trucks typically rest or park, which could be potential charging spots.

Fleet Electrification Assessment: Assess whether your fleet needs electrification based on factors such as logistics needs, operational characteristics, expenses including:

- Fuel Requirements:** Compare the fuel needs of your current fleet with the energy requirements of e-M&HDTs.
- Maintenance Costs:** Evaluate the maintenance expenses of ICE vehicles versus e-M&HDTs.
- Purchase and Installation:** Consider the costs associated with purchasing and installing new vehicles and charging infrastructure.
- Tax Benefits:** Analyze any potential tax incentives or benefits available for e-M&HDTs.
- Toll, Levy, and Congestion Exemptions:** Look into exemptions that could apply to EV, reducing operational costs.

Adopting e-M&HDTs involves a detailed evaluation of various factors to ensure commercial viability and operational efficiency. Table 23 outlines the key considerations and value metrics that fleet managers should assess when building a business case for e-M&HDT adoption.

Table 23 Key Considerations of Business case and Value metrics for e-M&HDT Adoption

Category	Consideration	Description	Value Metrics
Financial Viability	TCO	Evaluate overall costs including purchase, maintenance, and operational expenses over the vehicle's lifecycle.	- Initial Purchase Cost - Maintenance Costs - Fuel/Energy Costs - Depreciation and Residual Value
	Vehicle Uptime	Assess improvements in operational metrics like reduced downtime and enhanced fleet management.	- Uptime Percentage
	Charging Time	Evaluate the time required for charging and its impact on operations.	- Average Charging Time
	Route Predictability	Measure the consistency and predictability of routes.	- Route Consistency Index
Operational Efficiency	Load Capacity Utilization	Assess how effectively the vehicle's load capacity is utilized.	- Load Utilization Rate
	Carbon Emission Reduction	Measure the reduction in greenhouse gas emissions.	- CO2 Emission Reduction
	Air Quality Improvement	Evaluate improvements in air quality due to reduced emissions.	- Reduction in Pollutants
	Noise Pollution Reduction	Assess the reduction in noise pollution.	- Noise Level Reduction
Environmental Impact	Tax Benefits	Consider available tax incentives and benefits.	- Tax Savings
	Government Subsidies	Evaluate subsidies available for purchasing e-M&HDTs.	- Subsidy Amount
	Toll and Congestion Charge Exemptions	Assess exemptions from tolls and congestion charges.	- Cost Savings from Exemptions
	Battery Life	Evaluate the maturity and suitability of battery technology.	- Average Battery Life
Regulatory Compliance	Charging Infrastructure Availability	Assess the availability and reliability of charging infrastructure.	- Number of Charging Stations
	Vehicle Performance Metrics	Evaluate the performance metrics of the e-M&HDTs.	- Performance Score
	Stakeholder Engagement	Foster partnerships with relevant entities.	- Number of Partnerships
Technological Readiness	Collaborative Partnerships	Foster partnerships with relevant entities.	- Number of Partnerships

Category	Consideration	Description	Value Metrics
Financial Models	Availability of Loans and Grants	Explore financing options to support the transition.	- Loan Approval Rate
	Leasing Options	Consider leasing as a viable financial model.	- Leasing Rate
Operational Support	Training Programs	Provide training for drivers and maintenance personnel.	- Training Completion Rate
	Maintenance Support	Ensure availability of maintenance services.	- Maintenance Service Availability
Social Impact	Job Creation	Assess the broader social benefits including job creation.	- Number of Jobs Created
	Public Health Improvements	Measure improvements in public health due to reduced emissions.	- Health Improvement Index
Risk Mitigation	Insurance Coverage	Ensure comprehensive insurance coverage for e-M&HDTs.	- Insurance Coverage Rate
	Contingency Plans	Develop contingency plans to address potential issues.	

If suitability assessment proves that e-M&HDTs are viable, involve relevant stakeholders such as finance, procurement, energy/sustainability teams, site management, senior leaders/or business strategy teams (if sustainability is part of business strategy) and Marketing and/or customer relations (if sustainability is part of brand positioning). Share the suitability assessment results with the stakeholders, matching viability findings with their objectives.

STEP 2: PLANNING STAGE

Proper planning is crucial to ensure a smooth transition to an electrified fleet. This phase involves a detailed assessment of baseline needs and opportunity analysis, followed by techno-commercial feasibility studies.

- **Opportunity Analysis:** Conduct an opportunity analysis to evaluate the viability and profitability of electrifying different segments of your fleet. Consider logistics needs, existing fleet servicing capabilities, tonnage versus usage mapping, and the current carbon footprint.
- **Operational Characterization:** Analyze the operational characteristics of your fleet, including urban versus rural operations, daily mileage, fleet age, replacement schedules, and Power Take-Off (PTO) requirements for specific applications.
- **Techno-Commercial Feasibility:** Assess the feasibility of transitioning to e-M&HDTs by evaluating vehicle options, use cases, fleet scheduling, charging infrastructure, power demand, and overall cost-effectiveness.
- **Conduct an electrical site survey:** Once the charging locations are chosen, company should conduct an electrical site survey to ensure that the installation is practical and efficient.

STEP 3: PILOT STAGE

Once the planning phase is complete, validate the techno-commercial analysis through a pilot study:

- **Funding Opportunities:** Identify and secure funding for the pilot, ensuring transparency of costs.
- **Business Case Consistency:** Ensure the pilot's business case aligns with regular operations to avoid miscalculations.
- **Monitoring and Data Tracking:** Monitor the pilot 24/7 to track trip time, charging time, idle time, and other performance metrics. Collect and communicate data on safety, maintenance, and breakdown aspects. To capture these value metrics effectively, involve top management to ensure alignment with strategic objectives and to drive pilot success.

STEP 4: ROADMAP PHASE

Upon successful pilot completion and confirmation that e-M&HDTs are suitable for your fleet, prepare a comprehensive roadmap for full fleet electrification. A roadmap should include a deployment plan with quarterly targets, success measures, and enabling factors. This approach allows for gradual e-M&HDT adoption while building expertise with the technology.

- **Deployment Plan:** Develop a deployment plan with short-term, medium-term, and long-term goals.
- **Success Measures:** Define success measures and enablers to track progress and ensure continuous improvement.

STEP 5: PROCUREMENT PHASE

This is the stage where, after completing all considerations, you are ready to procure your first e-M&HDT or fleet. When procuring trucks, consider available incentives, subsidies, and grants. Follow the same process established during your pilot and adhere to your roadmap.

- **Incentives and Grants:** Explore rebates, tax credits, and other incentives to offset initial costs.
- **Grant Funding:** Apply for grants to reduce expenditures and leverage tax exemptions.

STEP 6: SET-UP AND OPERATION PHASE

Once procurement strategy is finalized, company should:

- **Identify the charging infrastructure strategy:** Company needs to determine its charging infrastructure strategy by considering the type of chargers required for e-M&HDTs and the charging levels that vary in price and duration. It should also consider contracting charging and maintenance services with logistics service provider or using public charging if feasible and negotiate a fair, set charge with the power company to avoid overpaying.
- **Obtain permits and approvals:** Increasing power complicates land use, right-of-way, and permit requirements. Company needs to obtain all the necessary permits and authorizations, such as electrical permits, building permits, environmental permits, and right-of-way permits and submit full compliance documentation for installation and inspection process.
- **Execute and manage charging infrastructure:** After obtaining all necessary permits and approvals, company should order and install the charge point hardware, manage its charge points by enabling clever functionality through real-time visibility of the charging network usage, etc.
- **Fleet operations and Monitoring:** Company should schedule its fleet as per its requirement and the learnings from the pilot for hassle-free deliveries. Monitoring and checking of safety aspects, driver training and technical support are crucial to ensure project success. Finally, company should enable telematics to optimize the value of its investment by using operational data.
- **Review and improve:** Company should continuously assess the feasibility of transitioning additional M&HDTs to electric and adjust the roadmap and targets accordingly.

VALUE PROPOSITION FOR E-M&HDT ADOPTION

The adoption of e-M&HDTs in India is poised to transform the freight transportation landscape, driven by the need for sustainable and environmentally friendly logistics solutions. To facilitate this transition, a robust ecosystem marked by strategic partnerships and collaborations is essential. The widespread adoption of ZETs can be significantly accelerated through the collaborative efforts of key stakeholders, including Original Equipment Manufacturers (OEMs), Corporates, Charge Point Operators (CPOs), Financiers, Insurers, and Truck Operators. These collaborations may help mitigate perceived risks to make ZET adoption more attractive for truck operators. Table 24 below shows the roles of various agencies and their role in partnerships among key stakeholders.

Table 24 Role of key stakeholders

Risk Head	Risk Component	Potential Financial Risk Mitigation Strategy	Stakeholder
 TECHNICAL	Battery Life & replacement cost	Battery leasing or financing Interoperable standards for battery OEMs	OEM
	Adequate performance for optimum utilization	OEM, top management from logistics company and the shippers' assurance on vehicle performance and upkeep	OEM, logistics company and shippers
 FINANCIAL	Borrowers credit worthiness	Second loss guarantee	Policy
	High upfront costs	Market based credit programs / Interest subvention schemes / Lease purchasing and as a-service model	Policy and Financial Institutions
		Addresses financial issues such as shorter tenures, high interest rates, and high security deposits for borrowers Insurers may allocate premiums to encourage adoption of e-M&HDTs among truck operators	Financiers and Insurers
	Residual value risks	Facilitation of data such as battery health, vehicle tracking with financiers to foster mutual trust Provides financial security by offering a predetermined salvage value for BETs	OEM, LSP & Shipper
 OPERATIONAL	Charging Infrastructure	Interest subvention schemes and risk-sharing mechanisms / Concessional financing / Green bonds	Policy & multilateral institutions
		Innovative business models (such as CaaS, TaaS) Provides services like telematics, etc.	CPOs
	Adequate vehicle availability	Demand Aggregation	Policy
	Business Assurance	Long-term business contracts to ensure financial security by taking the role of guarantor	Shipper
	Performance Uncertainty	Performance assurances and more robust warranties, along with stringent testing methodologies certified by an accredited body, ensure the range ZETs can cover	OEM
		Sign up for proper AMCs, driver training for LSP/shippers, safety awareness program for operation staff/government, complementary driver training & safety programs	Govt., OEM, LSPs/Shipper
		Addresses operational aspects to optimize performance Setting up AMCs and collaboration with OEMs by signing up for driver training and safety awareness programs	Truck Operators

Alignment of efforts from these key stakeholders in the ecosystem can pave the way for effective risk mitigation strategies. This collaborative approach will create a conducive environment for accelerating the adoption of BETs toward faster adoption of e-M&HDTs in India. Therefore, the value proposition for e-M&HDT adoption in India is strengthened by the strategic partnerships among OEMs, Corporates, CPOs, Financiers, Insurers, and Truck Operators. These collaborations help mitigate risks, provide financial security, optimize operations, and foster innovation. By aligning efforts, stakeholders can create a supportive ecosystem that accelerates the transition to e-M&HDTs, paving the way for a sustainable and zero-emission future in India's freight transportation sector.

Key takeaways:

1

A robust business case for e-M&HDT adoption involves suitability assessment, planning, pilot studies, and roadmap development.

2

Key considerations include financial viability, operational efficiency, environmental impact, and regulatory compliance.

3

Strategic partnerships among OEMs, Corporates, CPOs, Financiers, Insurers, and Truck Operators are crucial for risk mitigation and operational optimization.

4

Innovative financing models like sales-and-leaseback, crowdfunding, and green bonds can facilitate ZET adoption.

9. Conclusion

This chapter aims to encapsulate the main findings of our study and provide actionable recommendations for stakeholders in the e-M&HDT ecosystem. The transition to ZETs presents both significant opportunities and challenges that require coordinated action from the government, OEMs, and the logistics industry.

Main Findings:

- **Ecosystem Readiness:** Current state of the e-M&HDT ecosystem in India shows promising potential for short, medium, and long-term adoption. However, technological, operational, and financial barriers need to be addressed to fully realize this potential.
- **Commercial Viability:** TCO for ZETs is becoming increasingly competitive, especially with advancements in battery technology and supportive government policies. However, innovative financing models and ownership structures are essential to bridge the viability gap.
- **Global and Local Developments:** International best practices and policy mandates provide valuable insights for India's ZET adoption. The PM E-drive initiative exemplifies the government's commitment to accelerating the transition to e-Mobility, urging the industry to capitalize on this momentum.

Recommendations ⁹⁵

The transition to ZETs is accompanied by several challenges and opportunities, as identified through stakeholder consultations and workshops. Details are provided in **Annexure 10: Workshop Summary**. Key challenges include high upfront costs, longer charging times, potential payload loss, and a lack of suitable e-M&HDT models. However, opportunities such as government incentives, strategic deployment of charging infrastructure, and innovative financing models can drive adoption.

- **Government Action:** The PM E-DRIVE scheme, with its INR 500 crore fund, is a pivotal step toward transport decarbonization. By replacing the FAME scheme, it is effective from October 1, 2024, to March 31, 2026, promoting EV adoption, infrastructure development, and the EV manufacturing ecosystem in India. Inspired by successful fiscal policies in the U.S. and Europe, India's scheme may consider incorporating variable incentives with higher support for heavier vehicles, like the N3 category, and introduce energy efficiency benchmarks to encourage innovation. Additionally, expanding the scope to include zero-emission technologies, such as hydrogen fuel cells, may create a technology-agnostic framework similar to global best practices.⁹⁶

Expanding existing EV policies to M&HDTs and creating more specific demand- and supply-side policies may catalyze the ZET market and set the sector on the pathway to high electrification.

⁹⁵ Bharat Zero Emission Trucking (ZET) Policy Advisory, GoI- PSA, 2024

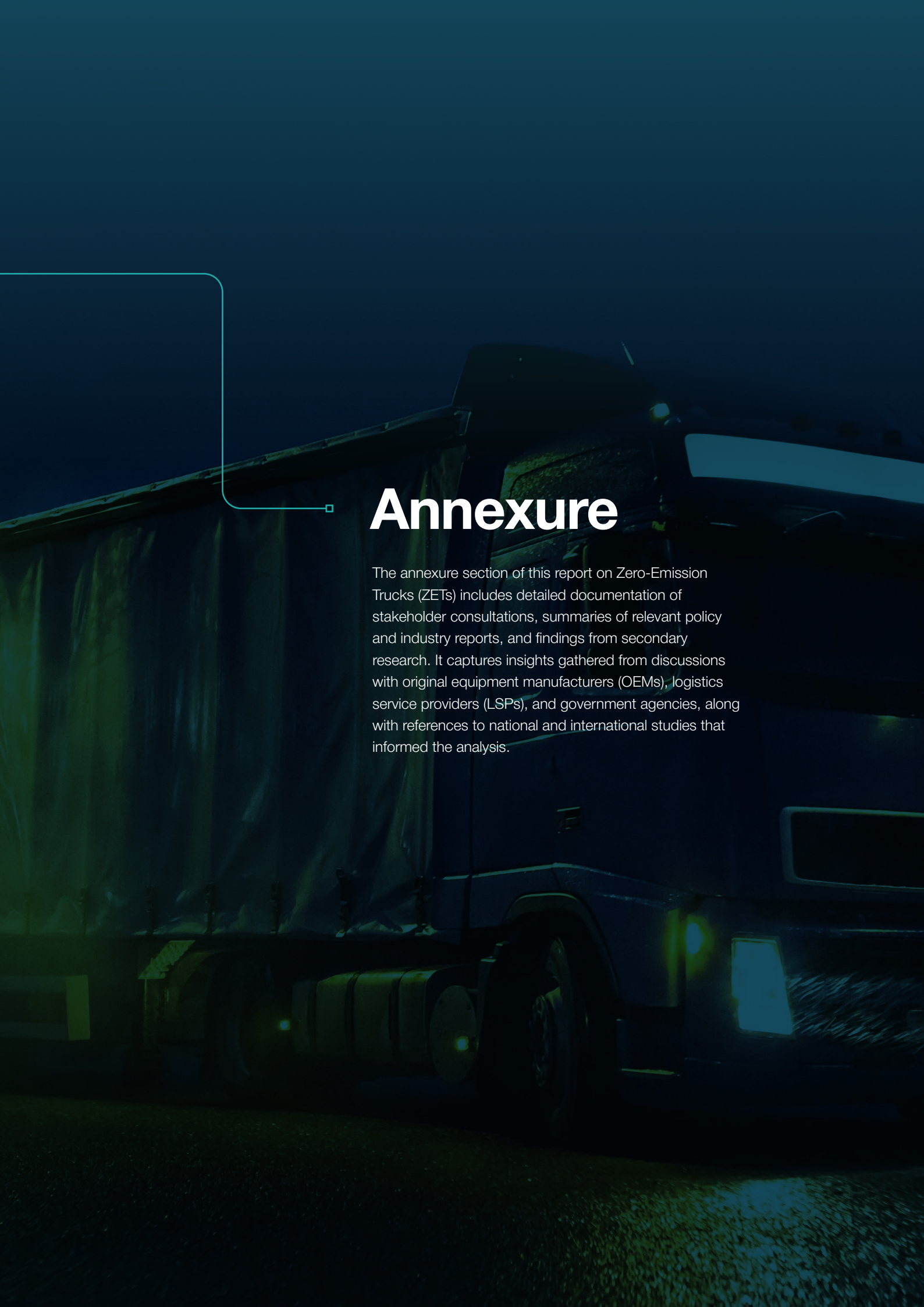
⁹⁶ Designing Electric Truck Incentives for India, UC Davis, 2024

Demand-side policies	Supply-side policies
• Purchase subsidies could help bring down the upfront cost of ZETs; special pilot incentive programs for small fleet owners and drivers • Feebates could incentivize ZETs with rebates while disincentivizing diesel trucks with fees • Interest subvention could alleviate high ZET interest rates to propel adoption • Fleet purchase requirements could establish a fleet electrification timeline for commercial freight operators • Scrappage policy and incentives could help eliminate high-emitting, old, and unfit trucks from India's roads • Zero-emission zones could provide unrestricted access to zero- or low-emission vehicles and restrict polluting vehicle use	• ZET credit schemes ensure a certain percentage of an OEM's new truck sales are zero-emission • ZET targets send a market signal that the government is committed to electrifying the trucking sector • Fuel efficiency (FE) norms reward OEMs manufacturing vehicles with low emissions while penalizing those with high emissions; CAFE norms tightening and ZEV credits • Interoperable standards for BET batteries • Refueling infrastructure deployment criteria by road classification

- **OEMs' Role:** OEMs are expected to focus on developing robust ZETs suitable for Indian conditions. Leveraging global trends in battery swapping prevalent in China, OEMs could explore modular battery designs and collaborations with technology providers to enhance flexibility and efficiency, while building and expanding reliable service networks. Upscaling manufacturing capacity and localizing component production, as seen in international markets, would be crucial for cost reduction and market growth.
- **Logistics Industry:** The logistics sector should consider integrating ZETs to cut operational costs and environmental impact. Drawing from the U.S. and European experiences with pilot projects, India plans to identify suitable use cases and corridors for demonstrations, fostering broader network expansion. Training programs and telematics integration have the potential to enhance operational efficiency.
- **Shippers' Role:** Shippers play a pivotal role in accelerating the adoption of Zero-Emission Trucks (ZETs) by fostering stable, high-utilization use cases. Given that ZETs are assets on Logistics Service Providers' (LSPs) books, ensuring contract terms align with loan tenures can enhance financial viability and de-risk investments. Prioritizing high-utilization applications, such as hub-to-hub freight movement or dedicated routes, can maximize efficiency and cost-effectiveness. Additionally, leveraging ESG performance incentives and exploring carbon credit mechanisms could create further financial benefits, aligning sustainability goals with business value.

The e-M&HDT ecosystem in India is undergoing a transformative phase, marked by technological advancements, supportive policy frameworks, and increasing market acceptance. With over 13,000 e-M&HDTs on the road by 2024, market growth is driven by government initiatives and rising environmental awareness. As seen globally, collaboration across stakeholders—from policymakers to manufacturers—is essential to realize the full potential of e-M&HDTs, paving the way for a greener transportation landscape.

The PM E-DRIVE scheme's inclusion of e-truck incentives marks a critical moment in India's decarbonization journey. While upfront costs are a barrier, the Rs 500 crore incentive program aims to support 45-65% of the market potential, incentivizing 2,000-3,000 electric trucks over two years. Inspired by global practices, the program plans to incorporate equity-focused design to avoid market distortion, expand to include a broader range of zero-emission technologies, and establish stringent energy efficiency requirements. Investment in infrastructure, such as dedicated e-truck chargers, is crucial to enhance market uptake, drawing lessons from robust infrastructure development in Europe and the U.S. Localization of components, aligned with India's Phased Manufacturing Program, can strengthen the domestic ecosystem. The scrappage policy, linking incentives to the retirement of old vehicles, offers net-positive benefits by reducing emissions and revitalizing the economy, similar to strategies observed in international markets.



Annexure

The annexure section of this report on Zero-Emission Trucks (ZETs) includes detailed documentation of stakeholder consultations, summaries of relevant policy and industry reports, and findings from secondary research. It captures insights gathered from discussions with original equipment manufacturers (OEMs), logistics service providers (LSPs), and government agencies, along with references to national and international studies that informed the analysis.

Table 25: Business & Financing Models

Business & Financing Models	Description	Financing Details	Target Customers	Value Proposition
Direct Sales Model	Selling ZETs directly to customers, including fleet operators, logistics companies, and municipalities	- Direct Purchase: The operator buys the ZET outright, using a combination of cash and loans. They make an initial deposit and then pay off the remaining value of the asset plus interest through monthly payments to the financier. The operator owns the asset from the beginning. - Hire Purchase: The operator pays an initial deposit for the asset and then makes monthly payments, including interest, to the financier. They are responsible for road taxes, insurance, and maintenance. Ownership of the asset is transferred to the operator after the final payment. These purchases can be done through Third-party financing: - Term Loans: A bank or financing institution provides a monetary loan to an operator, which is repaid in regular payments over a set period of time. These loans can be taken out to fund the upfront capital payment for a new ZET. - Concessional Loans: The operator obtains a loan from a financing institution with more favorable lending conditions, such as lower interest rates or longer repayment schedules. Concessional loans can also be used as part of: - Blended financing (e.g., co-funded with private investments or public grants) - Manufacturers/financiers can take out large-scale loans to increase production or purchase infrastructure and ZETs in bulk. These assets are then leased out to operators at more favorable rates and longer repayment schedules. The economies of scale in borrowing and production enable manufacturers and financiers to offer lower interest rates and lower-cost assets to operators.	Large commercial fleet operators, government agencies, and private companies with substantial transportation needs	Ownership of advanced, environmentally friendly vehicles with lower long-term operating costs and compliance with government regulations

Business & Financing Models	Description	Financing Details	Target Customers	Value Proposition
Leasing Model Operational Lease	Offering trucks on lease for a fixed period with comprehensive maintenance and service packages included	There are two types of leasing agreements: “dry” lease and “wet” lease. Dry lease: The lessor (financier) provides the ZET, but the lessee (customer/operator) is responsible for crew, maintenance, and insurance. Wet lease: The lessor (financier) provides the ZET with taxes, maintenance, and insurance included in the cost to the lessee (customer/operator).	Companies preferring lower upfront costs and avoiding long-term commitments	Reduced financial burden, access to the latest technology, and simplified fleet management
Financial Lease	Customers pay for the truck over time and typically own it at the end of the lease term	Similar to an operating lease, the operator pays regular lease payments to the vehicle and infrastructure owner. However, at the end of the primary lease period, the operator has several options: - Sell the asset to a third party and receive a rebate of rental costs equating to the majority of the sale proceeds - Return the asset to the owner for sale. - Enter into a secondary lease period or arrange a purchase agreement for an agreed residual value of the asset	Businesses looking for eventual ownership but seeking to spread out the cost	Lower initial investment, tax benefits, and eventual ownership
Pay-Per-Use Model	Charging customers based on usage metrics such as miles driven or hours of operation Operators pay based on usage metrics, such as mileage or time. This model includes: Subscription Services: Monthly or annual subscriptions that cover the use of ZET and/or associated infrastructure Per km basis: Fees based on actual distance driven, which can include costs for maintenance and charging		Companies with variable usage patterns, such as seasonal businesses or those with fluctuating transportation needs	Cost aligned with actual usage, flexibility in operations, and no large upfront costs
Fleet Management Services	Providing comprehensive fleet management solutions, including vehicle supply, maintenance, telematics, and route optimization services		Large logistics and transportation companies, public sector fleets	Streamlined operations, enhanced efficiency, data-driven insights, and reduced total cost of ownership
Subscription Model	Offering trucks and associated services through a subscription, covering maintenance, insurance, and charging		Small and medium enterprises (SMEs) and startups looking for predictable costs and flexible terms	Predictable monthly costs, hassle-free maintenance, and the ability to scale up or down as needed

Business & Financing Models	Description	Financing Details	Target Customers	Value Proposition
Trucks-as-a-Service (TaaS) Model	Providing ZETs as part of a service package, including vehicle, battery, infrastructure, and management services	Integrated End-to-End Financing: An integrated financing package/solution, this model provides the operator with all necessary assets through a service model. The operator pays a fee for the availability and use of the assets on a per mile/km basis. The integration provider “bundles” the vehicle, battery (or fuel cell), and infrastructure assets into one package. The package typically includes the vehicle, battery or fuel cell, infrastructure assets, tax, insurance, and maintenance, and the operator pays a regular fee for use and access	Companies looking to outsource their transportation needs entirely	Comprehensive solution with minimal management burden, enhanced focus on core business activities.
Joint Ventures and Strategic Partnerships	Forming partnerships with logistics companies, battery manufacturers, and charging infrastructure providers to offer integrated solutions		Established companies looking to leverage combined strengths for greater market penetration.	Enhanced capabilities, shared risks and resources, and integrated solutions for end-users
Battery Leasing Model	Leasing batteries separately from the ZETs, allowing customers to upgrade or replace batteries as technology advances	Component Leases: The operator purchases most of the vehicle (e.g., chassis, cab, and motor) but leases the most expensive components, such as electric batteries, hydrogen fuel cells, or charging infrastructure.	Fleet operators concerned about battery degradation and looking for flexibility	Lower upfront vehicle cost, reduced risk of obsolescence, and access to the latest battery technology
Public-Private Partnership (PPP) Model	Collaborating with government entities to deploy zero-emission trucks for public services such as waste management, public transportation, and municipal services		Municipalities and government agencies	Access to public funding and incentives, support for public sustainability goals, and enhanced public service efficiency

INNOVATIVE FINANCING MODELS

The shift towards ZETs presents a significant opportunity for reducing the transportation sector's carbon footprint. However, the considerable upfront costs associated with ZETs, including the vehicles themselves and the necessary charging infrastructure, can pose a challenge to widespread adoption. To overcome these financial hurdles and make the transition more accessible for businesses, innovative financing models are crucial. This section examines innovative financing models available for ZETs, exploring how they can alleviate the initial investment burden and facilitate a smoother adoption process. These financing solutions provide flexible and cost-effective options tailored to the unique needs of different stakeholders in the transportation industry.



Figure 33: Innovative Financing Models

- **Sales-and-leaseback (refinancing):** By utilizing the conventional approach of this model, the assumption is that the operator already possesses the asset, which is subsequently sold to a buyer in order to release capital, followed by leasing the same asset from the buyer. However, it is improbable that operators commonly own ZETs at present. Consequently, the feasibility of this model may lie in operators selling (refinancing) their existing diesel fleet (which they own) to a financier or manufacturer as a means to finance the acquisition of ZETs.
- **Crowdfunding:** Raising funds through crowdfunding platforms to finance the transition to ZETs
- **Residual Value Guarantee:** Grants or contractual agreements guarantee a percentage of the residual value of assets after the initial contract period and provide it to the operator.
- **Green bonds:** Bonds issued by governments, municipalities, financiers, or corporations to support more traditional forms of financing such as loan arrangements for ZETs. They can be purchased by corporations, governments, and individuals. This could become more prominent with the emergence of 'Green Investment Banks' and financiers with 'ESG' focused portfolios.
- **Revolving Fund:** The government typically establishes a revolving fund, which serves as a means to incentivize energy and utility companies to invest in energy efficiency. In this particular scenario, a primary financier, whether it be the government or other financial institutions, provides the necessary capital for investing in charging infrastructure and grid network connections for operators. Since the energy supplier or utility company stands to benefit the most from the enhanced efficiency of the infrastructure and the increased energy demand resulting from operators transitioning to electric fleets, they are responsible for repaying the costs associated with the infrastructure and grid upgrades using the additional profits generated from the energy consumed. As part of the agreement, a portion of the profit margin earned by the energy supplier or utility company is allocated to the principal financier until they are fully repaid or the terms of the agreement terminate.

- **Mezzanine Loan:** It is a loan provided to the asset owner (e.g., operator, technology provider, etc.) by the financier. If the owner defaults on repayments, the debt is converted into an equity interest in the operator company and is used when a buyer has exhausted its ability to take out senior debt (debt a company must repay first before it goes out of business). Mezzanine loans are predominantly invested in by pension funds, hedge funds, leveraged public funds, LPs, and insurance companies.
- **Partial Risk Guarantee:** Governments provide a Partial Risk Guarantee (PRG) to decrease the likelihood of default and enhance lending conditions for operators. This is achieved through a reinstatement provision, which grants operators additional time to repay funds in order to avoid default. In cases of operator illiquidity, the government guarantee can be utilized to cover debt service payments. However, any amounts drawn under the guarantee must be repaid within a prearranged timeframe to ensure they are available for future use during periods of illiquidity.
- **Demand Aggregation:** Demand from ZET operators can be consolidated by government entities, industry bodies, or private sector companies. Once a minimum threshold of demand is reached, this consolidated demand is presented to financiers. In some cases, there may be a maximum price limit and specific requirements set by operators. The assurance of guaranteed demand can serve as an incentive for financiers to offer appealing solutions. This process can be expanded to include a “reverse auction” approach, where operators who express interest are presented with the most attractive solutions from financiers. Ultimately, this allows operators to choose the deal that best suits their needs.

EXISTING E-TRUCK OEMS (M&HDT) AND THEIR PREVALENT E-TRUCK MODELS

Following are the list of Current Electric Truck (M&HDT) Original Equipment Manufacturers (OEMs) and the prevalent e-Truck models in India:

Tata

Tata ULTRA T7 Electric Truck is manufactured with advanced technological solutions that provide high performance. This model comes from Tata motors, which is famous for its exceptional quality commercial vehicles. The truck has a 1+2 seating capacity and is an ideal choice for transport of goods intra-city. This truck is India's FIRST intermediate commercial e-truck.

Parameter	Value
Category	MDT
GVW (Kg)	7490 kg - 8750 Kg
Battery Capacity (kWh)	62.5 kWh
Range (Km)	100+ Km
Top Speed (kmph)	80 kmph

ASHOK LEYLAND

Parameter	Value
Category	MDT
GVW (Kg)	11990 Kg
Range (Km)	300-350 Km
Top Speed (kmph)	80 kmph

The **Ashok Leyland Boss 1218 EV** truck is built for medium-duty transport, combining durability with efficiency. It features advanced safety systems and a user-friendly interface, making it a reliable choice for various logistics needs.

IPLTECH ELECTRIC

As a subsidiary of the esteemed Murugappa Group and a venture under TI Clean Mobility, IPLTech Electric envisions itself as a trailblazer in the Indian EV industry, fostering the rapid adoption of EVs in the heavy commercial sector.

IPLTech Electric has the RHINO range, which is India's first electric heavy commercial truck. The first offering from IPLTech Electric is the **RHINO 5536e**, designed to operate in all weather and road conditions.

Parameter	Value
Category	HDT
GVW (Kg)	55000 Kg
Battery Capacity (kWh)	258 kWh
Range (Km)	185 Km
Top Speed (kmph)	90 kmph

OLECTRA

Olectra's e-Truck is a heavy-duty electric tipper truck designed for applications like construction and mining. It prioritizes safety with features like high-end safety technology as per AIS-038 standards and fireproof batteries. Additionally, it integrates telematics with vehicle tracking and a battery management system for optimal performance. It is India's first homologated electric tipper.

Parameter	Value
Category	HDT
GVW (Kg)	28000Kg
Battery Type	Lithium ion Phosphate (LFP)
Range (Km)	120 – 150 Km

OMEGA SEIKI MOBILITY (OSM)

The **OSM M1KA 3.0** is the company's top truck in its category. This OSM truck is a great option for clean transportation of goods, as the M1KA 3.0's price is cost-effective based on its features. It has a battery capacity of 96.77 kWh. The truck produces 415 Nm of torque and 174 horsepower. It has a range of 180 km and a maximum speed of 90 km/h. Additionally, the OSM M1KA 3.0 has a load-bearing capacity of 5,500 kg.

Parameter	Value
Category	MDT
GVW (Kg)	5500 Kg
Battery Capacity (kWh)	96.77 kWh
Range (Km)	180 Km
Top Speed (kmph)	90 kmph

EICHER

The **Eicher Pro 2055** e-truck has been designed to perform in the e-commerce, FMCG, and P&C segments with business profitability in mind. Eicher's ground-up technology integrates high-energy storage batteries and a reliable all-electric driveline with unparalleled driver safety and comfort features to create a new-gen, efficient, clean, and silent logistics solution.

Parameter	Value
Category	MDT
GVW (Kg)	5450 Kg
Battery Capacity (kWh)	64.4 kWh
Range (Km)	174 Km
Top Speed (kmph)	80 kmph

The efforts of existing and upcoming OEMs have gained exceptional visibility. Moreover, additional e-Truck pilot projects

will be implemented across various sectors by Amazon, Apollo Tyres, Dalmia Cement, Flipkart, JSW Steel, Nestle, Shree Cement, Transport Corporation of India, and UltraTech, by 2025.

KEY COMPARISON OF LITHIUM-ION CHEMISTRIES PREFERRED IN BET

Key comparison of Lithium-ion chemistries preferred in BET is provided in Table 14:

Table 26 Key comparison of Lithium-ion chemistries preferred in BET⁹⁷

	Specific Energy (Wh/kg) Cell level	Life Span (Cycles)	Thermal Run-away temperature (Degree Celsius)	Price (Pack level-USD/ kWh)	Resource Bottleneck
NMC622	200-240	2000+	200	148	Co, Ni, Li
NCA	230-280	1500-2000	150	142	Ni, Co, Li
LFP	130-180	3000-5000	250	136	Li
LTO	50-120	5000+	280	1200	Li

TECHNOLOGICAL, FINANCIAL AND OPERATIONAL CHALLENGES & OPPORTUNITIES FOR ZET TRANSITION

This section delves into the key challenges faced by the trucking industry in its operations as well as the barriers encountered in the adoption of e-trucks. The information presented here is derived from primary stakeholder consultations conducted through virtual means and learnings from workshops organized by SFC. By capturing the perspectives of industry stakeholders, this section aims to shed light on the obstacles hindering the widespread adoption of e-trucks and explore potential mitigation solutions. Understanding these challenges and barriers is crucial for developing effective strategies and policies that can drive the transition toward cleaner and more sustainable trucking practices.

STAKEHOLDERS CONSULTATION

Key Participants:

- Shippers
- Logistics Service Providers (LSPs)
- Financial Institutions
- Think Tanks
- Government Representatives

KEY CHALLENGES IDENTIFIED DURING CONSULTATION

Stakeholder consultations validated that e-Trucking adoption is slower due to key challenges which are shown in Figure 32 and discussed in the earlier sections. Details of Stakeholder consultation is provided in **10: Annexure Stakeholder Consultation Summary**.

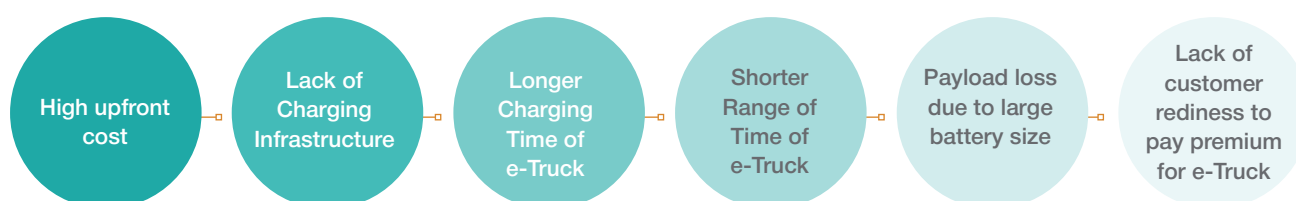


Figure 34 Showing Major Challenges to e-Trucking as per Stakeholders

97 Batteries for Electric Vehicles, US - Department of Energy, 2024

There are several points to consider when evaluating the feasibility of e-Trucks. Apart from the high upfront cost, these include longer lead times for charging and potential payload loss due to larger batteries, as well as concerns about the shorter range of e-trucks. At the operations level, customer readiness to pay a premium for e-trucks is still being developed. There is a lack of availability of suitable e-Trucks models from OEMs, and a strong industry establishment is required. Additionally, putting a large amount of CAPEX into an e-truck model without proven on-ground success can be a risky move for fleet operators.

OPPORTUNITIES (ENABLERS) IDENTIFIED BY STAKEHOLDERS

There are a couple of factors that could drive the adoption of e-trucks in the transportation industry. Firstly, there a push is required from the government in the form of incentives for companies that choose to run their fleets on e-trucks.

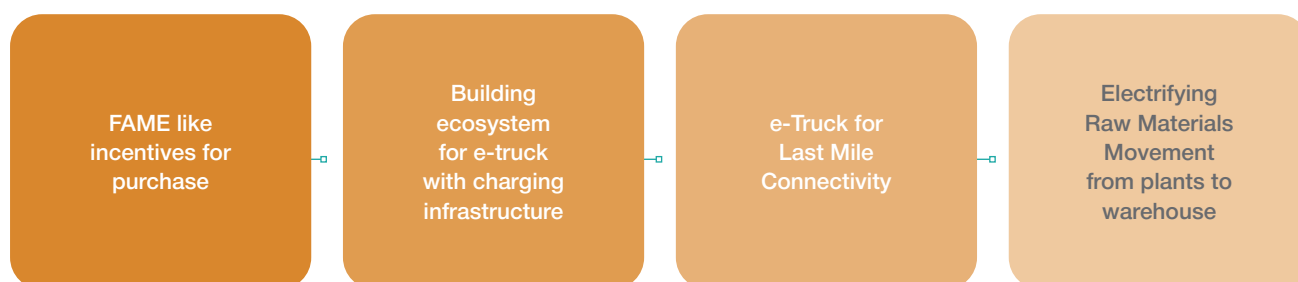


Figure 35 Showing Enablers to e-Trucking as per Stakeholders

The stakeholders emphasized the importance of selecting the appropriate use cases and corridors, along with the provision of charging infrastructure, to facilitate pilot demonstrations and establish a compelling case for expanding the network. By carefully identifying the most suitable use cases and strategically deploying charging infrastructure along key corridors, it becomes possible to demonstrate the viability of e-trucks and lay the groundwork for broader network expansion. This approach serves as a proof of concept, showcasing the benefits and feasibility of incorporating e-trucks into the transportation system.

SUMMARY OF CHALLENGES AND OPPORTUNITIES FOR E-TRUCKS ADOPTION

In addition to the Challenges identified by stakeholders, other important barriers to be addressed across the value chain for e-Trucks adoption are presented in the Table 24 with recommended opportunities (enablers) that incorporate the takeaways from benchmarking the global best practices.

Table 27 Compiled Challenges and Opportunities for e-Truck Adoption

CHALLENGES	OPPORTUNITIES
TECHNOLOGICAL	
- Low energy and power density of batteries compared to fossil fuels - Zero-emission range extender technologies (fuel cells) not yet mature - Limited availability of e-truck models in the market - Long charging times required - Large batteries that reduce payload capacity of e-trucks, thereby impacting revenue - Delayed enforcement of stringent emission standards	- Tax exemptions for ZET technology research and development spending by OEMs and suppliers - Upscaling capacity through leveraging existing ICE truck manufacturing with e-powertrain assembly pathways - Decentralized assembly facilities - Key partnerships for aftermarket cabin and load body building - Modular battery systems - Common minimum e-truck specifications for regulated applications - Standardization opportunities for demand aggregation

CHALLENGES	OPPORTUNITIES
FINANCIAL	
• High fixed costs • High import duties on sub-system components and high battery costs • Lack of priority sector lending • Limited financial incentives • Market volatility and no established residual value • Absence of interest subvention schemes • Limited interest from international manufacturers	• Fiscal incentives for zero-emission truck technologies (e.g., high energy and power density batteries, hydrogen economy, aluminum-air batteries) • Lower interest rates on e-trucks and chargers • Extended loan tenure aligned with battery life • Framework for refinancing of NBFC loans • Depreciation value assurance program • Framework for risk assurance and liability to enable e-truck financing • Free national permits for e-trucks for 5 years (2024-29)
OPERATIONAL	
• Limited viability for long-distance trips • High energy consumption rates • Need for demand aggregation • Increased trip times • Limited technical expertise available • Uncertain residual value of ZETs	• Engineering teams for adapting and integrating zero-emission powertrains • Marketing teams for effectively communicating e-truck benefits • Aftermarket teams for providing field support to ZETs
OTHERS	
• Limited credit schemes and absence of fuel efficiency norms • Lack of standardized e-truck homologation requirements • No vehicle salvage value assurance for loan defaults • Insufficient training and capacity building programs • Unclear roadmap and regulatory framework, including scrappage policy • Absence of battery recycling/reuse policies for EVs • Delayed adoption of stringent emission standards • Limited local capacity for automotive repair and maintenance • Inadequate charging infrastructure • Insufficient depot charging facilities for large fleet operators • Limited implementation of catenary charging along transport routes • Poor maintenance of road infrastructure • Limited grid access and unreliable power quality • Apprehension about EV technology adoption • Limited awareness among stakeholders	• Here's my proofread version with suggestions: • Technology roadmap development • International partnerships with OEMs and governments • ZET technology supplier development program • Subsidized electricity tariffs for e-trucks • Integration with private energy suppliers for depot charging infrastructure • Training needs assessment and capacity building programs • E-truck awareness programs for demand side (individual owners and fleet operators), e.g., EV100+ • E-truck awareness programs for supply side stakeholders • E-truck awareness programs for finance and insurance sectors • Forums for sharing pilot success stories in regional languages from global experiences

STAKEHOLDER CONSULTATION SUMMARY

Sub-category	Stakeholder	Key Challenges identified in Freight Electrification
Truck owners/ Operators	Rhenus Logistics	• Mentioned that currently, electric commercial vehicles with payloads ranging from 700 kg to 1,500 kg are available, and recently, a 4.5-ton payload capacity vehicle has been introduced by VE Commercial Vehicles. • Cited that the lack of vehicles with payloads between 9 tonnes and 25 tonnes is acting as a barrier to shifting logistics operations to electric • Mentioned that 50% of their business is contributed by chemical transportation, and automobile last-mile delivery also makes up a significant portion of their business. • Mentioned that a commercial EV with a range of 90 km has to run at least 200 km daily to justify the purchase cost and remain competitive in the market • Mentioned that they are working with Maruti Suzuki to install EV chargers at the latter's premises for charging commercial vehicles • Called for enforcing sustainability policies across different industries to boost EV adoption and give confidence to OEMs to start rolling out electric commercial vehicles. • Mentioned that they are conducting pilots with 10-11 Tata Ace EVs for their operations. • Mentioned that to boost electric commercial vehicle adoption, financing interest rates should be brought down and made comparable to those for Internal Combustion Engine (ICE) vehicles.
Shippers/end users	JSW	• Mentioned that they are into iron ore mining and they are in process of installing slurry pipelines in the iron ore operations to shift from road transport • Mentioned that they are focusing on freight electrification on the long haul distances between steel operations, inside steel operations and last mile delivery • Mentioned that one potential area of electrification in mining could be transportation from the mining site to the railway siding or from the mining site to the slurry pipelines • Mentioned that unavailability of technology and lack of proper maintenance services is challenge in electrification of trucks in mining operations • Said that they are studying the potential of freight electrification using 5 trucks (LNG and EV both) on a route of approximately 275 kms (Nandyala to Vijaynagar) where they can also have the control on EV charging infrastructure • Mentioned that logistics emissions make around 2-3% of overall CO2 emissions from operations • Mentioned that according to their internal study, LNG trucks and FCEVs are ideally suited for distances more than 400 km and for distances between 100-275 kms, BEVs are suitable

Sub-category	Stakeholder	Key Challenges identified in Freight Electrification
Financer	Sundaram Finance	- Mentioned that for funding of individual new trucks, various parameters are looked into which includes number of fixed contracts of freight transportation, association of the individual (purchasing truck) with a bigger fleet operator; and in case of old trucks, aging of the asset and asset condition is also looked into - Mentioned the age of old trucks which comes for financing is in the range of 4-12 years - Mentioned that used trucks financing market is 3 times that of the new truck financing - Mentioned that they also offer financing at 100% LTV ratio in select scenarios
Think-tank	IIT Madras	- Mentioned that sectors like petroleum and coal cannot be electrified due to safety reasons - Mentioned that FMCG and parcel sector can easily be electrified being in the organized industry - Mentioned that the sector which is consuming more diesel on a per annum basis, has high GHG emissions should be electrified on priority - Suggested two approaches for shortlisting priority use cases for electrification, first is eliminating use cases on the basis of safety, whether the sector is formal or informal, degree of easiness, and scale of benefit, and second is sectors comprising big players like iron ore transportation, cement transportation, e-commerce, FMCG which can lead forward and pave the way for electrification - Suggested that ideal pilot should comprise of big players having assets on their own account books, operating the pilot and monitor the success rate, and then accordingly handing over the operations to an operator. The success rate can be monitored by understanding the business model of operating diesel trucks, evaluating per km or per tonne costs through electrification and comparing the savings from ICE and EV model
Learnings from Previous Consultations		- Challenges/Barriers to adoption: - High monthly EMIs (or high upfront costs) of e-CVs can't be borne out by LSPs even though electricity is cheaper than diesel. - Cost efficiencies can't come without bringing fundamental technological efficiencies, motors are already 95% efficient and battery density can't be increased drastically. Therefore, reducing structural weight becomes very important. Obtaining less structural weight is a major challenge. Low carbon steel could be used but it's produced by few players and is also expensive. While using carbon fiber the weight decreases but the cost increases thus it doesn't solve the customer problem. Thus, it acts as a double-edged sword. - Lack of financing support from both government financial institution side as well as private financial institution side. - Need of policies and schemes for LCVs along with PLIs - Opportunities in the ZET ecosystem: - For lightweight vehicles (1-2 tonnes), 5.5 lakhs vehicles are sold every year. So, the space is huge and around a total of 6 million such trucks would be plowing in the cities. These are also widely used for unloading from bigger CVs. Therefore, electrification of such trucks is going to be important from decarbonization point of view. - CNG prices have also shot up, meaning more traction on electric. - Lower cost e-CVs (price range of 8-9 lakhs) translating to parity within a year on both monthly EMI payment and monthly fuel (electricity) cost would translate to higher adoption. - Support on e-LCV segment by government can lead to adoption of electrification in the LCV segment - The OEMs are building LCVs in India for 10-11 thousand dollars, which is being sold for 15-16 thousand dollars in India. In Europe, similar products are being built for 35-40 thousand euros. Indian OEMs can thus sell products in Europe for 20-22 thousand euros with few modifications.

WORKSHOP SUMMARY

Driving Zero Emission Truck (ZET) Deployment at Scale, Mumbai

Key Takeaways:

- There is a need to focus on adopting E-trucks, with minimal support given in terms of registration and road tax waiver.
- The major challenge for ZET adoption at scale will be the Capex at almost or more than double in the case of e-trucks. Financing will be the key to e-trucking.
- Upstream power availability is key to setting up charging stations on national highways. This is a nationwide problem that needs to be addressed.
- High upfront acquisition cost and residual value, which arises after the conclusion of asset ownership. Both factors significantly affect the TCO, which in turn affects the viability of the business.
- ZETs' running costs can be reduced through efficiency improvements, technology enhancements, and economies of scale.
- Demonstration fleets are crucial for building market confidence by demonstrating the viability of ZET across various parameters, including business and operational.
- Since the initial cost is higher, Op-Ex will depend on the trucks' running. ZETs should never be idle. If they remain inactive, the idle duration will undoubtedly lengthen, and the economy will be undermined.
- Mandates can boost ZET adoption. In the EU, the truck CO2 policy requires manufacturers to replace a significant amount of their fleet (>45%) by 2030 with ZETs. Supply-side mandates would push the industry to innovate and find solutions to solve the problems hampering ZET adoption.
- Proactive OEM and top management participation in ZET pilots is awaited, along with a clear view of upcoming models and timelines.
- Government intervention must come in through a comprehensive energy and investment plan. If a particular green corridor needs to be developed, there is a requirement for planning for charging stations
- The deployment of E-trucks depends heavily on the availability and feasibility of longer-duration contracts since the initial cost is higher. Longer shipper-LSP service boosts financial institutions' confidence.
- Innovation in battery technologies to address charging time and range issues will have a transformational impact on adoption. Swapping batteries across OEM models with standardization may work well as a solution to battery cost and performance concerns.
- Using blended finance to mitigate risks and offer dedicated loan products with OEM partnerships. Social and environmental value considerations are included in financing decisions.
- Engaging communities and educational institutions for talent development, research, and knowledge building.
- The role of insurance in the context of electric trucks (e-trucks) in India is crucial

The background of the slide is a photograph of a road winding through a forested area. Two large trucks are visible on the road. The image is darkened to serve as a backdrop for the text.

ZET TECHNOLOGIES: AN ECOSYSTEM PERSPECTIVE, CHENNAI

Key Takeaways:

- Decarbonizing the trucking sector is crucial for achieving India's net-zero emissions target.
- High upfront costs and OEM challenges are significant barriers to ZET adoption.
- Strategic deployment in proven use cases, battery advancements, and a reliable service network are essential for effective ZET adoption.
- Policy support for fast charging and a strong supply chain are critical for scalability.
- Making ZETs affordable and cost-effective is necessary for mass adoption and profitability.

Next Steps:

- Continue collaboration with key stakeholders to address operational and technological barriers.
- Focus on strategic deployment and building a reliable service network.
- Advocate for policy support to enhance fast-charging infrastructure and supply chain robustness.
- Work towards making ZETs more affordable and cost-effective for widespread adoption

Gearing for an E-Freight Future:
A Landscape Study and Favorability Analysis
