Title

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Authors
Ladha, Rijhul
Das Banerjee, Anannya
Bhattacharya, Tattaiyya
et al.

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Policy Interventions at a Sub-National Level

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Rijhul Ladha, Anannya Das Banerjee, Tattaiyya Bhattacharya, Aditya Ramji

India ZEV Research Centre, Institute of Transportation Studies, University of California Davis

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Abbreviations

AMC	annual maintenance contract
CAGR	compound annual growth rate
EV	electric vehicle
GHG	greenhouse gas
GSDP	gross state domestic product
GVW	gross vehicle weight
ICE	internal combustion engine
MHDT	medium & heavy-duty trucks
MHDV	medium & heavy-duty vehicles
MTPA	million tonnes per annum
MY	model year
NEV	new energy vehicle
NPV	net present value
OEM	original equipment manufacturer
TCO	total cost of ownership
USEPA	Unites States Environmental Protection Agency
VKT	vehicle kilometers travelled
ZET	zero emission trucks (e-trucks)

<u>Truck classes</u>

N1	trucks with maximum mass ≤ 3.5 tonnes (7,700 lb)
N2	trucks with maximum mass 3.5–12 tonnes (26,000 lb)
N3	trucks with maximum mass > 12 tonnes

Executive Summary

Road transport carries over 70% (3.2 of 4.6 billion tonnes) of India's annual freight demand. Over 95% of road freight is carried on an estimated 4 million medium and heavy-duty trucks (MHDTs). India annually registers about 22 million vehicles[1], of which MHDTs, with GVW> 3.5 tonnes are about 0.4 million. MHDTs are 40% of all commercial goods vehicles but carry over 90% of road freight demand. MHDTs account for less than 3% of all vehicles registered annually in India, yet they consume about 40% of the road transport sector's oil demand. As a result, MHDTs are the largest contributors to about 40% of direct vehicular CO_2 emissions and over 50% particulate matter emissions in the country. Hence, a transition to zero-emission trucks (ZETs) becomes crucial for achieving India's energy security and Net-Zero by 2070 goal.

India's electric vehicle (EV) mission is driven by multiple schemes at the central level and sub-national level EV policy respectively. While schemes provide demand incentives and encourage manufacturing of electric vehicles, the state EV policies provide important market signal for demand creation at a sub-national level and enable a cohesive environment for capital flow towards the EV ecosystem. Over 30 of 36 states and Union Territories in India have either a draft or notified state EV Policy that focuses on demand-side incentives including vehicle purchase subsidies, tax benefits, and incentives for charging infrastructure and supply side incentives that promote investments in EV manufacturing. Out of these, only about 8 states provide purchase subsidy while 16 states provide tax exemptions for light commercial vehicles (N1), and only 2 states provide for MHDTs yet. This presents an opportunity for inclusion of MHDTs in their EV Policy roadmap.

Telangana is the 9th largest state in the country, with a nominal gross state domestic product (GSDP) of INR 14.65 lakh crore in 2023-24. The state contributes to about 5% of India's nominal GDP. Reportedly, the state recorded a GSDP growth rate of 11% in the last decade 2014 to 2024, higher than the national nominal GDP growth rate of 9% over the same period. As of 2024, Telangana accounts for about 7% (323 billion tonnes km) of India's annual freight demand and has grown at a compound annual growth rate (CAGR) of 9.7% from 2014 (128 billion tonnes km).

During the same period, the commercial truck sales in the state have also grown at a CAGR of 9%. It increased from about 14,000 in 2014-15 to 33,000 in 2023-24. Our estimates suggest that the road freight demand in the state will increase to 500 billion tonne-kms with a corresponding increase in commercial trucks sales to about 48,000 by 2030. Additionally, as per the state logistics policy, the state envisions a ten-fold growth in the logistics sector by 2035 that will create demand for MHDT trucks. It has created subsequent investments stream to support large-scale domestic EV manufacturing as well. In 2023, the state endorsed Global MoU for ZET suggesting the need and intent for transitioning to e-trucks. E-truck adoption in Telangana will not just align with the states EV target and Net-zero ambition but also set a precedent for other states.

The state of Telangana is also one of the few states in the country that has notified a state-wide net zero energy goal for 2047. Transitioning to ZETs provides an avenue of opportunity to align road transport electrification goals with the wider net zero goals as well.

The study develops four policy scenarios to evaluate its sensitivity on the total cost of ownership (TCO) of e-trucks. The study assumes that the introduction of four policy interventions in an incremental timeline will make e-truck adoption an attractive proposition, resulting in a subsequent increase in the penetration of e-trucks. The policy interventions considered in the study includes (a) demand-side interventions, (b) supply-side interventions, (c) reduced cost of financing, and (d) disincentivising operating diesel trucks. Furthermore, the study evaluates the impact of four policy scenarios on fuel consumption, tailpipe CO_2 emissions, energy required for charging and cost of implementing the policy interventions.

Estimates suggest that by 2030, 2035 and 2040, Telangana is projected to have approximately 1.75 lakh (0.175 million), 2.12 lakh (0.212 million) and 2.45 lakhs (0.245 million) trucks on road considering the trucks registered in the state only. With all policy interventions described above in place for the threshold years, the annual sales share of e-trucks is expected to be at 8%, 16% and 24% respectively. The key findings suggest

(i) The transition to e-trucks would result in converting up to 11% of annual MHDT vehicle kilometres to zero-emission by 2040.
(ii) The transition is estimated to reduce diesel consumption by MHDTs sold in the state by up to 13% (about 350 million litres) by 2040 from the base scenario with no e-truck adoption.
(iii) The transition is estimated to reduce tailpipe CO_2 emissions from MHDTs sold in the state by up to 1 $MtCO_2$ (11% lower than base scenario) by 2040 from base scenario with no e-truck adoption.
(iv) The annual energy requirement for charging e-trucks is estimated to be 137-274 MWh by 2030 depending on e-truck sales, annual vehicle km travelled and improvement in specific energy consumption of e-trucks.
(v) This transition would require INR 680 -2,850 crore from FY 2026 - FY2030 to support all e-trucks, depending on the sales share of e-trucks reached in the state and policy interventions implemented by FY 2030.

Key recommendations for e-truck adoption

- **Localization of EV supply chains can make investment for Telangana Mobility Valley attractive for vehicle manufacturers**
  The localization of the EV supply chain including components such as battery, battery management systems, electric motors can reduce manufacturing costs of up to 10%, thereby bringing down the TCO of e-trucks by 4-7%. The continued supply-side incentives for EV and EV components manufacturers could bring investment for Telangana Mobility Valley.
- **Provision of interest subvention to finance ZETs in Telangana**
  A 5% interest subvention for e-trucks has the potential to improve the TCO for e-trucks by 7-10% in the N3 segment and 6% in the N2 segment. This can reduce the risk-premium for e-trucks ownership, thereby making adoption of e-truck an attractive proposition to diesel counterparts.
- **De-incentivizing operation of older diesel trucks can reduce the TCO for N3 e-trucks relative their diesel equivalents**
  Levying a green cess (surcharge on taxes by the state) of INR 0.5/litre on diesel, doubling the 'Green tax' on diesel trucks older than 7 years, and increasing the toll by 25% on diesel trucks can achieve TCO parity for N3 e-trucks and make N2 e-trucks 28% cheaper than their diesel equivalents.
- **Demand incentives for N2 e-trucks can make them cheaper than their diesel equivalents**

Demand-side incentives such as purchase subsidies, registration fee waiver, road tax exemption, and road toll waivers could make e-trucks in the N2 segment 12% cheaper than their diesel equivalents. Similar incentives could bring down the TCO gap between e-trucks and diesel trucks in the N3 segment to 20-25%.

- **Prioritization of electrification of truck segments up to 7.5T**
  Trucks in the 3.5-7.5T GVW category form the second largest selling truck category in Telangana. Their TCO could be made up to 20% cheaper than their diesel equivalent through policy interventions, making them viable for last-mile delivery applications in e-commerce and fast-moving consumer good sectors.
- **Develop charging infrastructure along highways to create opportunity for e-trucks**
  Achieving the state's target of developing charging stations at every 50 km on major highway sections and at sites with heavy industry clusters such as cement, steel, and mining would build confidence to commence pilots for closed-loop operations and ensure utilisation of charging infrastructure.

Chapter I

Background

Globally, road transport is the predominant mode of both freight and passenger movement. Freight movement in India accounts for 14% of the nation's GDP and therefore is a key determinant of the economic development of the nation. Road transport carries over 3.2 billion tonnes of freight, which is 70% of the 4.6 billion tonnes of freight lifted in the country and this demand is expected to triple from 2022 levels to 9.6 trillion by 2050[2]. India, at present, has about 4 million freight vehicles i.e., trucks in the N2, N3 classes[1]. (N2: maximum mass 3.5 -12 tonnes (7,700- 26,000 lb); N3: maximum mass > 12 tonnes (>26,000 lb). These are internal combustion engine vehicles (ICE vehicles) that predominantly run on automotive-grade diesel. Annually, freight movement in the country generates a transport demand of 2.2 trillion tonne-kilometres (tonne-km) at the cost of ₹9.5 lakh crore[3]. Ninety percent of this road freight movement is carried by medium and heavy-duty trucks (MHDTs), which account for less than 3% of all vehicles registered in the country annually.

In addition, the National Institution for Transforming India (NITI) Aayog estimated that the number of MHDTs is expected to more than quadruple, from 4 million in 2022 to roughly 17 million trucks by 2050. This growing demand for trucks would increase demand for over US$1 trillion of crude oil imports for diesel production by 2050. The road freight sector presently consumes about 70.5 million tonnes of oil equivalent (Mtoe), which is about 40% of road transport sector's oil demand[4] and emits 213 Mt of CO_2 annually. The transport sector is also the third largest direct GHG emitter (14%) with these emissions having more than tripled since 1990[5]. Subsequently, the road transport sector in India accounts for over 12% of national energy-related CO_2 emissions[4]. The MHDTs alone emanate about 35%-40% of direct vehicular CO_2 emissions, and 53% of particulate matter (PM) emissions in India[3]. The high impact on energy security, GHG emissions, and air quality along with nascent transition technologies and high costs make MHDTs a hard-to-abate vehicle segment in the context of decarbonizing transport.

As India looks forward to making progress on their Nationally Determined Contributions (NDCs) and Net-Zero commitments to reduce emissions, there is a growing need to address road transport emissions, particularly from the trucking sector. Freight electrification plays a crucial role in advancing India's Nationally Determined Contributions commitments, improving air quality and expanding technology-enabled domestic automotive manufacturing. Although schemes like the Faster Adoption and Manufacturing of Electric Vehicles (FAME) have accelerated electric vehicle adoption in the passenger segments, we are yet to a similar phenomenon for the trucks. As India aims to reduce its GHG emissions and enhance its energy security through reduced dependence on oil imports, transitioning to electric freight systems becomes a pivotal strategy.

Freight Ecosystem in Telangana

Telangana is one of the richest states, with the 9th largest state economy in the country, and it contributes to 5% of India's gross domestic product (GDP). It is also one of the newest states in India, since its formation in 2014-15, the state gross state domestic product (GSDP) has been growing at a rate of 13.2%, which is higher than the nation's GDP growth rate of 7.2%[6]. The state registers about 40,000 trucks annually, which is about 5% of what India registers annually.

The state's economy is dependent on its illustrious industrial ecosystem, supported by its strategic location in the southern part of the country. Telangana's capital, Hyderabad, serves as a major logistics hub, connecting northern and southern markets. Even though the state is a major hub for the IT and services sector, there are some major industrial hubs present across the state in Warangal, Mahbubnagar, and Karimnagar districts which are well connected with major cities such as Bengaluru, Chennai, Mumbai, and Pune. Major industries that contribute to the state's GDP are the pharmaceutical, manufacturing heavy machinery, and food processing sectors. The state benefits from a well-developed road and rail infrastructure with about 450 thousand MTPA warehousing capacity.

In the last 25 years (2001-25), India registered over 62 lakh (6.2 million) MHDTs, of which 16 lakhs (1.6 million) were registered in the last five years alone[1]. Out of about 3 lakh MHDTs registered annually in the country, about 3% comes from the state of Telangana[7]. Based on our estimates, Telangana has registered about 75,000 MHDTs between 2014 to 2025.

In the last 20 years, the road freight movement in India has seen a compounded annual growth rate (CAGR) of 9.6% from 0.5 trillion tonne-km in 2000 to 2.9 trillion tonne-km in 2020[8]. The freight volume in India is expected to reach 9.6 trillion tonne-km by 2050, which is almost three times the present value. The MHDTs registered in Telangana on an average comprise of 67% heavy-duty trucks (GVW > 12 tonnes) and 33% medium-duty trucks (3.5 < GVW<12 tonnes)[7]. The freight movement in the state is projected to increase, so does the demand for MHDTs with growth in GSDP and definite industrial and logistics policy targets.

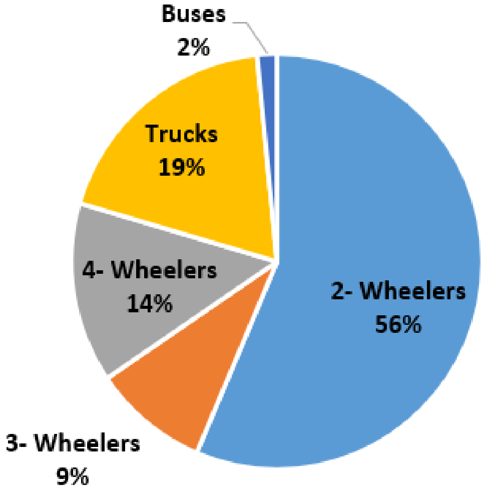
Imperative of ZET Policy in Telangana

The road freight sector can achieve 46% reduction in CO_2 emissions by transitioning to cleaner fuels and efficient vehicle technology by 2050.

The International Energy Agency (IEA) in its report (2023) on transitioning India's road transport sector has estimated that growing demand for freight transport could result in doubling the CO_2 emissions from the road transport sector by 2050 from 2023. However, NITI Aayog estimates that the road freight sector can achieve a 46% reduction in CO_2 emissions by transitioning to cleaner fuels and efficient vehicle technology by 2050[2]. These projections emphasize the need for immediate actions to transition the MHDT segment in India. Currently, India transports ~4.6 billion tonnes of freight annually, generating transport demand of 2.2 trillion tonne-kilometres (tonne-km) at the cost of ₹ 9.5 lakh crore[3]. In 2024, MHDTs constituted about 4% (0.88 million units) of all vehicles registered in the country, consuming over 25% of the nation's diesel imports but, in stark contrast, contributes to 34% and 53% of the CO_2 emissions and PM emissions from road transport, respectively[3,4]. This presents a dual challenge of meeting demand while keeping transport emissions in check.

Similarly, in Telangana, the road transport sector is the second largest source of CO_2 emissions[9]. MHDTs are the largest contributors to emissions from road transport. The sales share of MHDTs in total commercial vehicle sales has increased from 16% in 2019-20 to 21% in 2023-24, indicating a shift to higher GVW truck segments. This in turn increases CO_2 emissions from the road freight sector. Moreover, the ambient air quality has been deteriorating in Hyderabad, with increasing concentrations of particulate matter (PM10 and PM2.5)[10]. PM concentrations have been steadily increasing in Hyderabad since 2011, due to increased freight vehicles on account of it being a hub for e-commerce and the pharmaceutical industry and being a major transit point for industrial corridors within (to Warangal, Nalgonda, Mancherial) and through (to Vijayawada, Bengaluru, Nagpur) Telangana. As per the Transport Department of Telangana, the total vehicular pollution emitted in Hyderabad and Secunderabad alone is 1,500 tonnes per day[11]. The pollution load of CO, NOx, HC, SO_2 and suspended PM by different categories of vehicles is specified below in Figure 1.

Figure 1: Pollution load by different categories of vehicles in Telangana



Source: Transport Department, Government of Telangana, 2023

Telangana's Electric Vehicle Policy 2020 recognizes availability and accessibility of charging infrastructure as a pre-requisite for zero-emission transitions.

Telangana was one of the first states in India to adopt an Electric Vehicle and Energy Storage Policy in 2020. In addition to providing purchase incentives for small electric vehicle segments, the policy emphasized the development of charging infrastructure. Recognizing the need for accessible and widely available charging infrastructure to facilitate a zero-emission transport transition has been crucial. The policy designates TGREDCO (Telangana Renewable Energy Development Corporation) as the nodal agency for developing charging infrastructure in the state.

The state has set a goal of setting up an EV charging station every 3 kilometres (km) in cities[12]. TGREDCO also aims to establish public charging or battery swapping stations, develop a viable business model for private players to set up charging infrastructure, and provide charging stations every 50 km on national highways within the state for the passenger electric vehicle (EV) segment[13]. Currently, the state has nine fast chargers, each with an installed capacity of 120 kW. The increased adoption of ZETs is expected to drive investments in expanding charging infrastructure, eventually leading to higher utilization rates and better returns on infrastructure investment for charge point operators.

Telangana stands as the first Indian state to endorse the Global MoU for Zero-Emission Trucks (ZET), showcasing leadership and ambition for clean transport transitions.

Telangana stands as the first Indian state to endorse the Global MoU for zero-emission medium- and heavy-duty vehicles, showcasing leadership and ambition for clean transport transitions. Telangana's signing of the Global Memorandum of Understanding (MoU) for zero-emission medium- and heavy-duty vehicles displays vision and intent for including the hard-to-abate segment in the clean transport transition and opportunity to explore the development of fast charging infrastructure for ZETs[14].

The MoU pledges its signatories to have 100% of new truck sales to be ZEVs by 2040 and an interim 30% by 2030. This solidifies the clear intent to achieve zero-emission trucking through policy actions. This project also takes significance as the state of Telangana is preparing a roadmap for Net Zero by 2040 and addressing a hard-to-abate segment like MHDTs aligns clearly with those objectives.

Early adoption of ZETs in Telangana will set a precedent for other states and open the ZET market in the country.

Telangana's ambition of early adoption of ZETs can trigger certainty of ZET adoption within the state, thereby unlocking the domestic market in India. Furthermore, the Telangana state ZET policy would set a precedent, serving as an example for other states to emulate.

As of 2024, only about 400 e-trucks are deployed for closed-loop operations in pilot programs, either under the e-fast programme or through OEMs application testing with sectors such as the streel and cement industries. Even though there are ten e-truck models on the market, their overall sales penetration is minimal, making it difficult to project the e-truck growth in India.

Creation of Telangana Mobility Valley under provisions of the state EV policy to boost EV manufacturing

In one of the firsts in the country, the state of Telangana has envisioned the creation of the state's largest automotive manufacturing hub to attract investments in the manufacturing of electric vehicles including building Advanced cell Chemistry (ACC), energy storage systems, component manufacturing, and R&D in automotive. In February 2023, the Telangana government launched the Telangana Mobility Valley initiative during the Mobility Next Hyderabad Summit 2023. The Telangana Mobility Valley aims to attract investment worth Rs 50,000 crore (US $6 billion), generate 4 lakh jobs in 5 years, and promote mobility startups in the state. While most EV policies focus primarily on demand-side incentives, Telangana's emphasis on manufacturing and R&D can position it as a regional leader in EV manufacturing.

The 3000-acre valley will be a composite of four clusters: two OEM clusters at Zaheerabad and Seetharampur, an energy storage cluster at Divitipally, and an engineering innovation cluster at Yenkathala. As of Feb 2023, the state reports that it was successful in attracting investments of estimated worth Rs 8,000 crores (US $900 million) from new OEMs such as Olectra, Mytrah, Gravton, PureEV, One Moto, Etrio, Eto, and Lite[15]. Triton EVs have set up manufacturing plants for e-buses and have the potential to expand to electric trucks, especially given that they have a model ready for production in the medium-duty segment elsewhere in the world. A clear adoption framework could help in spurring the ZET manufacturing investments as well.

There are existing manufacturing units for e-buses and electric powertrains in the state, including Olectra, Triton EV, and Blackbuck EV. This provides scope for attracting investments from e-truck manufacturers. An adoption framework for e-trucks would give clear signals for sales to the industry to invest in manufacturing. This would also spur investment in developing charging infrastructure, as seen in California after the implementation of Advanced Clean Trucks (ACT) rules in 2020. The 2021 and 2022 Californian state budgets included a total investment of $10 billion over 6 years to reduce CO_2 emissions from the transportation sector by supporting ZEVs and ZEV infrastructure[16].

While there have been generous efforts at the national level to improve supply-side dynamics and create supply certainty and a market for zero-emission trucks, the Telangana Mobility Valley initiative can position the state advantageously at the sub-national and national levels.

Telangana's Industrial Policy envisions a tenfold growth in the logistics sector by 2035, which will generate demand for a 10-fold increase in vehicle kilometers travelled and subsequent emissions from logistics

Telangana is one of the fastest-growing economic hubs in India, with about a 12% annual growth in the freight industry. With the launch of Telangana Logistics Policy 2021-26 in conjunction with Telangana Industrial Policy 2015, the state envisions a tenfold growth in logistics by 2035, anticipating investment generation of Rs 10,000 crores[17]. The state also aims at developing robust logistics infrastructure, including multi-modal logistics parks and large-scale storage facilities. This would increase the demand and operational fleet of higher capacity rigid trucks and tractor-trailers for hub-and-spoke model-based logistics infrastructure development.

To prepare for the logistics sector, it is more crucial than ever for the state to implement a zero-emission truck policy with progressive sales targets to accommodate the anticipated demand

E-commerce as a driver for accelerated ZET adoption

With the IT industry boom in the 1990s, in Hyderabad since 2000 led to the establishment of large IT parks housing giants such as Microsoft, Google, Facebook, TCS, and Infosys, but also attracted e-commerce titans such as Amazon, IKEA, and Flipkart. Amazon has also set up one of its largest global hub in Hyderabad, further establishing the city as a major centre for generating goods movement. Manufacturing and service sectors together constitute about 80% of the state's economy[6].

Industry commitments can play a crucial role in accelerating clean transport initiatives for the state. Amazon plans to make Hyderabad city in Telangana, the home to its largest global hub, has set a target of deploying 10,000 electric delivery vehicles by 2025 across 20 major cities, including Hyderabad. Reportedly, Amazon India has met its 2025 goal in 2024[18]. Hyderabad is also home to IKEA's largest in-store facility, generating substantial intra-city and intercity goods movement. IKEA has committed to achieving 91% of its delivery trips with EVs by 2025 and has already transitioned to 100% EV last mile deliveries done with its under-3.5 tonne vehicle segment[19]. Currently, these last-mile delivery vehicles make up 88% of IKEA's overall EV transition target. For larger vehicles beyond 3.5 tonnes, IKEA has partnered with Ashok Leyland[20].

Other e-commerce giants such as Flipkart, Big Basket, and Zomato have similar commitments and are actively participating in campaigns to promote electric vehicle adoption. This growing awareness and involvement from major players can significantly contribute to Telangana's goal of EV adoption and further strengthen the EV manufacturing ambition of the state.

The transition to ZETs offers the opportunity to help advance the state's larger climate change commitment and create avenues for meeting renewable energy obligations.

Telangana identifies transportation as one of the key sectors for climate change mitigation for the state action plan on climate change (SAPCC). To meet the sub-national climate change target, all Indian states are mandated to formulate their SAPCC by the Ministry of Environment, Forests and Climate Change (MoEFCC). The SAPCC identifies a broad framework for enabling the adoption of low (and zero) emission vehicles, proposes interventions to enhance fuel-efficient vehicles and vehicles using alternate fuels and phasing out old polluting vehicles.

A shift to ZETs can help the state to not only meet its EV adoption target but also reduce vehicular tailpipe emissions, improve the state's air quality, and contribute towards targets for the transportation sector under the state SAPCC. Therefore, the ZET transition offers a clear opportunity and leverage to help advance the state's clean road transport transitions as well as its larger climate action.

Chapter II

Policy levers for statewide ZET adoption

At the national level policies are primarily focused on incentivization of the passenger segment (electric 2-wheeler, 3-wheeler, 4-wheeler, and public buses). The FAME 1 policy (from 2015-19) supported 2.8 lakh light-duty vehicles and 425 public buses, and the FAME 2 policy (from 2019-2023) supported over 14 lakh light-duty vehicles and about 5,600 public buses. These schemes also supported building charging infrastructure for electric vehicles. In addition, there were various regulations and guidelines for setting up the necessary infrastructure, such as those for charging for light-duty electric vehicles and e-buses including the Guidelines and Standards (2024) by the Ministry of Power, and Amendments to the Model Building Byelaws (2016) by the Ministry of Housing & Urban Affairs.

India currently does not have a specific transition target for trucks, but multiple deliberations are ongoing to push for a truck transition to electric.

On the supply-side regulations, Corporate Average Fuel Economy (CAFE) standards for light duty four-wheeler passenger vehicles were notified in 2017. As of 2024, the light-duty vehicle CAFE norms are being revised, while the fuel economy regulations for heavy-duty goods vehicles were yet to be formulated. However, in 2019 and 2022, fuel consumption standards were notified to regulate light-duty vehicles and MHDV models sold in the country.

In addition to national policies, Telangana's EV policy 2020 and recent update in 2024 aim to increase demand and production of electric vehicles. There are additional policies and regulatory provisions that impact the trucking ecosystem with potential expansion to support the electric transition of MHDTs (Table 1).

Table 1: State-level policies/acts that directly impact the trucking ecosystem

Timeline	Policy	Impact on the Trucking Ecosystem
2020	Telangana Electric Vehicle and Energy Storage Policy	No direct impact on trucks, but there is road tax and registration fee exemption for electric light commercial vehicles (GVW < 3.5 tonnes including electric 3-wheelers) & e-tractors.
2021	Telangana State Logistics Guidelines	Incentive support for fleet owners who buy at least 20 commercial vehicles in a year.
2022	Amendment to Telangana State Motor Vehicles Taxation (Acts & Rules)-1963	Enhancement of 'Green Tax' on trucks beyond 7 years of age.
2024	Intervention by Department of Transport, Telangana	Extension of 100% exemption from road tax and registration fee for all electric LCVs and e-tractors till end of 2026

Source: Collated by India ZEV Centre, ITS-UC Davis, 2024

Scope for inclusion of commercial vehicles in the state EV policy

Aligning with India's Vision EV30@30 and other state policies, the Telangana state EV policy was limited to passenger segment vehicles. Between 2020 to 2024, Telangana provided fiscal rebates in the form of 100% exemption of road tax and registration fee to push adoption of electric vehicles in the passenger vehicle and small last mile intra-city freight vehicles, for e-3 wheelers and light goods carriers it was capped to frst 10,000 to encourgae faster adoption[13]. Further from 2024 onwards, it increased the scope of the policy to exempt the fiscal rebates for all EVs registered in the state till FY 2026. This is estimated to save up to INR 1.5 lakhs for two-wheeler and Rs 3 lakhs for four-wheelers[21].

At a national level, for the first time in 2024, the Ministry of Heavy Industries allocated Rs 500 crore under PM e-drive for e-truck adoption. Our previous study[22] suggests that a strategic variable purchase incentive structure can cover 40–45% of the price difference of e-trucks over diesel trucks with GVW ≥3.5 tonnes in the next five years. E-trucks come with a price differential that can vary anywhere between 2-3.5 times higher than its diesel counterparts, indicating only a proportionally higher level of subsidy may be required to provide incentive to e-truck in the market.

As of 2024, about 30 states have a notified EV policy, and multiple states are on the verge of notifying their second phase of state EV policies. But Maharashtra is the only state to have a specific structured incentive for e-trucks. Under the e-FAST[23] India program, multiple sectors, such as steel and cement, have commenced e-truck pilots for their closed loop operations. It should also be noted that these sectors also have their Net Zero commitments to transition faster[24]. Such policies will favour faster transition in such use cases, thereby aiming for faster economies of scale in this segment. EV policies provide an avenue at the sub-national level to create a framework for wider e-truck adoption in the state.

Introduction of Green tax to restrain polluting fossil fuel vehicles in the state

In 2022, the state of Telangana introduced the 'Green tax'[25] under section 3-B of the Telangana State Motor Vehicles Taxation (Act 5 of 1963), applicable for all transport vehicles that carry goods except for three-wheelers below GVW of 3.5 tonnes. The tax is levied quarterly on the basis of GVW and age of the truck, excludes vehicles operated exclusively by liquefied petroleum gas, compressed natural gas, battery, or solar power (Table 2). The Green tax increases with the increasing age of vehicles (Table 2).

Table 2: Quarterly tax rates per vehicle in Telangana for trucks

GVW (tonnes)	Quarterly tax rate per vehicle (INR)
3 to 4.5	1,200
4.5 to 5.5	1,595
5.5 to 9	2,435
9 to 12	3,050
12 to 15	3,710
More than 15	3,710 + 360 per tonne

Source: Transport Department, Government of Telangana, 2022

Table 3: Green tax rates per vehicle for trucks in Telangana

Age (years)	Rate of Green tax per vehicle (INR per annum)
7 to less than 10 years	Half of the Quarterly tax
More than 10 to less than 12 years	Quarterly tax
More than 12	Twice the Quarterly tax

Source: Transport Department, Government of Telangana, 2022

State logistics policy emerges as a low-hanging opportunity to leverage adoption of EV truck fleet for logistic operations

The state's draft logistics policy 2021 with a five-year timeframe aims to boost growth in the logistics sector through the increase in private sector investments and cost optimization in logistics[17]. This policy aims to support purchase of high-capacity commercial fleets in the state by providing demand-side incentives such as reimbursement of vehicle registration costs and national permit costs to entities that buy at least 20 commercial vehicles in 1 year. While this mandate applies to all trucks above 15 tonnes registered in Telangana irrespective of their fuel types, it creates an opportunity for e-truck adoption (Table 4).

Table 4: Exemptions for truck fleet as per the state's logistics policy

Vehicle Class	Gross Weight (Tonnes)	Reimbursement Amount
Non-reefer Truck	Greater than 30 MT	Vehicle Registration Cost- 100% National Permit Cost- 100%
	More than 20 MT & Less than 30 MT	Vehicle Registration Cost- 50% National Permit Cost- 50%
Reefer Truck	More than 15 MT	Vehicle Registration Cost- 100% National Permit Cost- 100%

Note: The reimbursement of registration cost is one-time, whereas national permit costs can be reimbursed for 5 years. Source: Industries & Commerce Department, Government of Telangana, 2024

Learnings from global pathways for ZET Adoption

As the focus on electrifying road transport expands beyond light-duty vehicles, the ambition to electrify MHDTs takes centre stage in India. Since 2021, there has been growing momentum to adapt and electrify this hard-to-abate segment, particularly in an accelerated manner.

Globally, we have witnessed how the United States Environment Protection Agency (USEPA) and European Commission have been able to implement incrementally stronger fuel economy norms and emission regulations to achieve clean vehicles target. In addition, over 15 cities across the world - including London, Los Angeles, Quito, Madrid, and Seoul - are implementing zero-emission (green) zones for freight. Delivery and freight vehicles may enter these zones only if they are zero-emission vehicles. California's Advanced Clean Cars (ACC) and Advanced Clean Trucks (ACT) rules for light-duty and heavy-duty vehicles, respectively, have increased clean vehicle adoption through mandatory sales targets that incorporate self-financing options such as credit trading for OEMs.

As a result of these efforts, ZET sales around the globe have grown rapidly. Reportedly, in 2023, 54,000 e-trucks were sold globally 70% of them in China, 20% in Europe, and 5% in the USA, making these the largest of the e-truck markets. This is barely 1.2% of all trucks sold globally, but this was a 35% jump from 40,000 e-trucks sold in 2022. China is also the market to 60% of e-truck models available globally. In terms of adoption volume, while most economies are still at the bottom of the growth curve and, like India, are implementing pilots, China is the only country to have demonstrated a large-scale e-truck adoption across applications[26].

Global best practices suggest efforts in concerted clean transport vision, EV policies, aggressive policy targets, fuel economy regulations, sales targets, and investments to drive faster e-truck adoption. Global campaigns such as the Global Memorandum of Understanding for ZET adoption, EV 100 by the Climate Group, and NITI Aayog's E-fast campaign has further contributed to the efforts. As of 2024, the Global MOU was signed by 38 countries and over 70 sub-national governments, including Telangana in 2021. This raises the commitment to 100% ZETs by 2040, with an interim goal of 30% ZET sales by 2030.

Table 5: Comparison of zero-emission truck adoption targets across Europe and the United States

Region/ Country	Target	Policy Type	Target Year	Adoption Year
EU-27	Austria - 100% of ZETs (<18T) and 60% ZET (N3)	Ambition	2030	2021
	Finland - Cumulative 5 400 ZETs	Ambition	2030	2021
	France - 65 000 low-emission HDVs	Target	2028	2020
	Germany - 33% of heavy road haulage kms to be zero emission	Target	2030	2022
United States	California - 40 – 55% of new truck sales to be zero-emission in 2035 across different segments	Target	2035	2020

Note: Ambition is non-binding, and target is a binding policy. Source: Collated by India ZEV Centre, ITS-UC Davis from the Council of the European Union (2024a), California Air Resources Board (2021); IEA (2023), and Federal Ministry, Republic of Austria (2021).

The regulatory efforts to push ZET adoption globally can be summarised in 4 broad categories as described below:

i. Sales mandates to drive ZET adoption

Sales mandates for clean vehicles are an effective policy tool to accelerate the adoption of cleaner vehicles in all segments, including MDHTs. Governments can ensure a gradual but steady increase in the share of ZETs in the market through an incrementally increasing and legally binding requirement for manufacturers. These mandates bind OEMs to manufacture a certain percentage of ZEVs in the product mix to be able to meet the ZEV sales as a percentage of total sales within a specified timeframe. Sales mandates are often successful in creating a predictable market for vehicles and attracting demand from the industry use cases.

Several states in the United States have its state-level ZET sales requirements. California state, in 2020 adopted the ACT regulations that prescribe MHDV manufacturers to sell an incrementally higher percentage of zero-emission trucks from model year 2024. The state also adopted the Advanced Clean Fleets (ACF) regulation in 2023 which stimulates demand for zero-emission commercial vehicles by requiring large private and public fleet owners to purchase an increasing percentage of zero-emission MDVs and HDVs over time.

ii. Fuel economy norms and emission standards to drive ZET adoption

Stringency in fuel economy norms has been the most effective tool for causing a long-term transition to cleaner trucks. Manufacturers are able to comply with fuel economy norms including in their product offerings a higher share of zero-emission vehicles, including electric trucks. The stricter emission standards aim at the reduction of vehicular emission in an area, often leading to an increase in cleaner vehicles in the sales proportion.

United States – The USEPA has published Phase 3 of GHG emissions regulations and multi-pollutant emissions standards for MHDVs applicable from the model year (MY) 2027 to MY 2032 and beyond. The standards for HDVs propose a reduction of 15-53% from MY 2027 to MY 2032 for vocational vehicles, about 26% for tractors, and 15% for heavy-haul tractors. The regulations for

MDVs propose a 40% reduction in fleet-average CO_2 emissions along with a 66% reduction in fleet-average non-methane organic gases (NMOG) and NOx emissions by MY 2032 from MY 2027 (Environmental Protection Agency, 2023). The USEPA emission regulations Phase I for MY 2014 to 2018 and Phase II for MY 2021 to 2027 were announced in 2011 and 2016, respectively.

European Union – In 2019, the European Union set CO_2 emission performance standards for MHDVs requiring a 15% reduction by 2025 and 30% by 2030. It was appliable to rigid and tractor trucks with a GVWR of 16 tonnes and above[27].

China **–** China's fuel consumption targets for HDVs are similar to US and EU equivalents. Unlike the US with GHG emission reduction targets and EU with tailpipe CO_2 emission reduction targets, China has adopted fuel consumption targets.

iii. Demand-side policies for Zero-emission trucks

Demand-side interventions have been the most effective tool to initiate a category creation, which in this case is electric trucks. In the case of zero-emission trucks, major markets such as the US and the EU are providing purchase incentives based on truck classes (elaborated in Annexure A.1. Similarly, Canada has introduced the Incentives for Medium and Heavy Duty Zero Emission Vehicles (IMHZEV) Program in 2022, which provides purchase incentives of up to 2,00,000 USD for the purchase of electric trucks[28].

Designing purchase incentives is crucial and one must consider multiple factors such as increase in price due to change in technology, quantity of subsidy price, disbursement of incentives, eligibility for incentives, flexibility mechanism to access incentives, and any compliance mechanism. An inadequate incentive program without any regulatory interventions to create a market can lead to market price distortion, and limit technology innovation, impacting market scale and model availability. An inadequate program can also trigger reliance on a new product based only on demand incentive, and often it can fail to create a long-term impact for transition[22].

- Price differential between a Battery Electric and ICE truck **-** Provides a better understanding of the viability gap between different powertrains. Further, it enables an assessment of the role of upfront price subsidies in relative terms to other incentives, such as lower energy costs, toll and tax waivers, and interest rate subventions.
- Quantum of the purchase incentive as a function of the price differential **-** Typically, incentives are designed to cover anywhere up to 80% of the incremental cost of e-trucks over diesel trucks, with purchase incentives covering about half, and the remaining can come from other operating cost incentives and technology innovations from manufacturers.
- First come, first serve is the most effective incentive implementation process, especially in early market transformation. It benefits both OEMs and end-users by incentivizing them to transition faster and drives overall market demand.
- Incentives should be decoupled from market and ownership parameters, i.e. they should not be restricted to use cases or public or private fleets. In early market conditions, with lack of clarity on viability of e-trucks and the financial risk appetite of fleets to adopt such vehicles, incentives should support the development of e-trucks in different segments allowing for private and public market stakeholders to make decisions for deployment and scale.
- Encourage flexibility in incentive utilization **-** Incentive utilization criteria should not be restricted to specific truck categories, fleet application, or highway corridors only,

because in early market conditions many niche applications will emerge that will likely deploy e-trucks, including the private sector. The incentive program should also be flexible in responding to emerging market trends and model availability.

- Streamline compliance requirements with limited complexity for early market creation. While eligibility criteria for incentive disbursement are important, the processes and ability to access these incentives should be relatively simple, as high complexity in incentive eligibility requirements can negatively impact the market.

iv. Air pollution and emission reduction policies to fund state-level ZET adoption

While the national policies set ambition and direction, the state-level policies drive responsibility at the regional level. Globally, we have witnessed multiple countries scale their e-truck adoption through attractive incentive programs at the state level, largely motivated by improving ambient air pollution and reaching vehicle emission reduction targets.

In the United States, 29 states, including California, have funded ZET adoption through national and state-level schemes, voucher incentives, and grants. Federal funds that had state-level provisions include the Diesel Emissions Reduction Act (DERA) fund, the National Highway Traffic Safety Administration's Congestion Mitigation and Air Quality (CMAQ) fund, and the Volkswagen Settlement Fund (VW Settlement). In addition to these, multiple states had their own funding sources. Examples include California's General Fund (GF), Air Quality Improvement Program (AQIP), Air Pollution Control Fund (APCF), Congestion Mitigation and Air Quality (CMAQ) Improvement Program, and Greenhouse Gas Reduction Fund (GGRF); the Regional Greenhouse Gas Initiative (RGGI) fund in New Jersey and Massachusetts; Chicago's Voucher incentive program; and New York's Truck voucher incentive program[29,30].

As of 2024, the EU probably has one of the most stringent pollution regulations to drive the adoption of e-trucks. In addition to fuel economy norms, the commission has applied a "polluters pay" principle to freight movement on trans-European transport (TEN-T) network roads by adopting a directive that offers up to 75% toll discounts to zero-emission MHDVs, among other ZE vehicles, starting in 2024[31].

In terms of key takeaways, each country has focused on its strengths and tailored its strategies according to its commitments and needs. In the US, policies emphasize a mix of federal and state-level incentives, which help lower upfront costs of ZETs through subsidies, tax credits, and operational incentives such as reduced tolls. Europe's strategies centre around strict emissions regulations, fines for non-compliance, long-term carbon reduction targets, and extensive investment in public charging infrastructure, especially along major freight corridors, which could guide Telangana in building a supportive charging network. Meanwhile, China's approach focuses heavily on supporting domestic ZET manufacturers; supporting battery-swapping in closed-loop operations for ports, steel, and mining industries; and implementing large-scale rollouts within designated clean zones and urban centres.

Stakeholder mapping for implementing ZET transition in the state

Successful deployment and integration of ZETs into the transportation framework necessitate a holistic and collaborative approach involving multiple governmental departments. While each department has specific responsibilities, they work in tandem to address the diverse facets of the ZEV ecosystem from infrastructure and regulatory measures to technological advancements and economic incentives.

From the state EV policy Phase I implementation, it can be concluded that there are three key departments at the sub-national level to orchestrate the implementation of the EV Policy in the state. Led by the Department of Industries and Commerce (I&C), the Telangana State EV policy recognizes the role of Telangana Renewable Energy Development Corporation (TGREDCO) and the Department of Transport. Different stakeholders play a specific role in ensuring an effective policy implementation. As per the assessment, the detailed impact and the role each stakeholder will play in creating a sustainable e-truck ecosystem is given below (Table 6).

Table 6: Stakeholder mapping for e-truck ecosystem in Telangana

Function	**Government Bodies**	**Role**
Manufacturing	Department of Industries and Commerce (I&C) Commissionerate of Industries	Creating a market supply for electric trucks
Vehicles (license, permit, taxes)	Department of Transport	Registering vehicles in the state, issuing permits Issuing licenses for drivers
Charging infrastructure	Telangana Renewable Energy Development Corporation Ltd. (TGREDCO)	Identifying the demand for charging stations, creating a sustainable business solution and aggregation
Energy supply, Tariff	Telangana Electricity Regulatory Commission (TGERC)	Identifying the need for different tariffs and regulations
Land regulatory agencies	Hyderabad Metropolitan Development Authority, Municipal Corporations	Provisioning land for developing charging infrastructure
Air quality monitoring	Telangana Pollution Control Board (TGPCB)	Support for e-truck adoption due to their role in air quality improvement

Source: Collated by India ZEV Centre, ITS-UC Davis, 2024

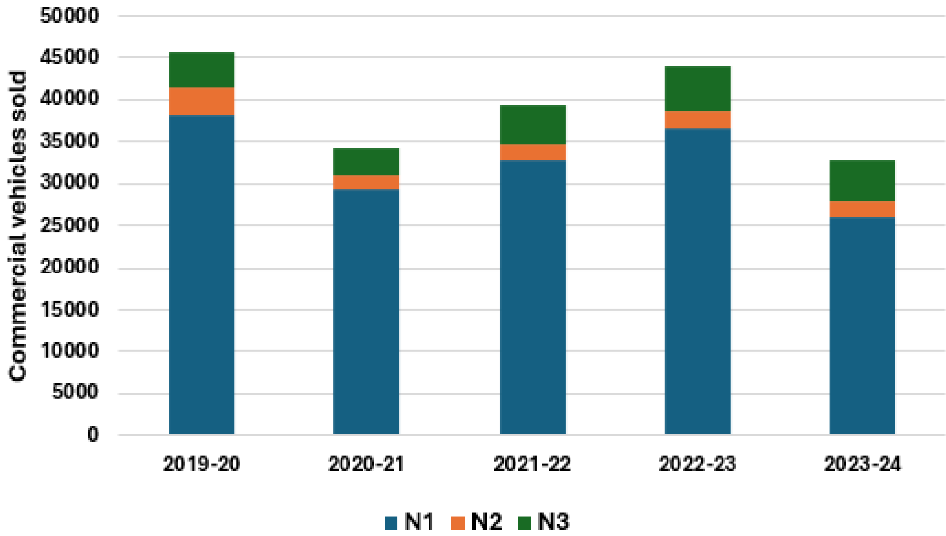
Chapter III

Evaluating MHDT market in Telangana

Commercial vehicle sales in Telangana account for 5% of commercial vehicle sales in the country.

Telangana annually registers about 12,38,000 vehicles, of which about 40,000 (3%) are commercial vehicles. Annual sales data from 2019 to 2024 suggests that of commercial vehicle sales, light commercial vehicles (LCVs) (or N1 category with GVW<3.5 tonnes) constitute about 83%, and medium (N2 with GVW between 3.5-12 tonnes) and heavy-duty (N3 with GVW>12 tonnes) commercial vehicles constitute an average of 5% and 12%, respectively (Figure 2)[7].

Figure 2: Commercial vehicle sales in Telangana from 2019-20 to 2023-24

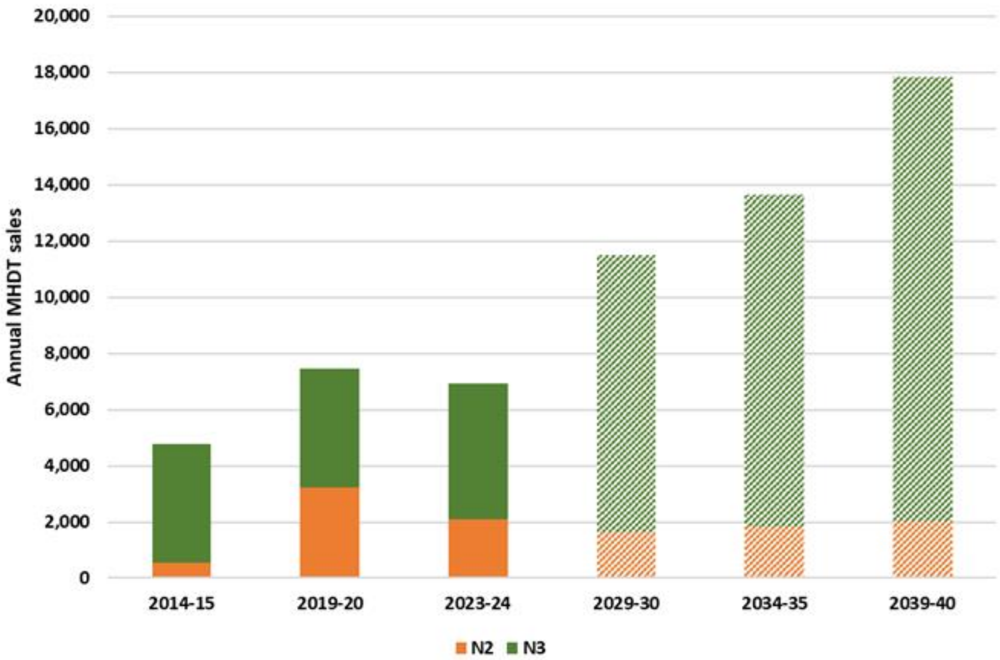


Source: Collated by India ZEV Centre, ITS-UC Davis from Open data portal, Government of Telangana, 2024

Telangana is estimated to register about 48,000 commercial vehicles by 2030

Telangana registered about 33,000 commercial vehicles in 2023-24, of which MHDTs constituted only about 5% and 12%, respectively[7]. The annual commercial vehicles sales are projected to grow at a CAGR of about 5% and increase to 48,000 by 2030, of which about 25% (12,000) would be MHDTs (Figure 3). Since the sales in the Indian trucking industry follow a cyclic nature with a period of 4-5 years, an exponential forecast function is used to project truck sales for Telangana. The projection factors the state's projected growth in freight and historical GDP.

Figure 3: Estimated MHDT sales in Telangana till 2040



Source: Authors' analysis from Open data portal, Government of Telangana, India

The share of MHDTs in commercial vehicle sales in the state is estimated to increase from about 21% in 2024 to 24% by 2030 and 33% by 2040, showing a shift towards higher GVW vehicles.

Within the MHDT segment, the share of N2 trucks is one-third and N3 trucks is two-thirds at present. The annual sales trucks in the N2 segment in the future are estimated to remain around 2,000, but the sales in the N3 segment are estimated to grow 3-fold by 2040: from 5,000 in 2023-24 to more than 15,000 by FY 2039-40 (Table 7).

Table 7: MHDTs sales in 2023-24 and sales projections in Telangana

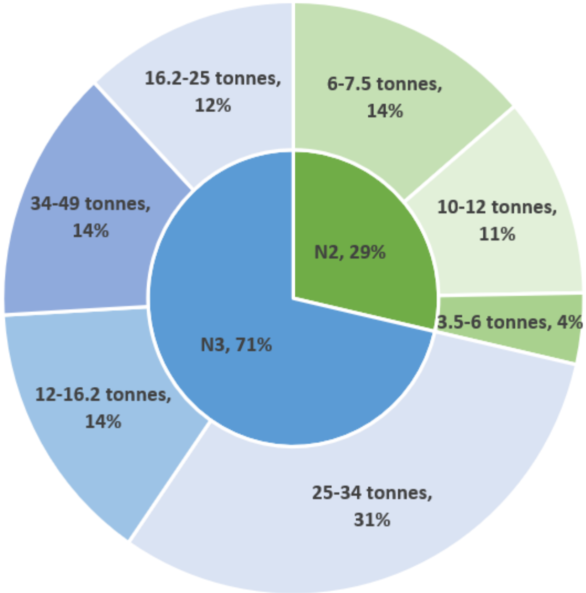
	2023-24	**2029-30**	**2034-35**	**2039-40**
N2	2,081	1,630	1,824	2,006
N3	4,846	9,871	11,834	15,817
Total	6,927	11,501	13,658	17,823

Source: Open data portal, Government of Telangana, India

N3 contributes to 70% of MHDT sales in the state

Freight movement in the country is carried by a diverse set of truck models that can be categorized into seven weight categories. Segmentation of the MHDT market in Telangana suggests that the truck market in the state is dominated by the segment with GVW 25-34 tonnes, contributing to 31% of total MHDT sales. This category is largely used for dry goods such as grains, cement, minerals, and packaged goods. Other categories that dominate the market are GVW 12-16.2 tonnes, which predominantly carries e-commerce & other white goods; 34-49 tonnes constitute 14% and carries construction material; and lastly 6-7.5 tonnes, which constitute another 14% and provide urban last-mile services[7] (Figure 4).

Figure 4: MHDT sales breakup in Telangana by GVW for 2023-24



Source: Authors' analysis based on vehicle sales data from Open data portal, Government of Telangana, India

Evaluating impact of state's freight demand on MHDTs

Telangana generates about 7% of India's annual freight demand

The state generated 7% of the country's annual freight demand accounting for about 128 billion tonnes km in 2014 and this has grown to about 323 billion tonnes km in 2024 with a CAGR of 9.7% over the last decade.

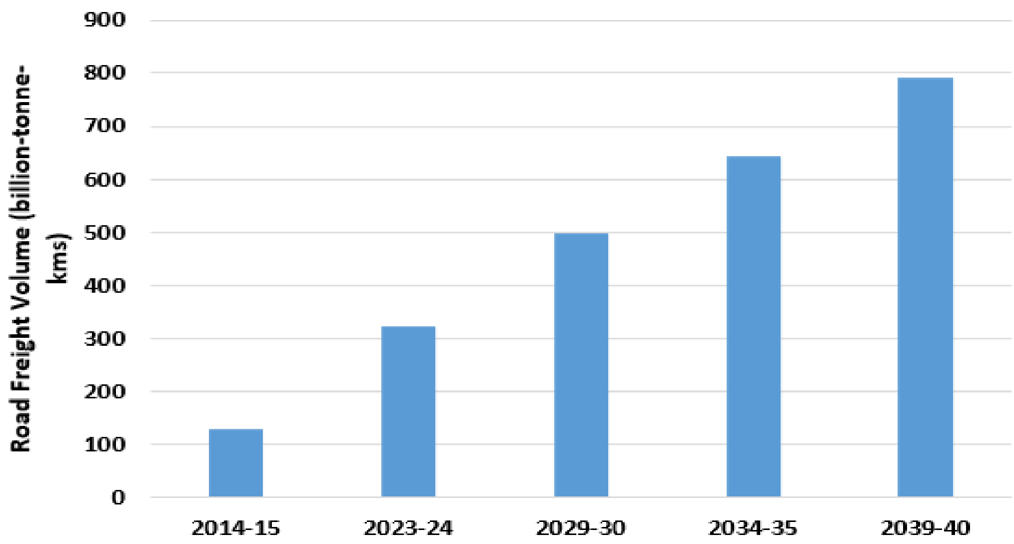
As per data from the Telangana socioeconomic survey 2024, the state has over 4,900 km of National Highway, which is about 5% of the total roads in the state[6] . According to the LEADS Report 2022, the state also has 450 thousand metric ton per annum of warehousing capacity including central, state, and privately-owned warehouses[32].

The state's freight ecosystem plays a crucial role in India's broader logistics and transportation network, given its strategic location in the southern part of the country. Telangana's capital, Hyderabad, serves as a major logistics hub, connecting northern and southern markets. The state benefits from a well-developed road and rail infrastructure, with national highways such as NH-44 and NH-65 passing through the state and connecting other major cities such as Bangalore, Chennai, and Pune, enabling efficient movement of goods across state borders. This study looks at the logistical, road freight, and industrial profiles to understand the ecosystem in the subsequent sections.

The increase in commercial vehicles sales directly correlates with the increase in road freight demand in the state

The road freight demand in the state has grown from about 130 billion tonne-kms in 2014 to about 320 billion tonne-kms in 2024, with a CAGR of 9.7%. The commercial vehicle sales have grown with a similar CAGR of 9% over the same period. As per our estimates, with a corresponding growth in state's GDP, the road freight demand is expected to grow to about 500 billion tonne-kms by 2030 with a CAGR of 6% (Figure 5) considering a constant share of the state's GDP in national GDP. This also corresponds to an increase in commercial vehicle sales in the state.

Figure 5: Estimated freight volume of Telangana till 2040

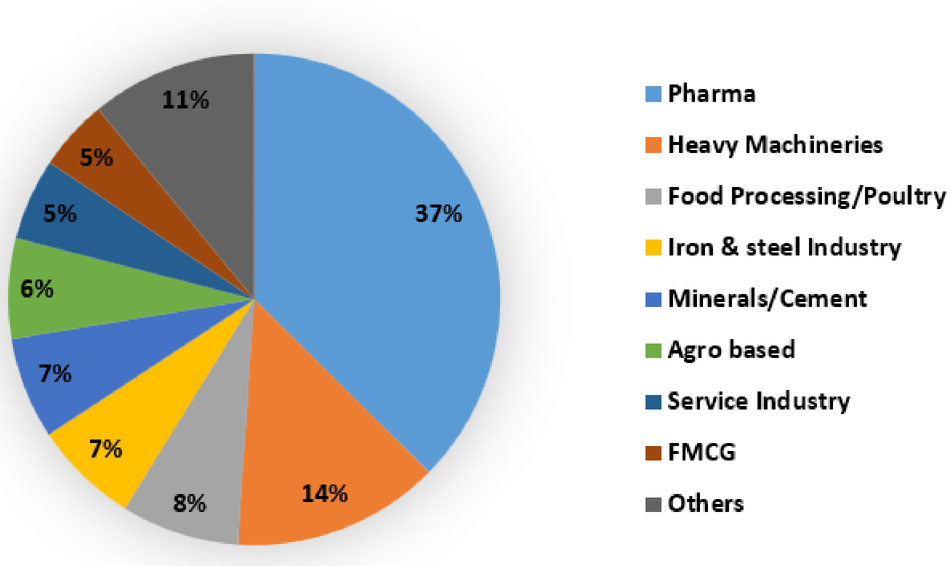


Source: Road Transport Yearbook 2019-20, MoRTH, India, 2024

Six major industry sectors generate about 75% of manufacturing GSDP in the state

The demand for trucks completely depends on its use case and the industrial sector has a direct impact on generating road freight demand for carrying raw materials and finished goods within and outside the state. Our assessment finds that six major industries such as pharmaceuticals, heavy machinery & automotive components, food processing, minerals & cement, and iron & steel industries contributed about 75% of the manufacturing gross state value added of the state in 2021-22[33] (Figure 6). The mining-quarrying and construction sub-sectors contribute significantly to the state's economy; the state has abundant granite and coal mines which witness growing demand for construction activities in the urban and industrial areas.

Figure 6: Distribution of Industry by their contribution to Telangana's economy



Source: Annual Survey of Industries report 2021-22, MoSPI, India, 2024

Table 8 : Description of industry sectors in Telangana

Pharmaceuticals	Includes all industries related to the manufacturing of pharmaceuticals, medicinal chemicals, and botanical products
Heavy Machinery	Includes Electrical/Electronic Machinery, Automobile, Defence & Aerospace related industries
Food Processing/Poultry	Includes plant-based & animal-based processed food industries
Iron & steel Industry	includes Iron/Steel and Metallurgy related industries (doesn't include quarrying)
Minerals/Cement	Includes all industries related to the production of cement, granite, glass & non-glass products
Agro based	Includes agriculturally based & Chemicals/Fertilizers related industries
Service Industry	Includes all service-based industries
Fast moving consumer goods	Includes tobacco, consumer products
Others	Includes other manufacturing services (5%), wood/ timber (0.5%), leather (0.1%), paper (5%)

Source: Annual Survey of Industries report 2021-22, MoSPI, India

Establishing MHDT truck use cases in Telangana

Each MHDT GVW category finds about 2-3 major use cases in the state

The study analysed 8 use cases based on the stakeholder engagements with manufacturers, shippers, and logistical service providers in the state. Each of the use cases is characterized by daily movement between origin and destination along with resting stops. In this case, 8-10 hours of movement with 1-2 hours/day of resting time has been considered for each use case, except for last-mile distances, i.e., 20-50 km. The fleet operators that were consulted had various fleet sizes ranging from 5 trucks to more than 10,000 trucks. None of these operators were currently operating battery-electric trucks.

Table 9: Segmentation of the MHDV truck market in Telangana

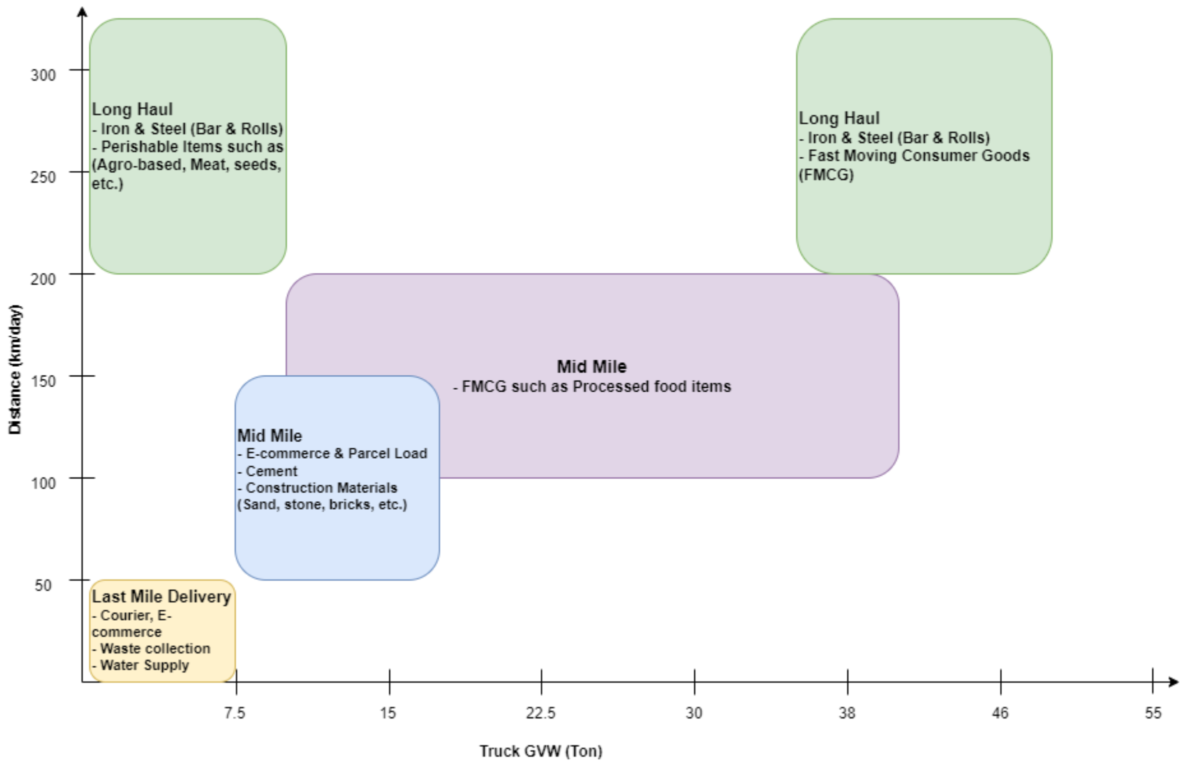
Truck GVW range (tonnes)	Truck Type	Mapped Use Case	Distance (km/day)	Range
3.5 - 7.5	N2- Rigid Body	Courier/E-commerce	20 - 50	Last Mile
	N2- Tippers	Waste Collection		
	N2- Tankers	Water Supply		
7.5 - 12	N2- Rigid Body	E-commerce/ Parcel Load	50-150	Mid Mile
		Construction Materials	100-150	
		Perishable Items	200-300	Long Haul
	N2- Tippers	Cement	100-200	Mid Mile
12 – 25	N3- Rigid Body	E-commerce/ Parcel Load	100-200	
25 - 35	N3- Rigid Body	Fast moving consumer goods	100-200	
	N3- Tippers	Cement	100-200	
35 - 55	N3- Rigid Body	Fast moving consumer goods	100-200	
	N3- Tractor Trailers	Iron & Steel (Bars & Sheets)	300-350	Long Haul

Source: Collated by India ZEV Centre, ITS-UC Davis based on stakeholder engagements, 2024

The use case classification given in the Table 9 has been made based on GVW and range. Any distance less than 50 km/day falls under the last-mile range. The distances (km/day) between 50 – 200 km/day fall under the mid-mile range, and beyond 200 km/day fall under the long-haul range. The most common use case is the e-commerce segment/courier/parcel load which is seen across all GVW segments. Within short distances, i.e., between warehouses or warehouse-consumer, the smaller GVW trucks (3.5-7.5 tonnes) are used. Also, waste collection and water supply are other use cases that fall under the same GVW and range. A larger portion of the truck segments between GVW 10 and 40 tonnes operates in the mid-mile range, i.e., between 50 and 200 km for intercity or interstate operations. This portion includes e-commerce, cement, construction materials, and fast-moving consumer goods use cases. Long-haul range, i.e., 200 km/day and beyond, consist mostly of iron & steel bars or rolls that are carried from ports and railway yards to their respective manufacturing locations, as well as perishable goods such as processed agricultural and meat-based products. In the case of mid-mile and long-haul, the number of trips made per day by the truck may or may not be one, depending on the case-specific origin and destination routes.

A summary of the use case mapping is provided in Figure 7 based on truck GVW (x-axis) and distance travelled per day (y-axis). The categories are divided into three main transport segments: last-mile delivery, mid-mile, and long haul, which correspond to various types of freight operations based on the nature of goods transported and the distance they cover.

Figure 7: Use Case mapping for Trucks in Telangana

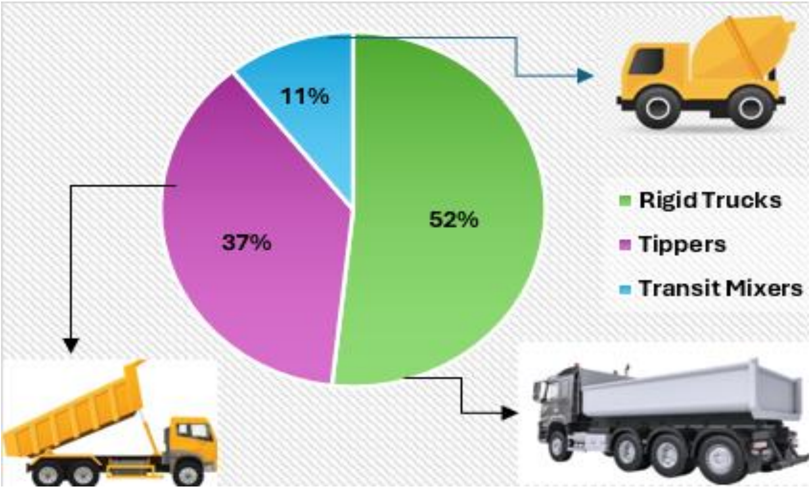


Source: Authors' analysis based on stakeholder engagements, India ZEV Centre, ITS-UC Davis, 2024

Rigid body trucks and tippers contribute 90% of MHDT sales in the state

Among the truck type, rigid trucks and tippers contributed to over 90% of the MHDT sales in 2024 (see Figure 8). Among the GVW categories of 6-7.5 tonnes and 12-16.2 tonnes, rigid trucks are the dominant truck types sold. They are used for urban and regional delivery applications suitable for the hub and spoke model. They are also used for mid-mile operations in industries including pharmaceuticals, engineering goods, and fertilizers. The highest sales share of rigid truck types corresponds to the manufacturing sector's contribution of about 50% to the state's gross state value added (GSVA) in 2023. Tippers dominate the sales in the GVW 25-34 tonnes category. They contribute to the freight movement in the mining, quarrying, and construction sub-sectors, which made-up about one-third of the state's gross state value added in 2023. The MHDT sales in the state match the dominant use cases identified from Telangana's industrial ecosystem review and stakeholder consultations held in the state.

Figure 8: Sales share of medium & heavy-duty truck types in 2023-24 in Telangana



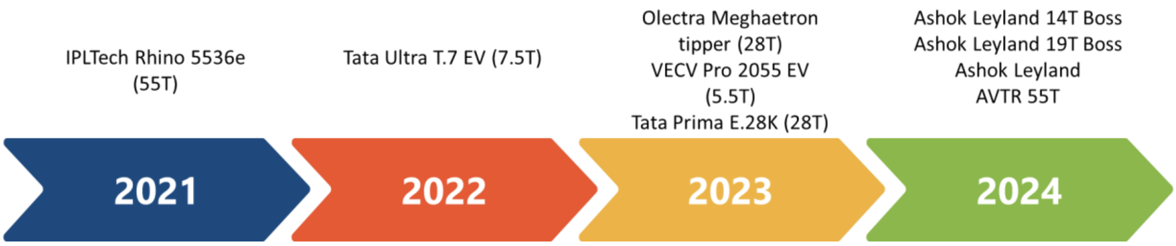
Source: Open data portal, Government of Telangana, India, 2024

Sales of vehicles in a particular state don't guarantee its usage within the same state limits

Even though Telangana registers 5% of all trucks registered in the country, the actual number of trucks operating in the state are much more. Our discussion with the Freight Vehicle Association in the state suggest that as high as 70% of vehicles associated with them are registered in other states[34].

Over the last couple of years, conventional MHDV OEMs namely Ashok Leyland, Tata Motors, Olectra, Volvo Eicher Commercial Vehicles (VECV) have already introduced 8 new e-truck models in 7.5 tonnes, 14 tonnes, 18 tonnes, 28 tonnes and 55 tonnes categories (Figure 9). These OEMs are prepared to launch about seven more e-truck models in the market by 2030. In addition, the market has already witnessed IPL Tech, an all-electric OEM that has emerged as a promising player in the 55-tonne category. Other startups like Tresa Motors, Blackbuck, and a few more promise to revolutionize the e-truck market with their efficient models. All these efforts have been successful in creating a positive signal for an e-truck transition in India.

Figure 9: Timeline of e-truck models launch in India



Source: Collated by India ZEV Centre, ITS-UC Davis, 2024

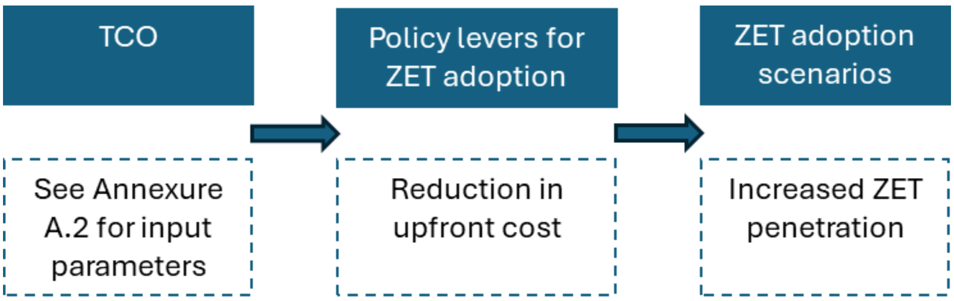
Chapter IV

Techno-economic feasibility for transition to ZETs

This chapter discusses the techno-economic feasibility of transitioning to ZETs in the state. The analysis follows a three-step process: (a) assessing the Total Cost of Ownership (TCO), (b) introducing policy levers, and (c) modelling ZET adoption scenarios.

Approach to assessing the total cost of ownership (TCO) of e-trucks

The study uses the 2024 WRI-UC Davis TCO tool as a base model to estimate the total cost of ownership for e-trucks in the state. Secondly the study assumes policy levers for ZET adoption and that respective policy levers will have a certain impact on the e-truck penetration scenario in the state.



For near accurate assessment of the operational viability of e-trucks in the state, the analysis incorporated operational parameters from the best-selling diesel truck models specific to the region and its respective EV variants. The e-truck market in India currently has about 8 e-truck models across GVW categories including 7.5-9 tonnes, 14 tonnes, 18 tonnes, 28 tonnes, and 55 tonnes.

According to Telangana's annual vehicle sales data, trucks in the 25-34 tonnes GVW, 12-16.2 tonnes GVW and 6-7.5 tonnes GVW (Figure 4) segments are the most sold segments, and therefore corresponding e-truck models are considered as reference models in this study (Table 10).

Table 10: Reference models for techno-economic viability of e-truck transition

GVW category (tonnes)	**Reference diesel truck**	**Reference e-truck**	**Truck type**	**Average distance run per day (km)**
6-7.5 (N2)	Eicher Pro 2059XP	Tata Ultra T.7	Haulage (short/mid-mile)	200
12-16.2 (N3)	Ashok Leyland Ecomet Star 1415	Ashok Leyland Boss 14 HB	Haulage (mid/long mile)	300
25-34 (N3)	Ashok Leyland UE 2825/39 tipper	Olectra Meghaetron tipper	Tipper	150

Source: Market research and stakeholder consultations by India ZEV Centre, ITS-UC Davis, 2024

Input parameters for TCO

The TCO model is a techno-economic analysis that considers 42 input parameters (refer to Annexure A2 for input parameters' values) grouped under four aspects - vehicle specification, vehicle cost and financing, operational characteristics, and operational costs. These are defined as follows:

i. Vehicle specifications include the fixed specifications of the truck model such as GVW, Payload, Engine/Motor power (hp), Battery capacity (kWh), vehicle range (km/kWh), axle configuration, number of tyres, warranty period for vehicle (years), warranty period for battery (years), estimated residual value (%) for vehicle & battery[35].
ii. Vehicle cost & and financing largely include upfront cost and financing cost for a truck – ex-showroom price of the vehicle, powertrain cost, battery cost, vehicle registration cost, road tax, other applicable taxes and cess; downpayment cost to financed cost of the vehicle (%), interest rate (%), loan term (years), and insurance premium (INR/annum). Regional variations are considered with registration costs and road taxes.
iii. Operational characteristics include operational parameters such as use case, vehicle utilisation/day (kms), number of operating days/month, vehicle kilometres travelled (VKT/annum), payload utilisation (%), and energy consumption (km/l and km/kWh) with and without payload.
iv. Operational cost includes all operational cost parameters including fuel cost (electricity/diesel), road tolls, year-on-year increase in fuel cost, crew cost per truck, annual maintenance cost (AMC), and cost of retreading tyres.

Some of the overarching price assumptions used in the analysis are listed below:

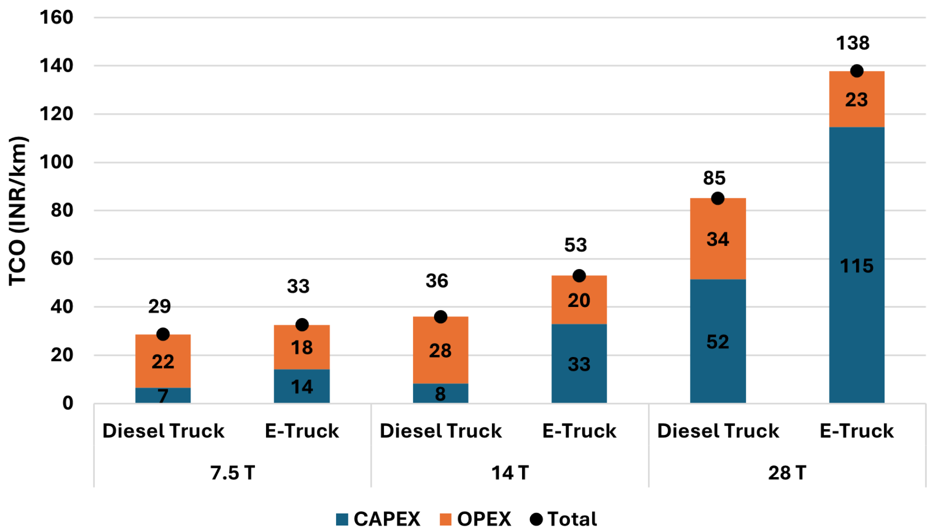
i. The ex-showroom price of an e-truck is about 1.5-3 times that of an equivalent diesel truck, depending on the truck GVW category. The battery cost makes up about 30-40% of the ex-showroom price of an e-truck. The analysis does not consider decline in battery price and powertrain costs over the vehicle's life.
ii. The maintenance cost of a diesel truck is considered 5% of the purchase price[36]. As per current market conditions and subsequent consultations, the maintenance cost for an e-truck is considered 20% higher than that of a diesel truck. The e-truck market in India principally does not exist in 2024, and stakeholder consultations suggested that e-truck maintenance should be priced 20% higher to account for the need to develop a service industry for e-trucks in India. This however might evolve and decrease as the market stabilises with economies of scale for e-trucks.
iii. The financing cost is considered 200 basis points higher for an e-truck, due to the additional financial risk associated with new technologies. Similarly, the annual insurance premium is considered 25% higher for an e-truck than for a diesel truck with the technological and nascent service industry risks built into the premiums.
iv. The average distance covered per day is considered constant for the vehicle life. The number of days of operation are taken as 300 in a year.
v. The diesel cost is taken as INR 97/litre with a year-on-year increment of 4%. The electricity tariff for e-truck charging is taken as INR 13/kWh, based on the recent commercial tariff of Telangana[37]. The cost of installation of charging infrastructure at trip origin and destination varies from INR 1,25,000 to 14,50,000, depending on the battery capacity and fleet size, and is included[38]. Because about 80% of India's fleet operators own less than six trucks, a similar fleet size of trucks is considered for estimating charging infrastructure costs[39].
vi. The vehicle life is taken as 15 years for both diesel trucks and e-trucks from 2025. The average battery life is assumed to be 5 years, which would require three batteries over the e-truck's life till 2039.

vii. Final TCO (INR/km) is calculated as a net present value (NPV) of the total costs over the vehicle's life of 15 years, at a discount rate of 6%.

viii. The base case for TCO analysis does not consider any purchase incentives, tax exemptions, or other supply-side incentives for e-trucks.

The upfront purchase cost for e-trucks constitutes 42-83% of the total cost of ownership in comparison to 24-60% for diesel trucks. The e-trucks benefit from the lower cost of operations due to lower energy costs with respect to their diesel equivalent. Maintenance cost within the operational cost bucket is currently higher, as mentioned above in (ii).

Figure 10: NPV TCO (INR/km) for reference models under the base case for 2024



Source: Author analysis based on the UCD-WRI TCO tool, 2024

In the base case, the TCO of 7.5T, 14T, and 28T e-trucks is still 11%, 48%, and 62% higher than their diesel equivalent models respectively (Figure 10) given the current market size and the base price points at which e-trucks are offered. This gap is expected to decrease with decline in battery and powertrain costs and economies of scale in production of e-trucks.

We model four policy scenarios in the next section based on addressing the challenges of the transition to e-trucks. We compare the impact of these policy scenarios on the purchase price and TCO of reference models to identify feasible policy measures in making e-truck adoption economically viable.

Introduction of policy intervention for ZETs

The study assumes that policy interventions introduced incrementally over time will make e-truck adoption an attractive proposition, resulting in a subsequent increase in the penetration of e-trucks. The policy interventions considered are: (a) demand-side incentives, (b) supply-side incentives, (c) reduced cost of financing, and (d) disincentives for operating diesel trucks.

These interventions result in development of four policy scenarios, each incorporating a stacking up (Table 11) of interventions mentioned above. However, these four scenarios are separate, and their impact on comparative TCO of e-trucks versus diesel trucks is also considered separately. The policy scenarios are described below:

Table 11: Policy scenarios considered for analysis

Scenarios	Interventions
Policy scenario 1 (PS 1)	Demand-side incentives
Policy scenario 2 (PS 2)	PS 1 + supply-side incentives
Policy scenario 3 (PS 3)	PS 2 + reduced cost of financing
Policy scenario 4 (PS 4)	PS 3 + disincentives for operating diesel trucks

- ***Policy scenario 1***

In this scenario, the state government provides demand incentives for e-trucks in the MHDT category in the form of a purchase subsidy and road tax and registration fee exemption. The road tax exemption is provided for 5 years from the date of purchase of the truck. The purchase subsidy considered is INR 10,000/kWh for the N2 category capped at 20% of the ex-factory price and INR 20,000/kWh for the N3 category capped at 30% of the ex-factory price of the e-truck. The existing Telangana EV policy provides demand incentives for e-trucks in the N1 category[10]. This scenario also includes operational cost support through road toll exemption for e-trucks for a period of 5 years from the date of purchase.

a. Fiscal incentives at INR 10,000-20,000/kWh to reduce the purchase cost of an e-truck.
b. Fiscal rebate on one-time registration fee at purchase along with on road toll and annual road tax for 5 years to reduce the operational cost of an e-truck.

- ***Policy Scenario 2***

In addition to demand-side incentives, it is assumed that supply-side incentives can reduce the cost of manufacturing e-trucks by 10%, based on stakeholder consultations with OEMs. The supply-side incentives include capital investment, tax reimbursements, and designated industrial areas for EV and EV-component manufacturing with existing support infrastructure. Supply side incentives can also include production-linked incentive support by the central or the state government to aid the scaling up of production and reducing of costs for manufacturing e-trucks, batteries, and other components. They can also include provisions for localization of the manufacturing supply chain of batteries, electric motors, battery management systems, etc. While supply-side interventions also include supply-side regulations such as introduction of stringent fuel economy norms and sales targets to influence large scale e-truck production, this is not considered in this study. In the long term, policies undertaken by the central government will impact ZET adoption in the state.

In 2023, the Telangana government launched the Telangana Mobility Valley initiative with the goal of attracting investments worth Rs. 50,000 crores to manufacture electric vehicles, batteries, and other EV components. By introducing supply-side interventions, the state can enhance its manufacturing capabilities by reducing production costs which will allow for the scaling of electric vehicle production. About 7% of freight activity in the country is generated from Telangana. Therefore, setting a sales target within the state under provisions of the Industry Department of Government of Telangana can effectively drive achievement of the state EV adoption and manufacturing targets.

The above measures are expected to position Telangana as a leading e-truck manufacturing hub in the country, contributing significantly to its industrial growth and EV production targets.

- ***Policy Scenario 3***

In addition to demand and supply-side incentives, the third crucial policy intervention is reducing the cost of financing an e-truck. In the Indian truck market, on average about 80% of cost of a truck is financed through loans from Non-Banking Finance Companies (NBFCs) or commercial banks. Based on consultations, the study considers a reduction in interest rate by 500 basis points for e-trucks, making their lending rate 300 basis points cheaper than their diesel equivalent. In India, Small Industries Development Bank of India (SIDBI) has taken de-risking measures such as creating a risk-sharing facility to lower the effective interest rate for EV loans for two and three-wheeler vehicles[40]. If this same lending and risk sharing mechanism can be extended e-trucks, it can potentially reduce cost of e-truck ownership as well.

At present cost of debt financing is 15% for a diesel truck but 17%-21% for an e-truck. With the addition of interest subvention, the effective cost of financing an e-truck can be reduced to 12%-16%. For calculation, this study considers an interest rate of 17% for debt financing of e-trucks, and with 5% interest subvention considered, this decreases to 12% in this scenario.

- ***Policy Scenario 4***

In addition to all policy interventions considered previously, this scenario considers additional restrictive measures for diesel trucks. In a long-term scenario, operating diesel trucks can be made expensive by increasing the tax rate for automotive diesel fuel, invoking fines, and taxation norms (such as pollution, permit, and registration costs).

The increase in diesel tax is a restraint strategy to bring the effective tax rate closer to incorporating the environmental and social costs of air pollution, CO_2 emissions, congestion, etc. into diesel pricing[41]. Such restrictive measures include congestion charging, time-based entry charging, environment cess on polluting fuel. These are well known measures adopted by countries through federal and sub-national law. In India, Delhi and Goa have introduced such measures[42] .

In this fourth scenario, the study assumes that the state of Telangana introduces an additional green cess on diesel of INR 0.5/litre, as has been levied by the governments of Delhi and Goa. It also considers doubling the existing 'Green tax' for diesel trucks older than 7 years, introduced in 2022 by the Department of Transport in the state. Additionally, the road toll tax for diesel trucks entering the state could be increased by 25%. This 25% increase is taken from the ratio of existing 'Green tax' to the quarterly road tax in the state.

A summary of the policy interventions for the policy scenarios considered is provided in Table 12.

Table 12: Summary of policy intervention considered for TCO analysis

Policy intervention	**Considerations**	**Relative impact on upfront cost**
Demand-side intervention	> Purchase subsidy of INR 10,000/ kWh capped at 20% of the ex-factory price for N2 & INR 20,000/kWh capped at 30% of the ex-factory price for N3 category > Road tax exemption for the first 5 years > Registration fee exemption > 100% road toll waiver for the first 5 years	Reduction in upfront cost by up to 20% and 30% for N2 and N3 e-trucks respectively
Supply-side intervention	Incentives on manufacturing Localization of e-truck supply chain Supply side regulations	10% reduction in cost of e-truck
Reduced cost of financing	5% interest subvention for e-trucks reducing their lending rate to 12%	5% reduction in lending rates for e-truck
Disincentivizing operation of diesel trucks	> INR 0.5/l cess on diesel > Doubling the 'Green tax' applied on diesel trucks older than 7 years > 25% increase in road tolls for diesel trucks	Increase in cost of operating diesel truck

Some of these policy interventions to push electric vehicle adoption have already been implemented through FAME[43] scheme and PM E-DRIVE[44] by the Ministry of Heavy Industries, Government of India, and in multiple states through state EV policies. The recently published report on 'Policy Advisory Report for ZETs, 2024' by the Office of the Principal Scientific Advisor (PSA) also considers these and several other interventions as policy levers for pushing electric truck adoption in India.

Impact of policy interventions on TCO of ZETs

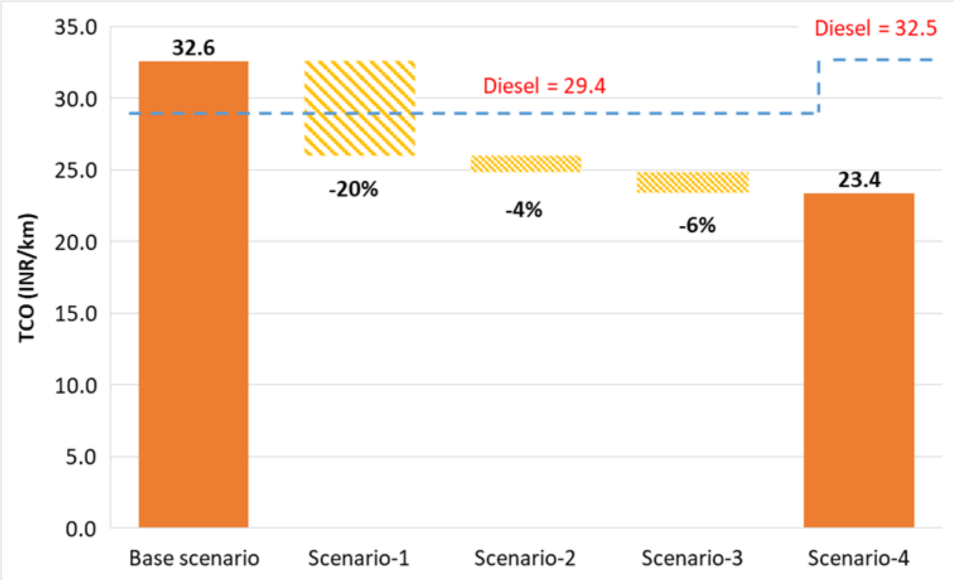
a. *TCO evaluation for a 7.5T e-truck model* - Without any policy intervention, considering the assumptions and considerations for Telangana, the TCO for the 7.5T e-truck stands at INR 33/km, much higher than the TCO for the diesel truck is at INR 29/km. The introduction of demand side incentives, supply side incentives, and a reduced cost of financing can potentially reduce the TCO of an e-truck by an estimated 20% (INR 26/km), 4% (INR 25/km), and 6% (INR 23/km), respectively. At the same time, creating restraints on diesel trucks can increase their TCO to INR 33/km (Figure 11).

b. *TCO evaluation for a 14T e-truck model* - Without any policy intervention, the TCO for the 14T e-truck stands at INR 53/km, which is 50% higher than the TCO for the diesel truck at INR 36/km. The introduction of demand-side incentives reduces the TCO of the e-truck by an estimated 19% (to INR 43/km). Supply side incentives and a reduced cost of financing reduce the TCO by an additional 5% (to INR 41/km) and 7% (to INR 38/km), respectively. At the same time, creating restraints on diesel trucks can increase their TCO to INR 37/km, making them more expensive in the long-term (Figure 12).

c. *TCO evaluation for a 28T e-truck model* - Without any policy intervention, the TCO for the 28T e-truck stands at INR 138/km, which is 60% higher than the TCO for a diesel truck, at INR 85/km. The introduction of demand side incentives would reduce the TCO of the e-truck by 25% (to INR 103/km), supply side incentives would reduce it by an additional 7% (to INR

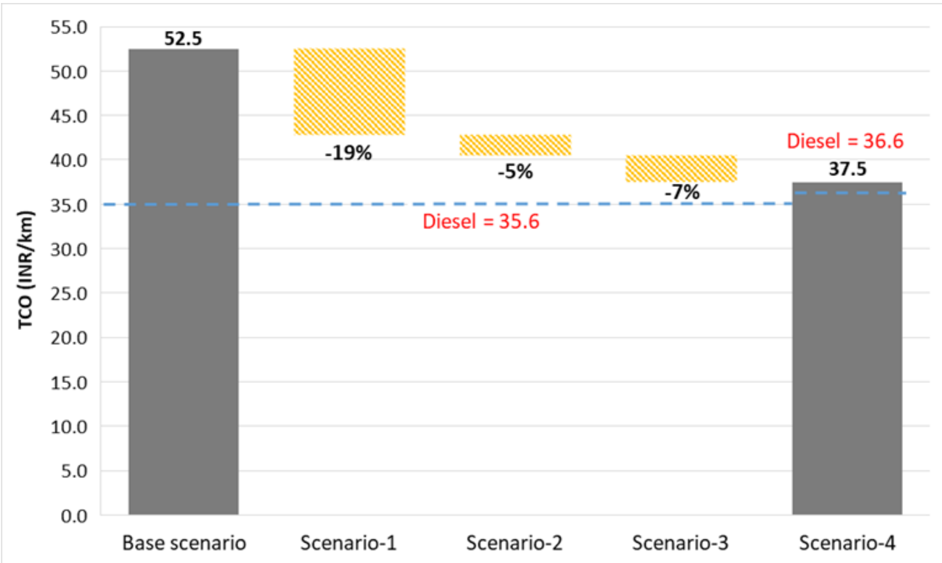
96/km), and cost of financing reduction, by an additional 10% (to INR 87/km). At the same time, creating restraints on diesel trucks can increase their TCO to INR 88/km (Figure 13).

Figure 11: TCO (INR/km) at NPV for a 7.5T e-truck model



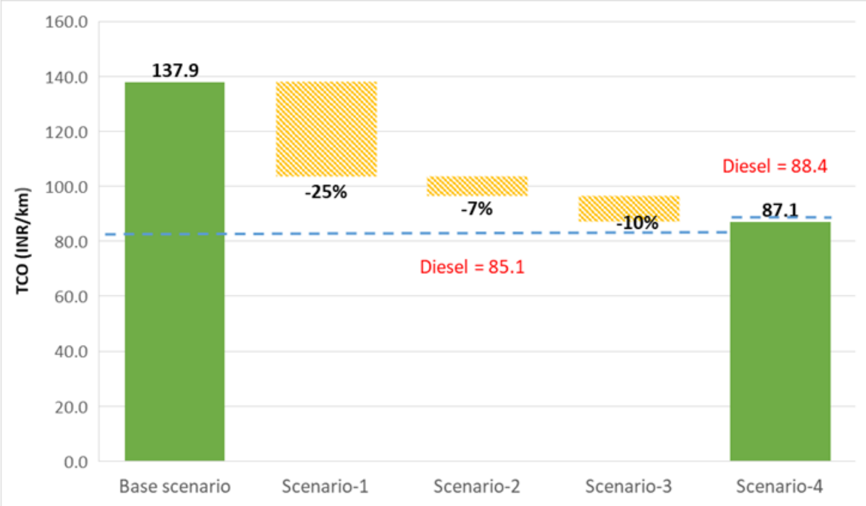
Note: 15 years is considered as the life of a truck.
Source: Analysis by India ZEV Centre, ITS-UC Davis, 2024

Figure 12: TCO (INR/km) at NPV for a 14T e-truck model



Note: 15 years is considered as the life of a truck.
Source: Analysis by India ZEV Centre, ITS-UC Davis, 2024

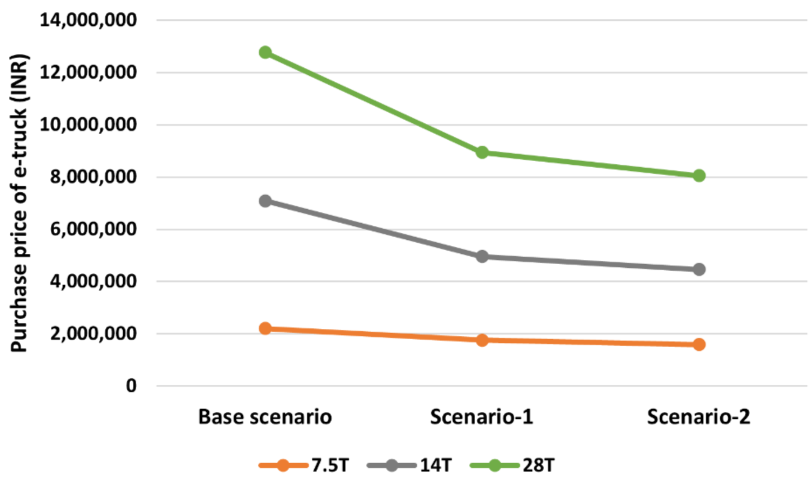
Figure 13: TCO (INR/km) at NPV for a 28T e-truck model



Note: 15 years is considered as the life of a truck.
Source: Analysis by India ZEV Centre, ITS-UC Davis, 2024

Policy interventions 1 and 2 have a direct impact on the purchase price of an e-truck. The purchase subsidy is estimated to reduce the purchase price by 20% for 7.5T e-truck and by 30% for 14T and 28T e-truck models. The supply-side incentive to truck manufacturers is estimated to reduce the purchase price by an additional 10% for all models (Figure 14).

Figure 14: Impact of policy scenarios 1 & 2 on purchase price of e-trucks



Source: Analysis by India ZEV Centre, ITS-UC Davis, 2024

Summary of reduction in TCO gap for the three e-truck models

TCO gap between an e-truck and diesel truck narrows with each policy scenario

- For 7.5T model, with each policy intervention, the TCO of e-truck becomes 12%, 16%, 20% and 28% cheaper than its diesel counterpart.
- For 14T model, with each policy intervention, the TCO gap between an e-truck and a diesel truck can be reduced to 20%, 14%, and 5% and almost attain parity under policy scenario 4.
- For 28T model, with each policy intervention, the TCO gap between an e-truck and a diesel truck can be reduced to 22%, 13%, and 3% and almost attain parity under policy scenario 4.

It can also be concluded that while the 7.5T e-truck becomes cheaper to operate than its diesel equivalent with demand-side incentives alone, whereas the N3 segment (14T and 28T e-truck models) can attain a favourable TCO with its diesel equivalent only when all four policy interventions are considered.

This analysis outlines the different policy interventions that can be considered to create an opportunity to transition to e-trucks in Telangana. A summary of the impact of policy interventions on the TCO of e-truck reference models is given in Table 13 below.

Table 13: E-truck TCO differential with respect to diesel trucks for the reference models

Models	**TCO of diesel truck (INR/km)**		**TCO of e-truck relative to TCO of diesel truck (%)**				
	Without Interven-tion	**With restraint**	**No interventi on**	**Policy scenario 1**	**Policy scenario 2**	**Policy scenario 3**	**Policy scenario 4**
7.5 T	29	33	11% ↑	-12% ↓	-16% ↓	-20% ↓	-28% ↓
14 T	36	37	48% ↑	20% ↑	14% ↑	5% ↑	2% ↑
28 T	85	88	62% ↑	22% ↑	13% ↑	2% ↑	-1% ↓

↑Higher TCO for e-truck than diesel

↓Lower TCO for e-truck than diesel

Key inferences from TCO analysis can be summarised as follows:

The analysis indicates that the transition to e-trucks for the state of Telangana presents both significant potential and challenges.

- The TCO analysis highlights that e-trucks offer long-term operational savings driven by lower operational costs. However, their adoption is constrained by high initial upfront cost, primarily due to battery costs, underdeveloped market and charging infrastructure.
- Strategic policy support is crucial for improving economic viability of e-trucks against their diesel counterpart. Demand-side incentives, such as subsidies and tax waivers, can alleviate up-front financial burdens, while supply-side support could reduce production costs and encourage local manufacturing.
- Reduction in interest rate for e-truck financing, coupled with increased taxes on older diesel vehicles, can incentivize market uptake of e-trucks by narrowing the TCO gap between e-trucks and diesel trucks.
- Projections under different policy scenarios suggest that, with adequate policy interventions both N2 e-trucks and N3 e-trucks could become more cost competitive than diesel.

Chapter V

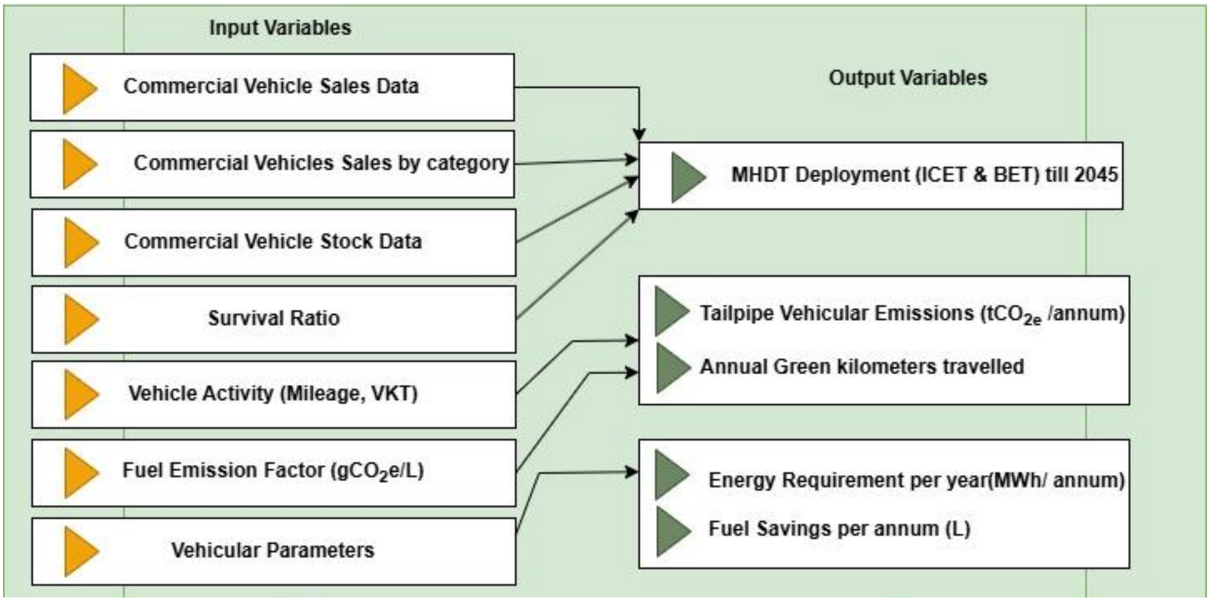
Impact of Policy scenarios on ZET adoption

As discussed in the previous chapter, the four policy interventions reduce the TCO of an e-truck relative to its diesel counterpart. Therefore, each policy intervention would presumably improve the viability of e-truck adoption and increase e-truck sales in the state. To understand the overall impact of these policy interventions, each policy scenario was then evaluated in terms of three key impacts: (a) reduction in fuel consumption, (b) reduction in tailpipe CO_2 emissions, and (c) impact on government budget.

The method for assessing these impacts is a five-step process that includes (i) estimating MHDTs on road, (ii) accounting for total VKT, (iii) estimating fuel consumption, (iv) estimating vehicular CO_2 emissions and (v) cost of implementing the policy interventions.

The input variables include goods vehicle sales data; vehicle stock; survival ratio; which are used to calculate number of electric trucks on road; vehicle activity, such as fuel efficiency and VKT; fuel emission factor (gCO_2/l); which are used to calculate tailpipe vehicular CO_2 emissions; annual green kilometres travelled; fuel savings; and electrical energy required for electric truck operation. Input variables in this study were substantiated with relevant secondary data and primary consultations with OEMs, logistical service providers, and shippers.

Figure 15: Evaluation of e-truck adoption scenarios



i. Projecting MHDTs and e-truck sales in Telangana

MHDT sales in Telangana has been growing at a CAGR of 4.2%. The annual sales have increased from 4,927 in 2014-15 to 6,927 in 2023-24. They are estimated to increase further, to 11,501 by 2030 and 17,823 by 2040 (Table 7). Historical data suggests MHDT consists of 85% N3 and 15% N2 and this is considered consistent in the sale projection.

In contrast to the overall MHDT market in India, the market for e-MHDTs is practically non-existent. As of 2024, India recorded only 400 e-trucks in sales for closed loop operations. The study therefore considers market estimates based on OEM industry estimates gathered during our stakeholder consultation with truck OEMs for policy scenario 1, and the estimates for policy scenario 4 that represents a high-ambition scenario based on estimates by NITI Aayog[2]. The e-truck sales penetration is assumed to incrementally increase from scenario 1 to 4 based on application of a combination of policy interventions as discussed in the previous chapter (Table 14).

Table 14: Assumed percentage electrification of MHDTs in the state under policy scenarios

Year	Base Scenario	Scenario 1	Scenario 2	Scenario 3	Scenario 4
2025	0%	0.7%	0.8%	1%	1.3%
2030	0%	4%	5%	6%	8%
2035	0%	8%	10%	12%	16%
2040	0%	12%	15%	18%	24%

Source: Consultations with truck OEMs, estimates by NITI Aayog

Out of the 17,823 MHDTs projected to be sold in Telangana in 2040, the estimated sales of e-trucks vary between 2,100-4,300 (12-24%) depending on the policy scenarios (Table 15).

Table 15: Estimated annual MHDTs and e-truck sales under different policy scenarios

Year	Estimated annual MHDT sales	Estimated annual e-truck sales				
		Base Scenario	Scenario 1	Scenario 2	Scenario 3	Scenario 4
2025	7,307	0	48	62	73	97
2030	11,502	0	460	575	690	920
2035	13,658	0	1,093	1,366	1,639	2,185
2040	17,823	0	2,139	2,674	3,208	4,278

ii. Estimating MHDTs and e-trucks plying on road

The volume of trucks on the road is estimated through an age-zero survival curve that represents the fraction of vehicles surviving from the original sales year. The survival curve uses vehicle sales data from 2014-15 to 2023-24 along with the projected sales till 2039-40 to estimate the number of trucks plying on roads in the state. This analysis presents a conservative estimate since it does not consider trucks sold in other states while estimating the trucks plying on roads in Telangana. The age of a truck is considered to be 15 years in accordance with existing scrappage regulations for MHDTs in India. The survival curve was modelled using Weibull's distribution method defined as:

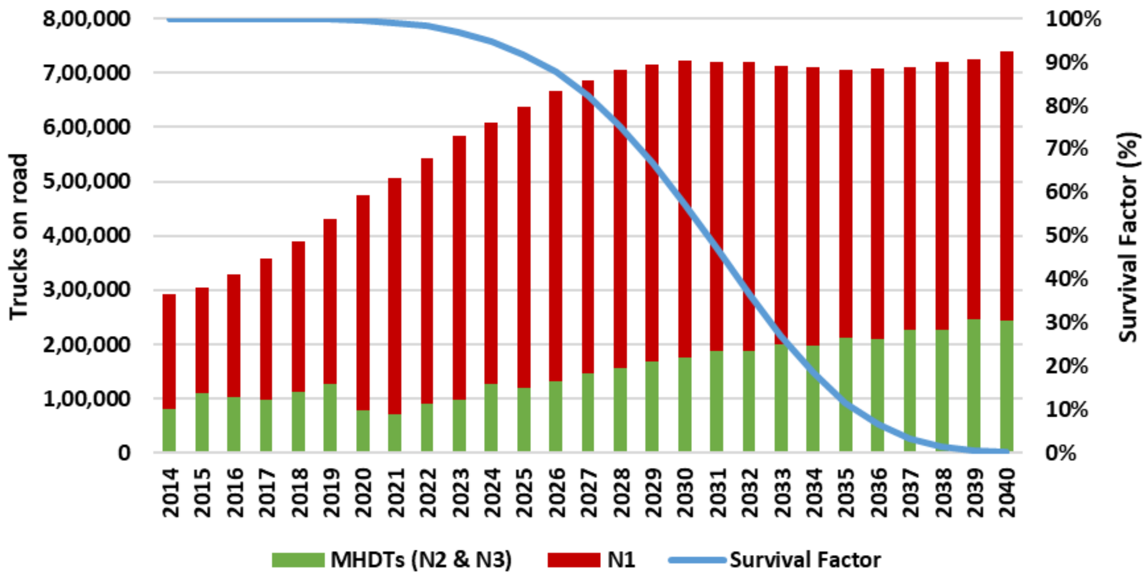
$$\textbf{Age zero Survival (C.V.)} = e^{-(x/L)} \textbf{\^{}k}$$

Where, x = Age of the Vehicle
L = Steepness Parameter (L=18)
K = Shape Factor (k=5)

Source: Formula based on Vehicle Survival Patterns in China (Hao, Wang, Ouyang & Cheng, 2011)

The derived survival curve for trucks, based on truck sales data from the Department of Transport in Telangana suggests that by 2030 there will be about 7.2 lakh trucks on the road, including about 1.75 lakh MHDTs. This would increase by 2040 to about 7.5 lakh trucks on road, including 2.4 lakh MHDTs (Figure 16). The sales share of MHDTs in overall truck sales is estimated to increase from 21% in 2024 to about 33% by 2040. MHDTs plying on roads in the state are estimated to double from about 1.2 lakhs in the present to 2.4 lakhs by 2040 (Table 16).

Figure 16: Survival Curve based projection for trucks (N1 & MHDTs) in Telangana



Source: Authors' analysis based on the Open Data portal of Telangana, Government of Telangana, India, 2024

Table 16: Estimated MHDTs on road in Telangana

Year	MHDTs on road
2024	1,28,252
2030	1,74,588
2035	2,12,215
2040	2,43,958

Source: ITS-UC Davis projections, 2024

Based on the sales projection and survival function, there could be an estimated 1,500 e-trucks on road in Telangana in the next five years if demand-side policy interventions begin. With more policy interventions in subsequent scenarios, this figure could be 25% to 100% higher than the number of e-trucks in Telangana under Scenario 1 (Table 17).

Table 17: Estimated total e-trucks on road in Telangana by year

Year	Base Scenario	Scenario 1	Scenario 2	Scenario 3	Scenario 4
By 2025	0	48	62	73	97
By 2030	0	1,402	1,755	2,102	2,802
By 2035	0	5,547	6,937	8,321	11,093
By 2040	0	14,000	17,503	21,000	27,999

iii. Accounting for vehicle kilometres travelled (VKT)

Various studies estimate the annual VKT or average daily distance travelled by MHDTs in India[45,46]. Based on a review of such studies and discussions with truck operators on VKT for the considered use cases of trucks, this study assumes the annual VKT to be 60,000 km for the 7.5T truck, 90,000 km for the 14T truck, and 45,000 km for the 28T truck (Table 18).

Table 18: Annual VKT per truck assumed for various truck models

Segment	GVW	Annual VKT per truck (km)
N2	7.5	60,000
N3	14	90,000
	28	45,000

Source: UC Berkley Lab 2022

We assume the annual VKT for N2 and N3 to be the average considered for the reference truck models in those segments. If we assume the annual VKT to be constant till 2040, the total VKT by MHDTs on road in the state would increase by about 40% by 2030 and over 90% by 2040 from the present levels (Table 19).

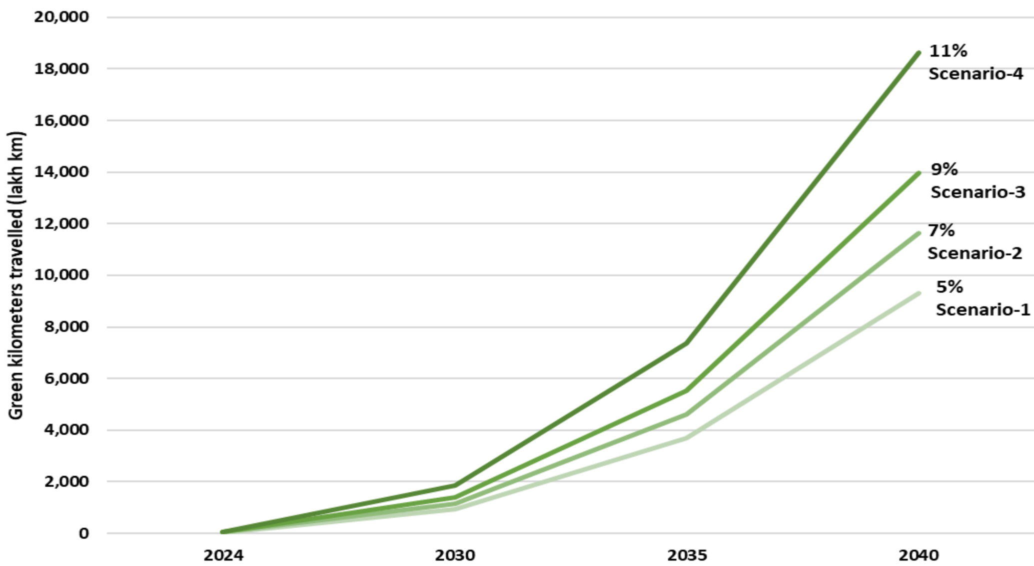
Table 19: Annual VKT for all MHDTs in the state

Year	Total MHDTs on road	Total annual VKT (million km)
2024	1,28,252	8,368
2030	1,74,588	11,599
2035	2,12,215	14,112
2040	2,43,958	16,261

Source: ITS-UC Davis projections, 2024

An increase in green kilometres (kilometres run by EV trucks) would lead to a corresponding reduction in diesel consumption and reduction of tailpipe emissions by MHDTs in the state. The annual distance travelled by the MHDTs is estimated to be over 16,000 million kms by 2040, assuming that the trucks drive a constant annual distance over their lifetime of 15 years. Of this, Telangana can potentially transition up to 11% (~1,860 million kms) of MHDT annual VKT to green kilometres (i.e., kilometres with zero tailpipe emissions), depending on policy scenarios (Figure 17).

Figure 17: Estimated green kilometres travelled by e-trucks on road from 2024-2040



Source: Analysis by India ZEV Centre, ITS-UC Davis, 2024

iv. Estimating diesel consumption by MHDTs

The projected increase in MHDT sales in Telangana would lead to additional kilometres run causing an increase in diesel fuel consumption. However, e-truck adoption can indirectly offset diesel fuel consumption by reducing the number of diesel truck in operation. This reduction has the potential to decrease the expenditure for buying diesel and lead to reduced vehicular tailpipe emissions, fostering a shift towards clean transportation in the state.

According to 2024 data, fuel efficiency for diesel trucks is 9 – 11 km/l for the N2 segment and 2.5 – 6.8 km/l for the N3 segment, factoring in the weighted average of full and empty load runs[47]. Considering improvements in the existing engine and powertrain components, the fuel efficiency of a diesel truck is assumed to improve by 4% annually[48] (Table 20).

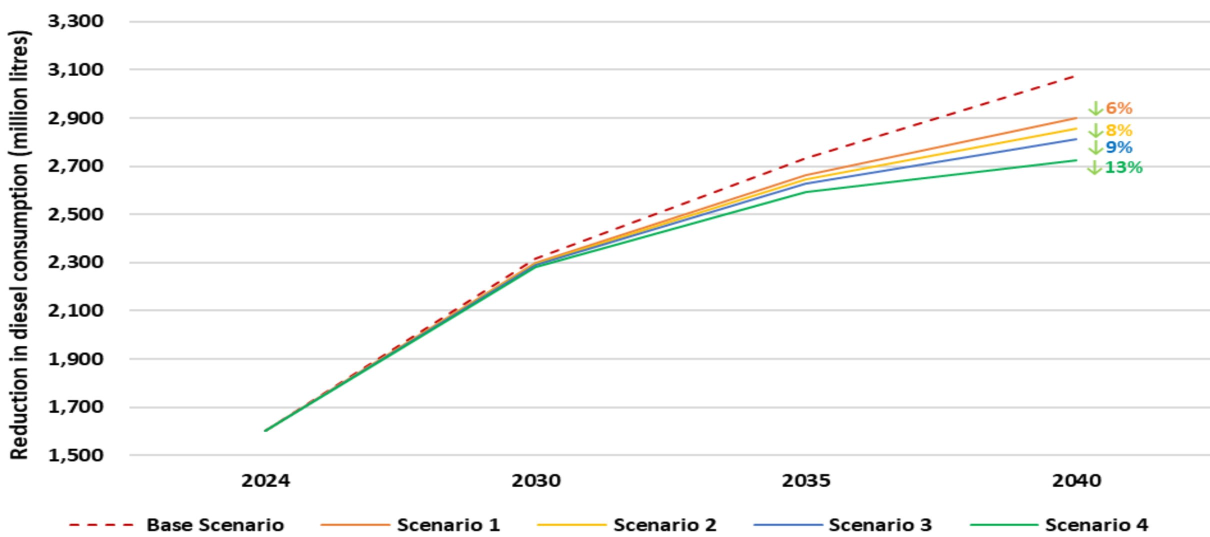
Table 20: Fuel efficiency for diesel trucks (km/l)

	Fuel efficiency for N2 trucks by GVW (km/l)				Fuel efficiency for N3 trucks by GVW (km/l)				
Year	**6-7.5**	**10-12**	**3.5 - 6**	**Average**	**25-34**	**12-16.2**	**34-49**	**16.2-25**	**Average**
2024	9.0	6.5	11.0	8.8	2.8	6.0	2.5	6.8	4.5
2030	9.4	6.8	11.4	9.2	2.9	6.2	2.6	7.1	4.7
2035	9.7	7.0	11.9	9.6	3.0	6.5	2.6	7.4	4.9
2040	10.1	7.3	12.4	9.9	3.1	6.7	2.6	7.6	5.0

Source: UCD analysis based on consultation; crosscheck with aggregated data from Truck Junction website

The projected increase in MHDT sales in Telangana suggests a 44% (2.3 billion litres) and 92% (3.1 billion litres) increase in diesel consumption by MHDTs by 2030 and 2040, respectively, from the present levels (1.6 billion litres), without any e-trucks adoption. However, as estimated, an increase in e-truck penetration in Telangana can lead to diesel consumption reduction of up to 2% by 2030 and 13% by 2040, depending on policy scenarios (Figure 18). This would translate to saving about 40 million litres of diesel by 2030, increasing to 350 million litres of diesel consumption avoided by 2040 for the state (Table 21). The diesel consumption reduction would contribute to reducing the state's emissions from the road transport sector.

Figure 18: Projected diesel fuel consumption by MHDTs in Telangana from 2025-2040



Source: Analysis by India ZEV Centre, ITS-UC Davis, 2024

Table 21: Diesel fuel savings due to e-truck penetration in different policy scenarios

Year	Base Scenario (million litres)	Scenario 1 (million litres)	Scenario 2 (million litres)	Scenario 3 (million litres)	Scenario 4 (million litres)
2024	0	0	0	0	0
2030	0	18	23	28	37
2035	0	71	89	107	142
2040	0	175	219	262	350

v. Estimating energy requirements for charging e-trucks

As per a study by ICCT, the specific energy consumption by a 12T and 55T e-truck in India is estimated to be 0.44 kWh/km and 1.34 kWh/km[48]. Based on consultations with OEMs and truck operators, the average power consumption for N2 and N3 segments is about 0.43 kWh/km and 1.43 kWh/km respectively. To compute the energy requirement for charging e-trucks, we consider an annual reduction of 4% for the specific energy consumption of e-trucks (in kWh/km) accounting for efficiency improvements in battery and other powertrain components[48].

The EV report of the Central Electricity Authority states that the charging requirements for EVs have consumed 5.73 GWh energy, of which 3.67 GWh have been consumed by heavy-duty charging stations, as of August 2024[49,50]. The power requirement for charging e-trucks in the state is estimated based on the specific energy consumption, annual VKT, and stock of e-trucks in the N2 and N3 segments. The annual VKT is assumed to be constant over the vehicle's life of 15 years.

Considering minimum threshold of energy requirement for e-trucks, the total energy requirement for charging e-trucks in Telangana would be up to an estimated 274 MWh by 2030 and 3,000 MWh by 2040, depending on policy scenarios (Table 22).

Table 22: Energy Requirement for e-trucks in each policy scenario

Year	Scenario 1 (MWh/annum)	Scenario 2 (MWh/annum)	Scenario 3 (MWh/annum)	Scenario 4 (MWh/annum)
2024	4	6	7	9
2030	137	182	206	274
2035	571	763	857	1,143
2040	1,515	2,033	2,273	3,031

Note: The table accounts for energy required to charge e-trucks with 10% charging losses but does not include stationary power requirements and other power infrastructure.
Source: Analysis by India ZEV Centre, ITS-UC Davis, 2024

vi. Reduction in tailpipe CO_2 emissions

Vehicular tailpipe emissions are a factor of annual vehicle kilometres travelled, engine standards and fuel consumption. The tailpipe emissions from MHDTs depend on the number of trucks on the road. The emission factor is calculated from vehicle fuel consumption and fuel emission factor as shown in the formula below.

Annual Tailpipe Emissions (kgCO_2/annum) = Emission factor (kgCO_2/km) x Annual VKT (km/annum) x vehicle stock (N2+N3)

Here, Emission factor (kgCO_2/km) = Fuel emission factor (kgCO_2/l of fuel burnt) x Fuel consumption of the vehicle (l/km)

According to a study by IIT Bombay, the fuel emission factor for diesel fuel in India was 2.64 $kgCO_2/l$[51]. The fuel efficiency of diesel trucks (in kilometres per litre) is assumed to improve by 4% annually, as mentioned in the previous section. Assuming the fuel emission factor to be constant, the average tailpipe CO_2 emissions for N2 and N3 segments are estimated to be 0.3 $kgCO_2/km$ and 0.6 $kgCO_2/km$ respectively at present (Table 23).

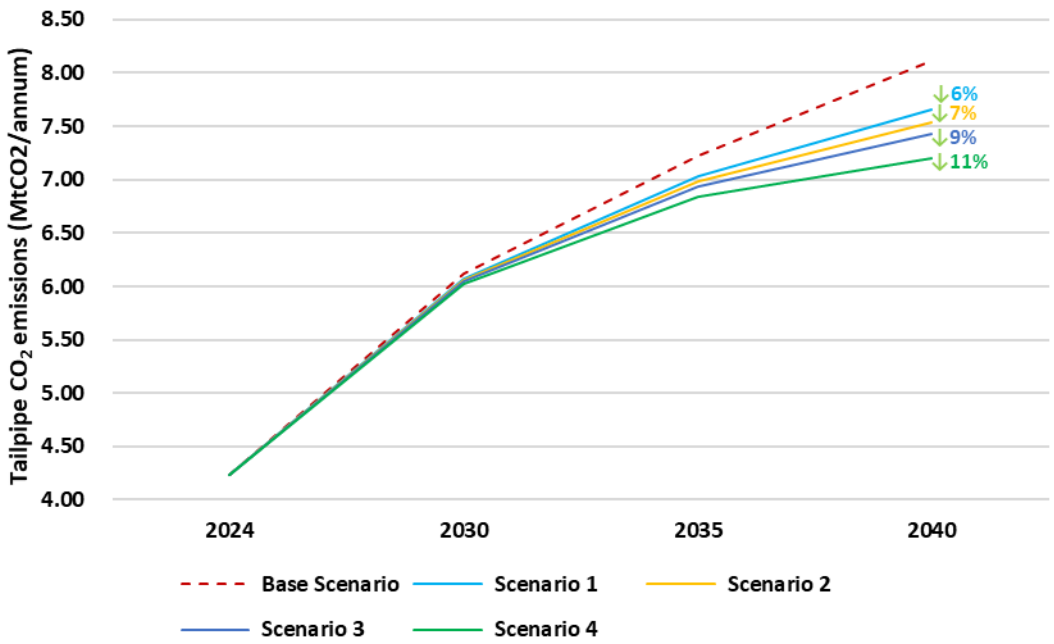
Table 23: Estimated CO_2 emission factors for N2 and N3 segments

	CO_2 emission factors for N2 ($kgCO_2/km$)				**CO_2 emission factors for N3 ($kgCO_2/km$)**				
Year	**6-7.5**	**10-12**	**3.5-6**	**Total N2**	**25-34**	**12-16.2**	**34-49**	**16.2-25**	**Total N3**
2024	0.293	0.406	0.240	0.29	0.960	0.440	1.056	0.388	0.59
2030	0.282	0.391	0.231	0.28	0.923	0.423	1.015	0.373	0.56
2035	0.271	0.376	0.222	0.28	0.888	0.407	1.015	0.359	0.54
2040	0.261	0.361	0.213	0.27	0.853	0.391	1.015	0.345	0.53

Source: Authors' analysis based on fuel emission factor and mileage, India ZEV Centre, ITS-UC Davis, 2024

The annual tailpipe CO_2 emissions from MHDTs on road in the state are estimated to increase by 44% (6.1 $MtCO_2$) by 2030 and over 90% (8.1 $MtCO_2$) by 2040 from the present levels (4.3 $MtCO_2$) without any adoption of e-trucks. However, with e-truck adoption in the state, the tailpipe CO_2 emissions from MHDTs are estimated to decrease by up to 2% by 2030 and 11% by 2040, depending on the policy scenarios (Figure 19).

Figure 19: Estimated tailpipe CO2 emissions from MHDTs in Telangana from 2025-2040



Source: Analysis by India ZEV Centre, ITS-UC Davis, 2024

This analysis does not consider the grid emissions associated with charging e-trucks and focuses only on vehicular tailpipe CO_2 emissions. The state's net GHG emissions has increased from 45.4 $MtCO_2$ to 66.5 $MtCO_2$ (~50%) over the period from 2014 to 2018. The transport sector contributed about 20% (13.18 $MtCO_2$) of these emissions in 2018[52]. Therefore, adoption of e-trucks provides an opportunity to reduce the vehicular tailpipe emissions by as much as 0.1 $MtCO_2$ by 2030 and 1 $MtCO_2$ by 2040 from MHDTs sold and running in the state.

Cost estimates for policy interventions

Policy interventions can also be considered as additional cost components that may affect the annual operating budget of the state. Each intervention modelled across the scenarios carries associated costs for the state and is likely to impact the revenue of the department. Therefore, the study includes a cost assessment to provide a representative picture for implementing the interventions.

Demand-side incentives represent an expenditure for the Transport department in the state. The road tolls waiver may result in loss of revenue for the Roads and Building Department at the state level, as well as the National Highways Authority of India (NHAI) under the Ministry of Road Transport and Highways (MoRTH). Similarly, the cost of interest subvention for financing e-trucks may incur expenditure from the finance department. Considering the current practices, the incentive amount required for each policy intervention for an e-truck bought in FY 2026 is estimated in the Table 24.

Table 24: Incentive amount per truck for the reference e-truck models bought in FY 2026

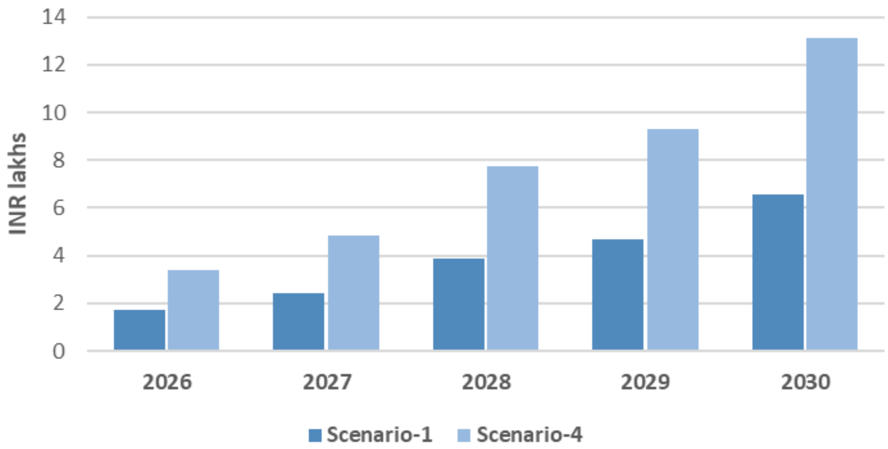
Policy interventions	**7.5T Amount (INR/truck)**	**14T Amount (INR/truck)**	**28T Amount (INR/truck)**
Purchase subsidy	4,40,000	21,24,515	38,30,400
Registration fee exemption	1,000	1,500	1,500
Road tax exemption (for 5 years)	48,700	74,200	1,67,800
Road toll waiver (for 5 years)	24,85,500	24,85,500	38,95,500
Interest subvention (for 5 years)	2,02,058	6,50,376	11,72,669
Note *- The registration fee is applicable at the time of vehicle purchase. On the other hand, a truck pays road tax quarterly. Registration fee[53] for N2 is INR 1,000 and N3 is INR 1,500. Quarterly tax is specified in Table 2.			

Source: Analysis by India ZEV Centre, ITS-UC Davis, 2024

For the cost estimation, we have considered e-truck sales for two policy scenarios: policy scenario 1 and 4 as projected in Chapter 5 (i) of the report. According to this, total e-truck sales in the state varies from 1400 e-trucks (4%) for policy scenario 1 to 2800 e-trucks (8%) for policy scenario 4 by 2030 (Table 7). The incentive amount for the 7.5T e-truck is considered representative of the N2 segment and the incentive calculated for the 14T and 28T e-truck models are equally representative of the N3 segment (Table 24). Considering the above assumptions, we derive cost estimates from FY 2026 to FY 2030.

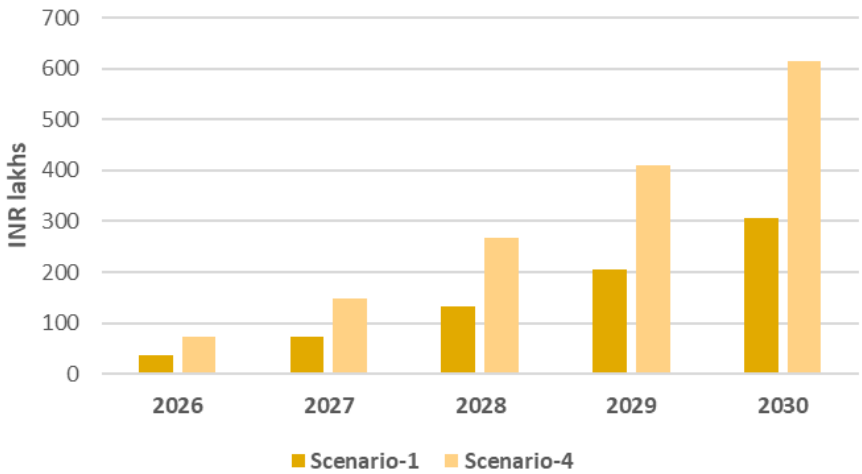
a. Registration fee exemption: It is estimated that for a policy period of five years, exemption in registration fees for e-trucks, which is paid once in a truck's lifetime, can cost somewhere between INR 19 lakhs to 39 lakhs from FY 2026 to FY 2030 (Figure 20).
b. Road tax exemption: It is estimated that for a policy period of five years, exemption in road tax, which is paid quarterly, can cost between INR 7.6 crore to 15.1 crore depending on the policy scenarios (Figure 21).

Figure 20: Cost estimates for registration fee exemption from FY 2026 - FY 2030



Source: Analysis by India ZEV Centre, ITS-UC Davis, 2024

Figure 21: Cost estimates for road tax exemption from FY 2026 - FY 2030

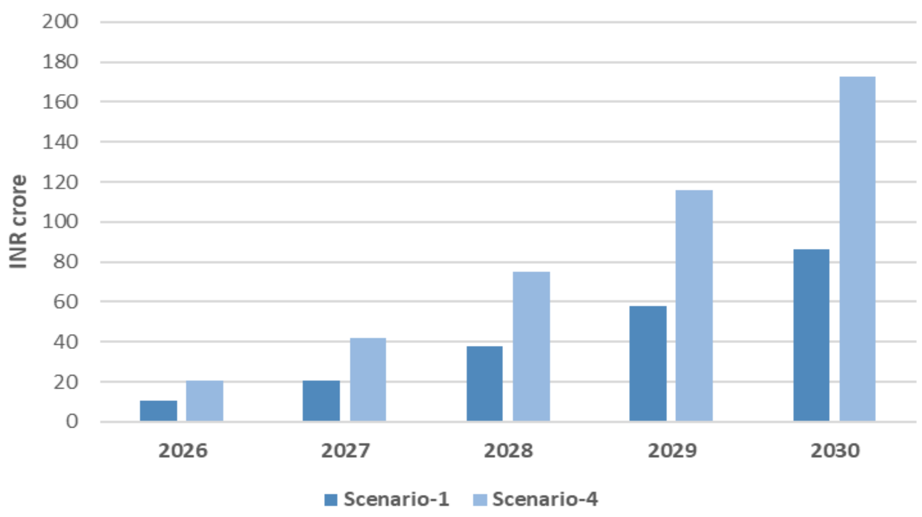


Source: Analysis by India ZEV Centre, ITS-UC Davis, 2024

The combined cost of registration fee and road tax exemption would amount to INR 7.8-15.5 crore for 1,400-2,800 e-trucks sold in the state over the five FYs.

c. Road toll waiver: Road toll payment is an operational expenditure depending on the distance travelled by the truck. It is estimated that for a policy period of five years, road toll waiver for all e-trucks sold in the state, could cost between INR 213 – 426 crore depending on the policy scenarios (Figure 22).

Figure 22: Cost estimates for road toll waiver from FY 2026 - FY 2030

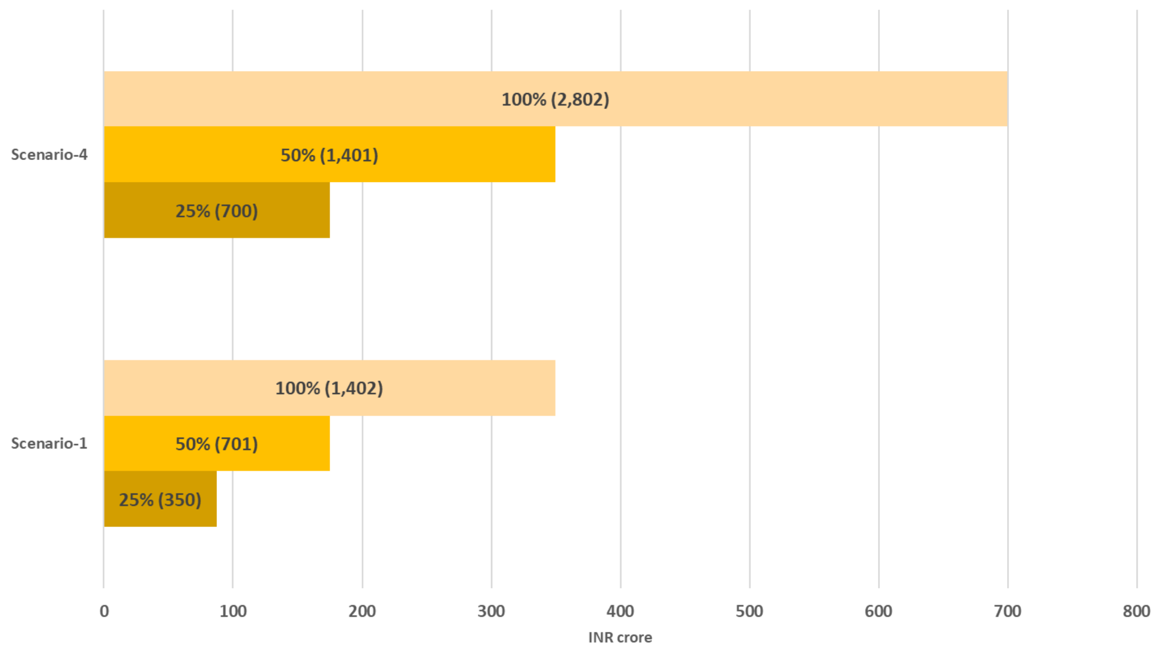


Source: Analysis by India ZEV Centre, ITS-UC Davis, 2024

d. Purchase subsidy: Currently, purchase subsidy allocation varies across states, with many states capping the subsidy for a certain number of EVs on a first-come, first-serve basis. Considering this, we have calculated demand incentive for 25%, 50% and 100% of e-trucks sold by those years.

   In the policy scenario 1, reaching 4% e-trucks sales share by 2030, purchase subsidy would cost between INR 88 – 350 crore depending on the percentage of e-trucks incentivized over five years, from FY 2026 to FY 2030. In the policy scenario 4, reaching 8% e-trucks sales share by 2030, purchase subsidy would cost between INR 175 – 700 crore over the same period (Figure 23).

Figure 23: Cost estimates for purchase subsidy from FY 2026 - FY 2030

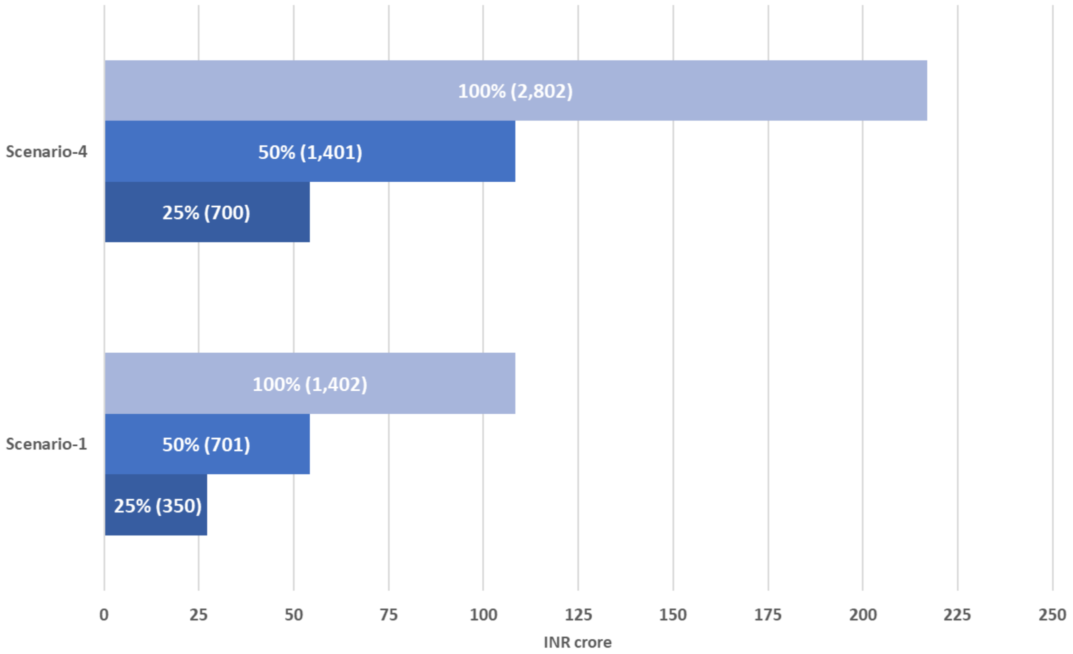


Source: Analysis by India ZEV Centre, ITS-UC Davis, 2024

e. Interest subvention: Similar to purchase subsidies, the provision of interest subvention varies across states. Currently, interest subvention is offered primarily for smaller electric vehicles, with only two states Delhi and Odisha providing a 5% subvention on financing new EVs. This same rate was considered for estimating cost of interest subvention for e-trucks Telangana.

Considering this, interest subvention would cost between INR 27-108 crore in the policy scenario 1 depending on the number of e-trucks eligible for availing this incentive from FY 2026 to FY 2030. The cost would increase to INR 54-217 crore for policy scenario-4 over the same period (Figure 24).

Figure 24: Cost estimates for interest subvention from FY 2026 - FY 2030



Source: Analysis by India ZEV Centre, ITS-UC Davis, 2024

Comparing the cost of each policy intervention discussed above for all e-trucks sold from FY 2026- FY 2030, purchase subsidy would cost the highest, followed by road toll waiver and interest subvention program to the exchequer (Table 25). Registration fee waiver and road tax exemption would be the least cost policy interventions for e-trucks.

Table 25: Cost estimates for policy interventions for e-trucks in Telangana from FY 2026 - FY 2030

Policy intervention	Cost estimates (INR crore)	
	Policy scenario-1 (1400 e-trucks)	**Policy scenario-4 (2,800 e-trucks)**
Purchase subsidy	350	700
Registration fee waiver	0.19	0.39
Road tax exemption (for 5 years)	7.8	15.5
Road toll waiver (for 5 years)	213	426
Interest subvention (for 5 years)	108	217

Source: Analysis by India ZEV Centre, ITS-UC Davis, 2024

The diesel cess of INR 0.5/l considered in policy scenario 4 would generate revenue for the state government. Considering an average fill size of 123 litres for MHDTs in Telangana[54] and estimates for MHDTs on the road from previous sections, the revenue generated from diesel sales to MHDTs could be INR 4.75 crore from FY 2026 till FY 2030. This amount is sufficient for providing registration fee waiver and road tax exemption for about 30% (~430) e-trucks sold in the state till FY 2030 as per policy scenario 4.

The estimates of the scope of cost do not include the cost of providing supply-side incentives for the state. This is due to a case-to-case basis approach on investment projects and a high variability of land purchase and allotment costs across the state. The analysis also does not consider fuel consumption and emissions from trucks not sold but operating in Telangana. The analysis could be expanded to include all trucks operating in the state, considering annual VKT degradation for older trucks and estimating well-to-wheel CO_2 emissions for electric and diesel trucks.

Key inferences from policy scenarios can be summarised as follows:

The assessment indicates that, under different policy scenarios the impact of e-truck adoption can vary significantly.

- As per estimates, about 1.75 lakh, 2.12 lakh, and 2.45 lakh MHDTs will be sold in Telangana by 2030, 2035, and 2040, respectively. Out of this, up to 2,800, 11,000 and 28,000 e-trucks could be on roads by 2030, 2035, and 2040, respectively, under different policy scenarios.
- The transition to e-trucks can lead to up to 1,860 million green kms, converting about 11% of annual MHDT VKT to zero-emission by 2040.
- This will also reduce diesel consumption by MHDTs sold in the state by up to 13%, i.e., about 350 million litres by 2040 from base scenario with no e-truck adoption.
- The transition would also reduce tailpipe CO_2 emissions from MHDTs sold in the state by up to 1 $MtCO_2$ (11% lower than no e-trucks adoption scenario) by 2040 from base scenario with no e-truck adoption.
- The annual energy requirement for charging e-trucks is estimated to be 137--274 MWh by 2030, depending on e-truck sales, annual vehicle kilometres travelled, and improvement in specific energy consumption of e-trucks.
- This transition would require INR 680 -2,850 crore from FY 2026 - FY2030 to support all e-trucks, depending on the sales share of e-trucks reached in the state and policy interventions implemented by FY 2030.

Achieving this transition will require significant investments in high-capacity charging infrastructure, strategic public-private partnerships, and sustained policy commitment.

Chapter VI

Way Forward

Subnational interventions in Telangana can play a strategic role in stimulating the regional e-truck market by introducing supply side interventions along with demand-side policies. Supply side measures, in particular can act as a catalyst to unlock opportunities for electrifying the truck ecosystem.

Localization of the EV supply chain can attract investments for Telangana Mobility Valley and bring down manufacturing costs

Inducing sales through fleet transition regulations for state Public Sector Undertakings (PSUs), and industrial sectors including cement, steel, and mining can benefit the state financially by creating investment opportunities in the Telangana Mobility Valley. Telangana has already attracted an investment of INR 8,000 crores in the manufacturing of EVs and EV components, along with developing EV testing and certification centres[55]. There have been investments in Li-ion cell and battery pack manufacturing for 2- and 3-wheelers in the state, providing an opportunity to use the manufacturing capacity for e-trucks as well[56].

The localization of the supply chain of EV components such as battery, battery management systems, electric motors, etc. can bring down the manufacturing costs by about 10% based on our consultations with OEMs in the state. This can bring down the TCO of e-trucks by 4-7%, depending on the truck GVW. If the cost reduction due to localisation is combined with demand-side subsidies, then the TCO of a 7.5T e-truck becomes 16% cheaper than its diesel equivalent. This policy combination could reduce the tailpipe emissions from MHDTs by 0.6 $MtCO_2$ and save over 200 million litres of diesel consumption from base scenario by 2040.

Interest subvention support from the state government for e-trucks

Debt financing plays a key role in India's trucking industry. The Non-Banking Finance Companies (NBFCs) are the major creditors in this market offering over two-thirds of such loans at higher interest rates than commercial banks[44]. More than 80% of trucking players are small fleet operators with low credit ratings. On top of this, e-trucks cost 2–3.5 times more than their diesel equivalents, and their sales are limited by a lack of confidence in the maturity of EV technology. This adds a risk premium to the interest rates charged by financial institutions. India had seen a higher interest rate during early years of financing electric car fleets for ride-hailing services and electric three-wheelers, with a 2% premium on EV loan interest rates compared to ICE vehicles. To alleviate this risk, an interest subvention program by the state government can build market confidence in the technology and lower the cost of financing e-trucks. A 5% interest subvention for e-trucks can lower their TCO by 7-10% for heavy-duty trucks and 6% for medium-duty trucks. Such programs could also provide data on costs and operations of e-trucks, thus creating a market confidence in the technology which can lead to lower risk premiums for private sector loans for e-trucks in the near future.

De-incentivising operations of older diesel trucks can make heavy-duty e-trucks achieve TCO parity

At present, Telangana levies a 'Green tax' on diesel trucks purchased more than 7 years ago, computed according to the GVW of trucks[17]. This disincentivizes operating light, medium, and heavy-duty diesel trucks after 7 years. Delhi levies an INR 0.25/litre air ambiance charge on diesel and Goa levies a 0.5% green cess on diesel to compensate for the higher emissions from diesel vehicles[47]. Telangana can introduce a similar 'green cess' of INR 0.5/litre on diesel to account for externalities associated with diesel use[41] along with doubling the Green tax to further disincentivize operating older diesel trucks on road. The state can also leverage the FASTags for commercial vehicles to enforce an increase in toll tax by 25% on diesel trucks to signal a policy shift towards e-trucks. These measures would increase the operational costs of diesel trucks, thereby reduce the TCO gap for heavy-duty e-trucks to their diesel equivalents. This policy intervention along with demand-side incentives, supply-side incentives and interest subvention would also reduce tailpipe emissions from MHDTs by 1 $MtCO_2$, with a consequent savings of 350 million litres of diesel consumption by 2040 from the base scenario.

Introducing purchase subsidies, extending the road tax, registration fee exemption and road toll waivers for medium and heavy-duty e-trucks can create early market impetus

A purchase subsidy of INR 10,000/kWh capped at 20% of the ex-factory price, combined with registration fee waiver, road tax exemption and a toll waiver for 5 years from purchase, can make the TCO of a 7.5T e-truck 12% lower than its diesel equivalent. Similarly, a purchase subsidy of INR 20,000/kWh capped at 30% of the ex-factory price, combined with registration fee waiver, road tax exemption and a toll waiver for 5 years from purchase for 14T and 28T e-trucks can bring down their TCO gap with their diesel equivalent to only 20-25%. All these measures are expected to increase the e-truck penetration to 4% by 2030 reaching up to 12% by 2040. The tailpipe emissions from MHDTs are estimated to decrease by 0.5 $MtCO_2$, with a consequent saving of 175 million litres of diesel consumption from base scenario by 2040. The demand-side incentives could cost about INR 95-357 crore from FY 2026-2030 depending on the volume of e-trucks to be incentivized out of the 1,400 e-trucks estimated to be sold under policy scenario 1.

The recent policy intervention by Transport Department in the state provides 100% road tax and registration fee exemption to cars and buses, which can be extended to include e-trucks as well. The purchase subsidy will complement the recent allocation of INR 500 crores under PM E-DRIVE for subsidizing the purchase of e-trucks. The road toll waiver can be operationalised by issuing a unique FASTag for EVs. This initiative is under active consideration by the Ministry of Road Transport and Highways (MoRTH) at the national level and can be used to implement road toll waivers for e-trucks across national highways.

Prioritisation of electrification in truck segments up to 7.5 T

Evaluation of the existing MHDT market in Telangana suggests that trucks between GVW 3.5-7.5T form about 20-25% of annual sales, making it the second largest selling MHDT GVW category in the state. While the upfront cost of EVs in this category is about 2-2.5 times higher than that of diesel equivalents, demand-side incentives can make their TCO 12% cheaper than diesel. The TCO for e-trucks in this category can be made up to 20% cheaper than diesel with availability of an interest subvention program and localisation of the EV supply chain. These truck segments up to 7.5T can also leverage overnight depot charging infrastructure with their intra-city applications.

Prioritization of commodity market/ sectoral /use case

Certain sectors have a faster transition target than the others and would pay to achieve this transition faster. The steel sector is under pressure towards NetZero compliance through both the Ministry of Steel and MoEFCC. Assessment by OEMs suggests that when electrification becomes a focal point in any sector's green transition, greater effort and therefore a significant cost will be borne by the sector. The greening supply chain commitment of the steel industry, cement industry, and e-commerce platforms such as Amazon creates an opportunity for a mass transition to e-trucks. Telangana can leverage the sectoral transition goals for its prominent steel and cement industry along with extensive e-commerce activities.

Developing charging infrastructure along highways in the state to create opportunities for e-trucks

Limited charging infrastructure availability on highways and the time loss in the logistics business due to slow charging were revealed as major hinderances for deployment of e-trucks during our consultation with stakeholders in the state. The state's EV policy has an ambitious target of developing charging stations every 50 km on major highway sections within the state[10]. Achieving this target would build confidence among shippers and logistical service providers to deploy e-trucks along major highways and industrial corridors. A corridor-based approach within and around industrial clusters such as cement, steel, and mining would build confidence to develop charging infrastructure, commence pilots for closed-loop operations, and ensure utilisation of charging infrastructure.

Electric truck adoption will need regulation-linked incentives and a set of coherent policies rather than just demand side incentives

So far, EV adoption in the country has been driven by policies and schemes with demand-side interventions that have led to adoption of light-duty passenger vehicles. However, in the past 10 years, the EV penetration has only been up to 6% at a national level and 7.4% for Telangana. Beyond this in impetus in adoption can be brought through incentives backed by regulations. Regulation-liked incentives such as sales credit mechanism or carbon trading would provide incentives for early adopters unlocking an additional revenue stream to invest in e-truck production. Global cases of California and EU prove that regulation-linked incentives increase e-truck product availability, reduce fiscal burden on governments, reduce e-truck prices due to increased competition among manufacturers and eventually increase e-truck sales.

Conclusion

The path to electrifying MHDTs at a sub-national level can be influenced through targeted policy interventions that reduce the total cost of ownership of a zero-emission truck. The state can consider interventions that promote localizing the EV supply chain, leveraging the sectoral transition goals, reducing tariffs for charging, and implementing financial incentives such as purchase subsidies, tax exemptions, toll waivers, and interest subvention to make the transition to ZETs more attractive for fleets. By the theory of scale, the integration of highway charging infrastructure and de-incentivizing operation of older diesel trucks will further enhance the viability of zero-emission freight. A holistic policy framework beyond just demand-side incentives will be crucial for driving long-term EV adoption and positioning Telangana as a leader in clean freight mobility.

Policy interventions that can positively influence the uptake of electric trucks include increasing permissible GVW for ZETs, instituting Corporate Average Fuel Economy norms, and credit mechanisms for trucks at the national level, low emission zones, and waivers of entry time and fee for ZETs in urban areas. Notably, some of these interventions and more have been also outlined in Bharat ZET Policy Advisory by Office of Principal Scientific Advisor, Government of India.

Annexure

A1. ZET adoption pathways in the US, EU, and China

United States (USA)

The US is committed to 30% ZET sales by 2030 and 100% ZET sales by 2040. This target was set up after the country had signed the Global Memorandum of Understanding on zero-emission medium and heavy-duty vehicles[11]. This was also signed by 18 other states within the country. However, there programs were in place prior to 2025 and are expected to have significant changes from 2025.

Regulations/ Standards: The National Highway Traffic Safety Administration (NHTSA) and the United States Environment Protection Agency (US EPA) are the regulatory authorities for establishing, respectively, the fuel efficiency and GHG emissions norms for the MHDT segment in the country. The following regulations were established for MHDTs:

- Phase 1 of Fuel Efficiency and GHG Emission Program for Medium- and Heavy-Duty Trucks, Model years 2014-2018. (*Launched in 2011*)[57]
- Final Rule for Phase 2 fuel efficiency and GHG emissions standards for medium- & heavy-duty vehicles, MY2018-2027. (*Launched in 2016*)[58]
- Final Rule and Related Materials for Control of Air Pollution from New Motor Vehicles: Heavy-Duty Engine and Vehicle Standards. (*Launched in 2022*)[59]
- Final Rule for HDPUV Standards Model Years 2030-2035 (for class 2b & class 3 vehicles). (*Launched in 2024*)[60]
- Final Rule for Phase 3 fuel GHG emission standards for Heavy Duty Vehicles MY 2027-2032 *(Launched in 2024)*[61]

In the case of sub-national regulations, California state adopted the Advanced Clean Trucks (ACT) regulations in 2020, which prescribes that manufacturers of medium-duty vehicles and heavy-duty vehicles sell zero-emission trucks as an increasing percentage of their annual California sales, starting from the 2024 model year.

Deployment Strategies:

- The purchase incentives played a major role in expediting the adoption of ZETs. The US Inflation Reduction Act (IRA) 2022, provides tax credits up to 40,000 USD or 30% of the vehicle cost for all-electric commercial vehicles weighing more than 14,000 pounds (6.3 tonnes) and 7,500 USD or 15% of the vehicle cost for 8,500 lbs (3.8-6.3 tonnes)[62].
- In addition to this, there are state-level purchase incentives for ZET which include California, Massachusetts, New York, and 26 other states[27].
- In 2021, the US Department of Energy (DoE) has helped fund 400 ZET deployments in states like Georgia, Texas & Florida, which do not have regulations for ZETs or have separate incentive programs[23].
- The country has also provided incentives and tax credits for charging infrastructure. As per the US IRA 2022, tax credits up to 1,00,000 USD or 30% of the alternative fuel vehicle refuelling infrastructure until 2032. As per the Infrastructure Investment and Jobs Act 2021, 7.5 billion USD was invested to install 5,00,000 EV chargers in the country by 2030[63].

As of the result of the policy levers and deployment strategies, more than 1,500 electric trucks were registered in the country by the end of 2023. Out of this, over 90% of the e-trucks were sold in 2022 & 2023 alone. The state of California leads the way with the greatest number of trucks registered in the state, followed by Texas, and New York[64].

European Union (EU)

The region does not have a separate target for the MHDT segment but is committed to a legally binding target of net-zero carbon emission by 2050 under the European Climate Law[65]. But certain countries have their national commitments for medium and heavy-duty vehicles. For example, Austria's National Mobility Master Plan targets zero conventional MDVs by 2030 and HDVs by 2035[66].

Regulations/ Standards:

- In 2019, the European Union set CO_2 emission performance standards for MHDVs requiring a 15% reduction by 2025 and 30% by 2030. These are applicable to rigid and tractor trucks with a GVWR of 16 tonnes and above[27].
- In 2022, the European Commission updated the EU's CO_2 regulation for trucks and buses wherein all new trucks and coaches must cut their CO_2 emissions by 90% in 2040 which applied to trucks above 7.5 tonnes[31].
- In 2024, the CO_2 regulations were updated to include more MHDT categories such as GVW 5-16 tonnes (4x2 axle) and vocational vehicles. The definition of ZEVs and penalties were also changed in these regulations.

Deployment Strategies:

- There are no purchase incentives for trucks at a regional level but individual nations in the EU have their own set of incentive support for electric trucks.
- The commission has applied a "polluters pay" principle to freight movement on trans-European transport (TEN-T) network roads by adopting a directive that offers up to 75% toll discounts to zero-emission MHDVs, among other ZE vehicles, starting in 2024. This is related to the CO_2 emissions level of the vehicle (for both battery-electric and fuel-cell electric vehicles).
- The Alternative Fuel Infrastructure Regulations (AFIR), 2023 targets the deployment of EV charging stations for HDVs with a minimum output of 350 kW at every 60 km along the TEN-T core network, and every 100 km on the larger TEN-T comprehensive network from 2025 onwards, with complete network coverage to be achieved by 2030[67].

As a result of the policy levers and deployment strategies, in 2023, about 10,000 e-trucks were sold (1.5% of total truck sales) in the EU, which is more than three times the 3,000 sold in the previous. The largest number of models for heavy-duty trucks are also available in this region: around 36, which is a 50% increase from the previous year[68].

China

As per the New Energy Vehicle Industry Development (2021-2035), the country has a target of fully electrifying their public sector vehicles by 2035 including buses, sanitation vehicles, and postal vehicles. China will also phase out ICE truck sales by 2030.

Regulations/ Standards: China does not have any direct, enforceable regulation for GHG reduction in the MHDV segment, but they do have fuel economy standards, launched in 2012, that directly affect the GHG emissions. In 2018, the country finalized the China-VI Standards, which involve two phases (a & b). The China VI-a (2019-2021) is similar to Euro VI standards and applied to internal combustion engine vehicles, whereas the China VI-b (2021-2023) adds compliance requirements for liquefied natural gas and natural gas-based truck engines too[69].

Deployment Strategies:

- The country updated its previous subsidy scheme for new energy vehicles (vehicles powered entirely or predominantly by electricity) in 2019 for trucks, which was directly related to the battery capacity used. The base incentive is 350 CNY/kWh (50 USD/kWh), capped at 55,000 CNY (7,800 USD) for MHDTs. This applied to 2 million NEVs per year from 2020 to 2022 (all classes combined)[70].
- The new energy vehicle subsidy scheme disapproves of upfront cost subsidies from local governments except for fuel-cell electric vehicles and new-energy buses but encourages subsidies for charging infrastructure from the local governments.
- The policy document "Implementation opinions on further improving the service guarantee capacity of electric vehicle charging infrastructure" (2022) supports the construction of swapping stations near mines and ports. It commits to 80% coverage of fast charging stations on highways in key pilot areas and areas for air pollution prevention and control and 60% coverage for other areas by 2025[71].

As a result of the policy levers and deployment strategies, China has the highest number of e-truck sales globally. As of 2024, over 50% (150) of the e-truck models (medium and heavy-duty) are available in the country. During the period of the new electric vehicle subsidy scheme, the country witnessed a rapid growth in electric truck sales from 6,700 in 2020 to 38,000 in 2023[68].

A2. Input data for TCO

	Parameters	Units	Diesel Trucks	Electric Trucks	Diesel Trucks	Electric Trucks	Diesel Trucks	Electric Trucks
Vehicle Characteristics	Vehicle Class		**N2**		**N3**			
	GVW segment	tonnes	**6-7.5**		**25-34**		**12-16.2**	
	Reference Model		Eicher Pro 2059XP	Ultra T.7 Electric	UE 2825/39 TIP	Meghaetron Electric Tipper	Ecomet Star 1415	Boss 14 HB EV
	Truck type		Haulage		Tipper		Haulage	
	OEM		VECV	Tata Motors	Ashok Leyland	Olectra Greentech	Ashok Leyland	Ashok Leyland
	Model GVW	tonnes	7.5	7.5	28	28	14	14
	Payload	tonnes	3.8	3.4	17.5	16	9.8	8.5
	Engine/Motor power	HP	120.7	220	248	362	160	160
	Battery capacity	kWh	-	62.5	-	200	-	201.5
	Vehicle range	km	-	110	-	175	-	230
	Axle configuration		4x2	4x2	6X4	6X4	4x2	4x2
	No of tyres	number	4	6	10	10	6	6
	Battery warranty	years	-	5	-	5	-	5
	Battery residual value	%	-	15%	-	15%	-	15%

	Parameters	Units	Diesel Trucks	Electric Trucks	Diesel Trucks	Electric Trucks	Diesel Trucks	Electric Trucks
Vehicle Cost and Financing	Cost of vehicle (Ex-showroom, Hyd)	INR	15,42,000	22,00,000	45,60,000	1,27,68,000	25,00,000	70,81,718
	Cost of powertrain (USD converted to INR)	INR	3,58,000	-	5,00,000	-	4,00,000	-
	Powertrain: Upfront cost	%	23%	40%	11%	40%	16%	40%
	% of upfront cost financed	%	80%	80%	80%	80%	80%	80%
	Interest rate of financing	%	15%	17%	15%	17%	15%	17%
	Annual insurance premium	INR	18,761	23,451	49,600	62,000	41,669	52,087
	Registration tax for the vehicle	INR	1,000	1,000	1,500	1,500	1,500	1,500
	Other taxes/cess	INR	1,69,233	1,46,100	5,83,105	5,03,400	2,57,845	2,22,600
	Battery cost	INR/kWh	-	14,058	-	14,058	-	14,058

	Parameters	Units	Diesel Trucks	Electric Trucks	Diesel Trucks	Electric Trucks	Diesel Trucks	Electric Trucks
Operational Characteristics	Distance travelled per day	km	200	200	150	150	300	300
	No. of operating days per month	number	25	25	25	25	25	25
	Dead km travelled per day	km	10	10	10	10	10	10
	Annual VKT	km	60,000	60,000	45,000	45,000	90,000	90,000
	Payload utilization	%	90	90	90	90	90	90
	Mileage w/ 100% payload	km/l | km/kWh	7	1.7	2.5	1	4.5	1.3
	Mileage w/o payload	km/l | km/kWh	10	1.92	3.75	1.1	6.5	1.4
	No. of on-road hours per day	hours	8	8	8	8	8	8
	Rest time per day	hours	4	4	4	4	4	4
	Loading/Unloading time per day	hours	2	2	2	2	2	2

	Parameters	Units	Diesel Trucks	Electric Trucks	Diesel Trucks	Electric Trucks	Diesel Trucks	Electric Trucks
Operational Costs	Toll charges/trip	INR	1,657	1,657	2,597	2,597	1,657	1,657
	Diesel price	INR/litre	97	-	97	-	97	-
	Electricity price	INR/kWh	-	13	-	13	-	13
	YoY change in diesel cost	%	4%	-	4%	-	4%	-
	Crew cost per month per vehicle	INR	15,000	15,000	30,000	30,000	30,000	30,000
	YoY increase in crew cost per vehicle	%	2%	2%	2%	2%	2%	2%
	Annual maintenance cost	INR	77,100	92,520	2,28,000	2,73,600	1,25,000	1,50,000
	AMC period	years	5	5	5	5	5	5
	Cost of retreading tyres	INR/tyre	4,000	4,000	9,000	9,000	9,000	9,000

A3. Stakeholder consultations

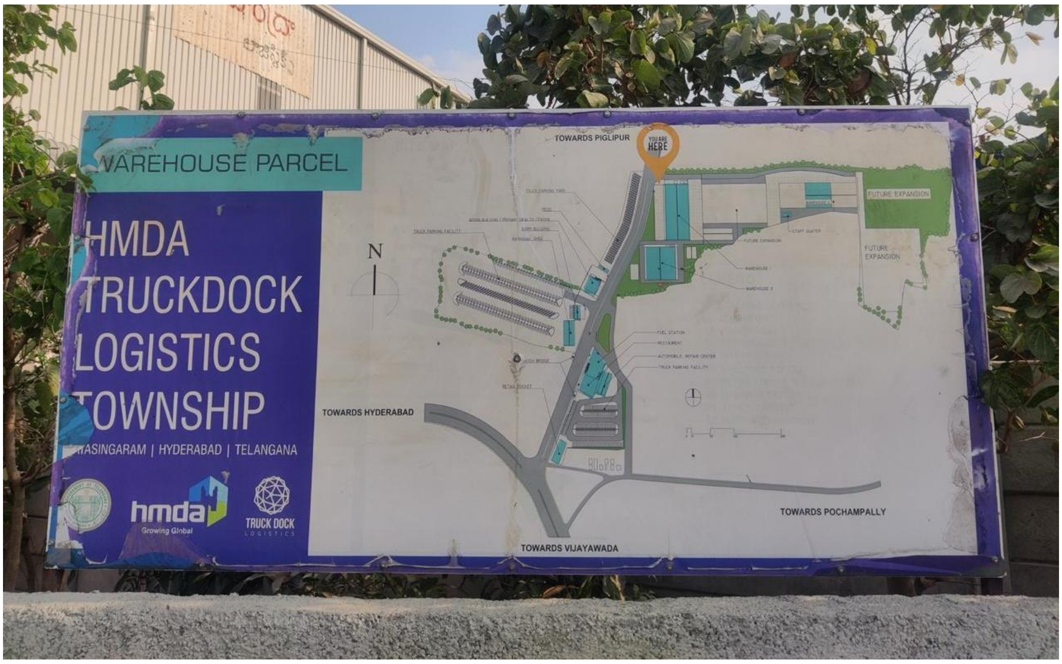
Stakeholder consultations with OEM, Fleet operators, Financiers in Hyderabad, Telangana

Stakeholder consultations with OEM, Fleet operators, Financiers in Hyderabad, Telangana

Stakeholder consultations with OEMs and charge point operators in Delhi, in association with ICCT

A4. Site visits in Telangana

Docking bays of trucks for loading and unloading at Hyderabad Metropolitan Development Authority (HMDA) truckdock logistics township



HMDA truckdock logistics township site map

Fleet operators working out of the warehouse at HMDA logistics park in Batasingaram, Hyderabad, Telangana

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