

Electrifying on-road freight: Straight trucks in long-haul transport in Yangtze River Delta, China

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INTRODUCTION

In 2024, zero-emission medium- and heavy-duty vehicle (ZE-MHDV) sales in China exceeded 230,000 units, more than double the total the previous year (Mao & Rodríguez, 2025). Battery electric trucks (BETs) accounted for over 75% of the ZE-MHDV market, driven primarily by the rapid electrification of on-road freight. In recent years, short-haul operations have been the primary use cases for BETs in segments such as port traction, bulk commodity transport, construction waste hauling, concrete delivery, and sanitation. Policy support—including mandates for clean transport in high-pollution industries and municipal pilot programs for electrification—has been crucial (Chu & Ye, 2025; Mao et al., 2024), and BETs have achieved competitive total cost of ownership (TCO) compared with diesel trucks in these segments (Mao et al., 2023; Niu et al., 2024).

Targeted policies have further supported the expanding use of ZE-MHDVs since 2024. The Ministry of Transport (MOT) has promoted BETs for zero-emission freight and green logistics and expanded networks for vehicle charging and battery swapping (Chang & Niu, 2025), while interministerial policies aim to integrate transportation and energy infrastructure to increase the use of electricity in the transport sector (MOT et al., 2025). Building on this foundation, pilot projects are exploring the use of BETs on truck freight routes and zero-emission corridors of 300–800 km (Smart Freight

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Centre, 2025). Charging-based BETs, enabled by rapid technological advancement in batteries and high-power charging above 240 kW, have been increasingly adopted in medium- and long-haul operations. For example, as of 2024, large batteries (e.g., 350 kWh and 423 kWh batteries) have become popular in the heavy-duty BET market (Mao & Rodríguez, 2025), while new megawatt (MW)-level chargers can enable a 300 kWh battery pack to achieve a full charge cycle in 15 minutes (Miao, 2025).

Despite these promising developments, several practical challenges hinder widespread use of BETs, particularly for medium- and long-haul operations. Key concerns include inadequate charging or swapping infrastructure, potential range and load-capacity limitations, reduced operational efficiency compared with diesel trucks, and questions about economic viability (Yufei et al., 2025). Although pilot uses of BETs are underway, comprehensive analyses of their real-world operational and economic performance in long-haul contexts are lacking. Without such evidence, policymakers cannot design targeted interventions, and fleet operators cannot assess whether BETs meet operational and financial requirements on long-haul routes.

This study addresses this gap by examining a real-world use case of charging-based BETs in long-haul logistics with one-way distances exceeding 400 km in China's Yangtze River Delta region. Drawing on data collected in 2025 by the China Automotive Technology and Research Center through fleet operator interviews and site visits, we present the current operational status of BETs in long-haul applications and analyze their performance in terms of TCO. By identifying the key success factors that enable long-haul BET operations and the specific obstacles that remain, this analysis provides evidence to inform targeted policy interventions that can accelerate the transition from short-haul to long-haul freight electrification in China.

USE CASE OVERVIEW

USE CASE INTRODUCTION

In this study, we analyzed the use of BETs in the long-haul cross-provincial transport of auto parts in the Yangtze River Delta region in China (see Figure 1). As shown in Table 1, the BET fleet deployed consisted of eight 18-ton straight trucks with a battery capacity of 330 kWh. These trucks can travel up to 300 km on a single charge, according to the vehicle manufacturer. Overall, the BETs have comparable specifications to diesel trucks, despite a higher curb weight primarily attributable to battery weight.

Figure 1
Straight trucks used in the long-haul transport of auto parts



Table 1
Vehicle model specifications

Vehicle specification	Electric truck	Diesel truck
Vehicle type	Straight truck	Straight truck
Gross vehicle weight	18,000 kg	18,000 kg
Curb weight	11,200 kg	9,000 kg
Size (L × W × H)	12,000 × 2,550 × 3,990 mm	12,000 × 2,550 × 3,990 mm
Cargo container (L × W × H)	9,800 × 2,480 × 2,500 mm	9,750 × 2,500 × 2,700 mm
Engine power (rated/max)	185/251 kW	162/220 kW
Battery capacity	330 kWh	N/A
Certified range	300 km	N/A

The route in this use case covered a total distance of 450 km one way, or 900 km round trip; 70% of the roads were highways, with an average driving speed of 75 km/h. Along the route, there were four logistics/charging stops in total, with charging facilities mainly located either at the truck depot or at the customer premises. The route and charging infrastructure setups for this use case were as follows (see also Figure 2):

Origin at truck depot: The BETs began their journey with a payload of 5–6 tons from a truck depot in Hefei, Anhui Province, an industrial park producing auto parts. At the depot, the BETs were fully charged overnight from 15% to 100% using 240 kW chargers installed by the operator.

Customer premises (first destination): BETs traveled 265 km (approximately 3.5 hours) to an auto parts distribution center in Liyang, Jiangsu Province. At the center, 40% of the truck's cargo was unloaded, during which time the truck was recharged

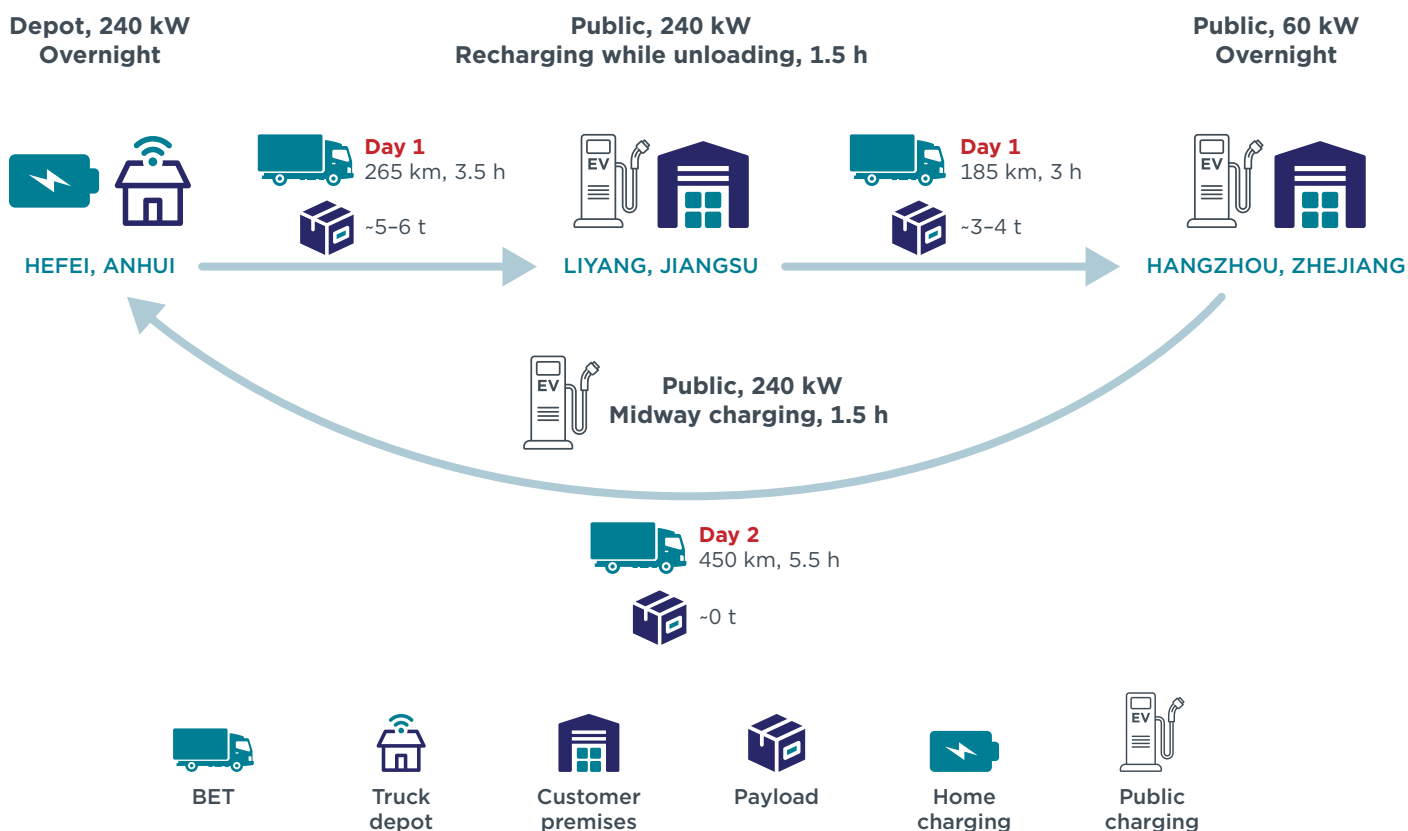
using 240 kW public chargers. This took the battery's charge from 15% to 90% state of charge (SOC) over the course of about 1.5 hours.

Customer premises (second destination): BETs traveled 185 km (approximately 3 hours) to an auto industrial park in Hangzhou, Zhejiang Province, where the remaining cargo was unloaded and the truck recharged overnight from 30% to 100% SOC with 60 kW public chargers.

Midway stop during the return trip: The following day, BETs returned empty back to Hefei, traveling approximately 450 km (approximately 5.5 hours), with a midway recharge from 15% to 100% SOC at non-highway service areas using 240 kW fast chargers over the course of about 1.5 hours.

Figure 2

Schematic diagram for e-truck use case



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MAIN CHALLENGES OBSERVED

Based on real-world operation for this use case, we identified four challenges for the application of BETs in long-haul transport, highlighting the multiple dimensions that currently hinder BET deployment.

Low operational mileage: The actual annual operational mileage for trucks in this use case is approximately 32,000 km per year, with 2-3 round trips per month. Low-mileage operations limit BETs' ability to recover their higher upfront costs through fuel savings, as operational savings scale with distance traveled.

Charging efficiency gap: BETs take an extra half day for the return trip, while diesel trucks can complete a round trip within a single day.

Payload loss: Due to a higher curb weight from the 330-kWh battery, BETs have a maximum payload of 6.8 tons, which presents a maximum payload loss of 2.2 tons (equivalent to 24%) compared with diesel trucks.

Low-temperature range loss: BETs experienced a 30%–40% reduction of battery range during winter months due to low temperatures.

TOTAL COST OF OWNERSHIP ANALYSIS

METHODOLOGY AND FRAMEWORK

This study also examines the operational and economic performance of BETs for long-haul delivery through an evaluation of TCO, using the Analyzer of Zero-Emission Transportation Energy and Costs (AZTEC) model detailed in an earlier ICCT report (Tianlin et al., 2023).

This analysis considers an Ideal Case and four scenarios to measure the performance of BETs; we used quantitative analysis to assess the impact of key challenges and to identify the most salient factors for the successful deployment of BETs. Table 2 outlines the framework of the TCO analysis and summarizes the key assumptions based on the empirical information for each scenario; bolded text indicates assumptions that depart from the Ideal Case.

Table 2
Assumptions summary by scenario for battery electric trucks and diesel trucks (DTs)

Items	Ideal Case	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Purpose	Assess the feasibility and TCO benefit potential	Assess the impact of low operational mileage	Assess the impact of a charging efficiency gap	Assess the impact of payload loss	Assess the impact of low-temperature range loss
Key assumptions					
Operational mileage	BET: -140,000 km/yr DT: -140,000 km/yr	BET: -32,000 km/yr DT: -32,000 km/yr	BET: -93,000 km/yr DT: -140,000 km/yr	BET: -140,000 km/yr DT: -140,000 km/yr	BET: -140,000 km/yr DT: -140,000 km/yr
Charging efficiency	BET: 1 day/trip DT: 1 day/trip	BET: 1 day/trip DT: 1 day/trip	BET: 1.5 days/trip DT: 1 day/trip	BET: 1 day/trip DT: 1 day/trip	BET: 1 day/trip DT: 1 day/trip
Payload loss	None	None	None	BET vs. DT: 2.2 t (24%)	BET vs. DT: 1 t (-10%)
Low-temperature range loss	None	None	None	None	Battery range loss of 35%, leading to the use of 450 kWh battery

Ideal Case: In this scenario, the BETs faced no major barriers. Like diesel trucks, BETs were able to complete a 900 km round-trip journey within a single day. To make this possible, BET operators had access to high-power charging solutions—such as 240 kW chargers at the second customer site—rather than relying on slow overnight charging. For operational mileage, the trucks were assumed to be retired after accumulating 700,000 km over a 5-year period of ownership, which translated to an annual mileage of 140,000 km (MOC et al., 2012). Moreover, we assumed that BETs did not have

any potential payload loss relative to their diesel counterparts and that there was no reduced range associated with low temperatures.

Scenario 1—Low operational mileage: In this scenario, BETs operated at the actual lower utilization rate, with an annual mileage of about 32,000 km. All other variables were identical to the Ideal Case.

Scenario 2—Charging efficiency gap: This scenario was like the Ideal Case, but BETs stayed at the second customer site for overnight charging due to limited access to high-power chargers. This required an extra half day for the return trip, reducing annual operational mileage by one third.

Scenario 3—Payload loss: All variables in this scenario were the same as the Ideal Case, except BETs faced a payload loss of 2.2 tons (equivalent to 24%) compared with their diesel counterparts.

Scenario 4—Low-temperature range loss: This scenario was similar to the Ideal Case, but BETs were assumed to face a range loss of 35% in winter due to low temperatures. To compensate for this loss, the BETs required a larger battery with a capacity of around 450 kWh instead of 330 kWh. The larger battery increased the capital expenditure of the vehicle purchase by about 20% and led to a corresponding payload loss of about 1 ton.¹

INPUTS AND ASSUMPTIONS

This section summarizes the key input data and assumptions for estimating the capital expenditures (CapEx) and operational expenditures (OpEx) of BETs and diesel trucks for each scenario.

Capital expenditures

Table 3 presents the input data and assumptions for CapEx related to the purchase of vehicles. For the comparative analysis of the low-temperature impact, we considered the purchase of BETs with 330 kWh and 450 kWh batteries.² All vehicles were assumed to have been purchased through a loan with a 30% down payment, a 4% interest rate, and a 3-year loan term. The analysis accounted for the tax-exempt status of BETs, while diesel trucks were assumed to face taxation at the point of purchase. In the study, the TCO was estimated over an ownership term of 5 years, and the residual value rate after 5 years was assumed to be 20% for BETs and 30% for diesel trucks, based on fleet operator surveys and the findings of Zhao and Ren (2022).

In addition, we accounted for costs associated with installing charging facilities at the truck depot. According to the surveys, the expenses included ¥600,000 for the installation of six 240 kW chargers in addition to ¥750,000 for connecting these chargers to the grid and installing a power distribution system. Fleet operator surveys indicated that the installed facilities could serve a fleet of 40 BETs, and the

1 We calculated this payload loss of approximately 1 ton based on the energy density of 130–150 Wh/kg for the lithium iron phosphate battery pack.

2 The cost of a BET with a 330 kWh battery was based on the actual cost provided in the operator surveys. The added cost to replace the 330 kWh battery with a 450 kWh battery reflected the actual battery cost of ¥788/kWh at that time.

infrastructure setup costs were amortized on a per-vehicle basis.³ The residual value of the chargers and power distribution system was estimated over lifecycles of 8 years and 20 years, respectively.

Table 3

Inputs and assumptions for capital expenditures related to the purchase of vehicles

Component	BETs (330 kWh)	BETs (450 kWh)	Diesel trucks
Vehicle purchase cost	¥480,000/vehicle	¥575,000/vehicle	¥280,000/vehicle
Purchase tax	Exempted	Exempted	¥25,450/vehicle
Loan for vehicle purchase	Yes	Yes	Yes
Ownership term	5 years	5 years	5 years
Residual rates	20%	20%	30%

Operational expenditures

Battery electric trucks generally demonstrated strong competitiveness in energy cost savings compared with diesel trucks, with reductions above half. Drawing from fleet operator surveys, Table 4 presents energy cost data for BETs and diesel trucks. Average energy consumption efficiency was 129 kWh/100 km for BETs and 30 L/100 km for diesel trucks. We examined two operational scenarios for BETs—completing the round-trip within 1 day or within 1.5 days—depending on the availability of 240 kW fast chargers at the second customer site. Using fast chargers instead of slow overnight charging increased the average energy cost by only 10%, from ¥790 per trip to ¥867 per trip, while still maintaining substantial savings over diesel trucks.

Table 4

Inputs and assumptions for energy costs

Charging location	BETs (1 day/trip)		BETs (1.5 days/trip)		Diesel trucks (1 day/trip)
	Chargers	Cost	Chargers	Cost	Cost
Truck depot	240 kW	¥0.3/kWh	240 kW	¥0.3/kWh	/
First customer site	240 kW	¥0.9/kWh	240 kW	¥0.9/kWh	/
Second customer site	240 kW	¥0.9/kWh	60 kW	¥0.6/kWh	/
Return trip	240 kW	¥0.9/kWh	240 kW	¥0.9/kWh	/
Average energy cost	¥0.75/kWh, ¥867/trip		¥0.68/kWh, ¥790/trip		¥7.13/L, ¥1925/trip

Aside from these energy costs, we considered other OpEx in the TCO analysis based on the empirical data collected from the fleet operator. For example, diesel trucks were subject to an annual ownership tax of ¥660, whereas BETs were exempt from this tax. Both BETs and diesel trucks faced a toll fee of ¥700 for a 900 km round-trip. Table 5 outlines these additional expenses.

³ The 1,440-kW charging station consisted of six 240 kW chargers. Based on an average charging session of 1.5 hours per BET per day, we assumed that the station served a fleet of about 40 BETs per day, with an average utilization rate of approximately 40%.

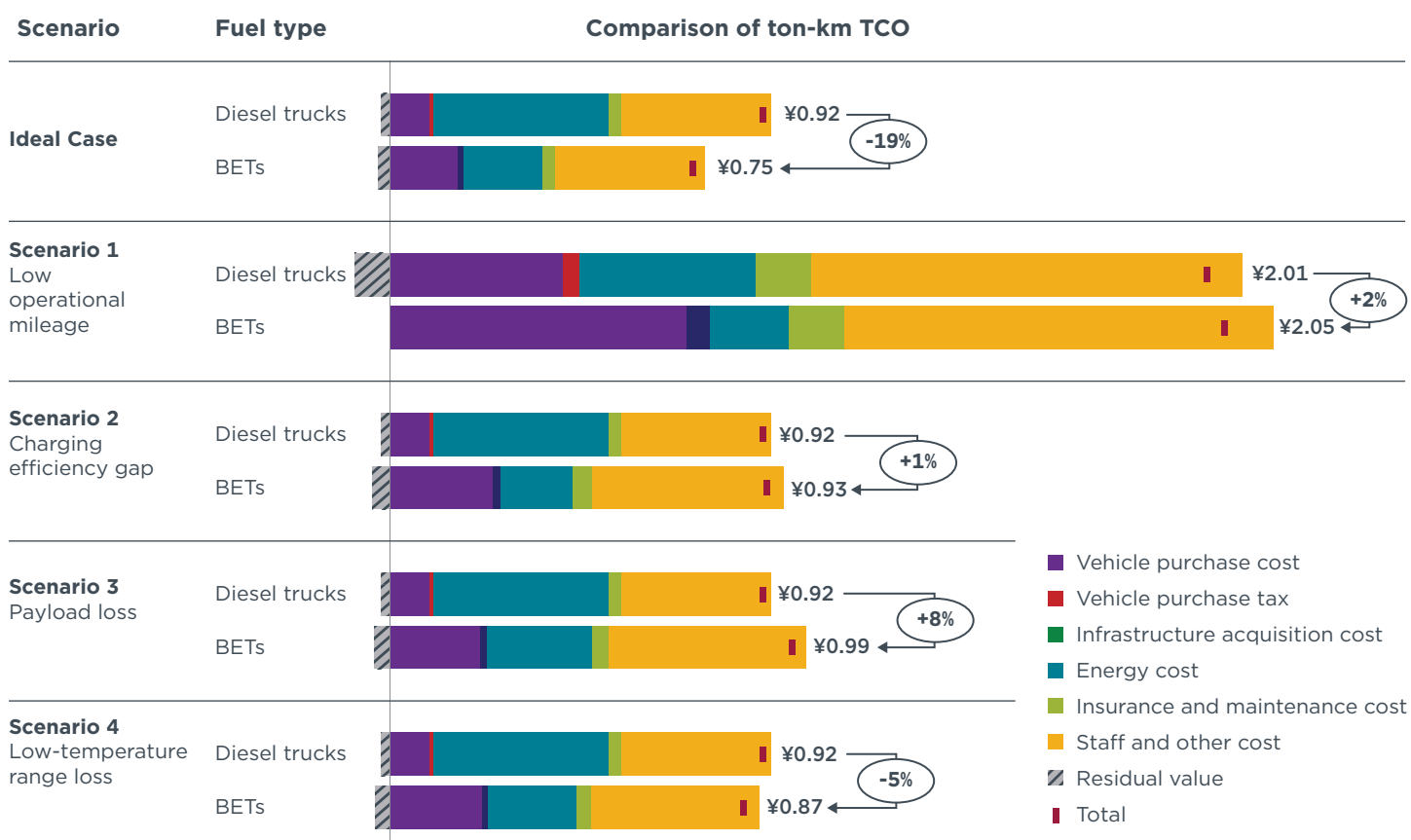
Table 5
Inputs and assumptions for other operational expenses

Component	BETs	Diesel trucks
Insurance cost	¥14,000/year	¥12,000/year
Maintenance cost	¥8,000/year	¥10,000/year
Highway toll fee	¥700/trip	¥700/trip
Staff cost	¥144,000/year	¥144,000/year
Ownership tax	Exempted	¥660/year

RESULTS AND DISCUSSION

Figure 3 presents the main results of the TCO analysis. Through a side-by-side comparison of the scenarios, the figure shows key findings on the impact of the four identified challenges on TCO. After reviewing these findings, we outline key lessons learned for successful BET deployment in long-haul operation in the following section.

Figure 3
Scenario comparison of ton-km TCO



Ideal Case

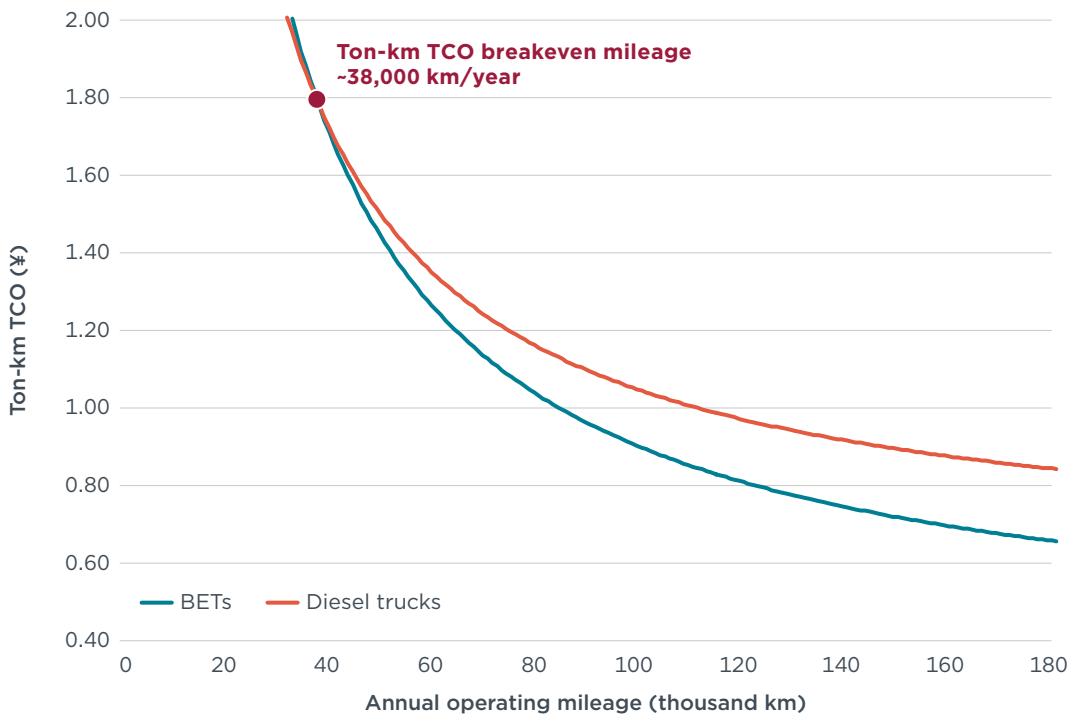
Despite the challenges modeled in the other scenarios, the Ideal Case demonstrated that, under the right circumstances, electrified freight is technologically and operationally viable for haulage operations above 400 km one-way and 900 km daily round-trip. With advanced BET models, high-power charging solutions, and effective route planning (e.g., leveraging logistics/recharging stops with available charging infrastructure), BETs are operationally competitive with diesel trucks. Moreover, charging strategies—such as overnight charging while the BET is not in service or charging during loading/unloading periods—can effectively save recharging time and improve operational efficiency.

In addition to the proven feasibility of deploying BETs in long-haul operations, BETs also demonstrated substantial economic benefits. As Figure 3 shows, when trucks operated at a mileage of 140,000 km per year, the ton-km TCO for BETs was 19% lower compared with diesel trucks, with strong competitiveness in energy cost savings—as much as 55%–60%.

Scenario 1—Low operational mileage

The TCO for BETs was significantly impacted by operational mileage; primarily due to reduced energy costs, higher mileages favored BET options compared with diesel trucks. In the Ideal Case, when trucks were assumed to operate at a mileage of 140,000 km per year, the ton-km TCO for BETs was 19% lower than for diesel trucks. However, when BETs operated at the lower annual mileage of 32,000 km assumed in Scenario 1, BETs showed TCO disadvantages, with a ton-km TCO that was 2% higher compared with diesel trucks (see Figure 3).

However, as indicated in Figure 4, once the annual mileage surpassed a TCO breakeven threshold of 38,000 km, the ton-km TCO savings for BETs grew swiftly. According to a report by the China Automotive Technology and Research Center, long-haul highway transport for heavy-duty trucks averages 65,000 km annually (Zhao & Ren, 2022). This suggests that BETs can be economically viable for long-haul transport, with an estimated 10% ton-km TCO savings at this average annual mileage.

Figure 4**Comparison of ton-km TCO for BETs and diesel trucks by annual operating mileage**THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION [THEICCT.ORG](https://theicct.org)

Scenario 2—Charging efficiency gap

Charging infrastructure efficiency and availability were crucial for BET operational performance and TCO savings. Full access to 240 kW fast chargers enabled BETs to match the operational efficiency of diesel trucks, thereby yielding a ton-km TCO savings of 19%, as shown in the Ideal Case. When there was no such access to fast chargers, BETs instead saw a ton-km TCO that was 1% higher compared with diesel trucks (see Figure 3).

Although BETs could complete a trip in 1 day in the Ideal Case, they still required an additional 3–4 hours compared with diesel trucks. High-power charging infrastructure, such as 240–600 kW direct current fast charging and MW charging systems, could enhance operational efficiency by significantly reducing the current 1.5-hour charging time required per session.

Scenario 3—Payload loss

Payload loss—the reduction in cargo-carrying capacity due to battery weight—poses a challenge to the operational and economic viability of BETs because it reduces the volume of goods that can be transported per trip, consequently reducing revenue and profitability.

Compared with the Ideal Case, the 2.2-ton payload loss (equivalent to 24%) eliminated the TCO advantage of BETs over diesel trucks, turning a 19% TCO advantage into a ton-km TCO that was 8% higher compared with diesel trucks (see Figure 3). This highlights payload loss as a critical issue that must be addressed for the successful adoption of electric trucks in long-haul transport.

Scenario 4—Low-temperature range loss

Low temperatures reduce battery efficiency and range, presenting seasonal operational limits for BETs, especially for long-haul transport. When maintaining spare capacity specifically for winter conditions, BETs saw weakened economic performance. Although they still had a ton-km TCO savings over diesel trucks of 5%, savings were 14% lower than in the Ideal Case (see Figure 3). Relatedly, range anxiety—including in the case of reduced battery capacity due to low temperatures in winter—is a key obstacle for BET adoption, particularly in long-haul cases. Moreover, the interim solution of employing larger batteries appears impractical, especially given the payload loss constraints discussed above.

SUCCESS FACTORS AND POLICY IMPLICATIONS

This study explored the current status of BET adoption in long-haul transport. Through a deep dive into a 450 km cross-provincial use case in China's Yangtze River Delta, the study evaluated the operational and economic performance of BETs in long-haul transport, identifying and analyzing the main challenges for BET deployment. Based on this analysis, we delineate the key success factors and policy considerations for BET deployment in long-haul operations.

KEY SUCCESS FACTORS

Based on the findings of the study, the key factors for the successful deployment of BETs in long-haul operation are as follows:

Sufficient operational mileage: Operational mileage had a significant impact on the TCO for BETs, with higher daily or annual mileages yielding more substantial TCO advantages over diesel trucks. While operational mileage for long-haul transport varies depending on the transport demand of specific cargos and the fleet utilization by operators, our results showed that, when BETs have an annual mileage ranging from 38,000 km to 140,000 km, they demonstrate a strong potential for BET cost reductions, with ton-km TCO savings up to 19%.

Access to efficient charging: The availability of robust charging infrastructure is crucial for the efficient operation of BETs in long-haul operations. Full availability of 240 kW fast chargers enabled BETs to save a half day on a 900 km round-trip journey; this in turn allowed BETs to complete a long-haul operation within 1 day, making their operational efficiency comparable to that of diesel trucks. Bridging this half-day efficiency gap between BETs and diesel trucks contributed to a ton-km TCO savings for BETs of 20% when compared with diesel trucks. Moreover, access to higher-power chargers above 240 kW could reduce the current charging time of 1.5 hours required per session, further enhancing the operating efficiency of the BET.

Improved payload capacity: Due to the added weight of the battery pack, BETs often have a reduced payload capacity relative to their diesel counterparts. Our results showed that addressing the issue of payload loss for BETs considerably improved their operational and economic performance compared with diesel trucks. Specifically, closing the 24% payload gap between BETs and diesel trucks contributed to a ton-km TCO savings of 27%.

Improved low-temperature performance: Low temperatures degrade battery performance by reducing battery efficiency and range. Maintaining optimal performance in low temperatures is important for achieving widespread adoption of

BETs, especially in long-haul scenarios and in regions with harsh winters or extended cold seasons. Our analysis indicated that the interim solution of employing larger batteries in low-temperature conditions is impractical: due to the extra capital expenditure and battery weight, increasing the battery's spare capacity reduced the ton-km TCO savings for BETs by 14% compared with diesel trucks. This suggests that battery technology optimization and active thermal management are crucial for improving BET reliability and market acceptance.

POLICY CONSIDERATIONS

Our findings suggest that the following targeted policies can enhance BET competitiveness and accelerate deployment in medium- and long-haul applications:

- 1. Broaden BET targets and promote BET pilots for medium- and long-haul use cases.** Our results showed that existing technological solutions—including 330+ kWh batteries, 240+ kW fast chargers, and current vehicle designs—enabled BETs to complete 400 km one-way haulages and 900 km daily round-trip haulages. Routes of approximately 400 km, such as those in the Yangtze River Delta's auto industrial cluster, present viable opportunities for pilot deployments. Policymakers could consider:
 - » Establishing specific deployment targets for BETs on routes of 300–500 km;
 - » Designating priority corridors for long-haul BET pilots; and
 - » Providing technical and financial support for fleet operators transitioning to BETs on these routes.
- 2. Accelerate deployment of high-power charging infrastructure on key freight corridors.** The lack of efficient charging infrastructure is a key barrier to the operation of BETs in long-haul transport. In this study, limited availability of high-power chargers extended trip duration from 1 day to 1.5 days, reducing operational efficiency. To address this constraint, policy support could be dedicated to:
 - » Providing financial support for high-power charging infrastructure installation, particularly at logistics hubs and highway service areas; and
 - » Supporting the deployment of complementary electrification infrastructure solutions—including both high-power charging and battery swapping—tailored to different operational needs.
- 3. Address payload constraints through regulatory adjustments and targeted incentives.** Battery weight currently reduces BET payload capacity, creating a competitive disadvantage compared with diesel trucks. The findings in this study indicated that BET payload loss substantially affected their operational and economic performance, especially for the long-haul operations that require sufficient battery range and heavy cargo load. Policymakers could consider:
 - » Revising GB1589 vehicle dimension and weight regulations to permit higher maximum-allowable weight limits for BETs, specifically accounting for battery mass (Ministry of Industry and Information Technology et al., 2016); and
 - » Implementing incentives such as payload and mileage-based subsidies that compensate operators for the lost income resulting from lower payloads.

4. Develop technical standards and certification programs to improve cold-weather performance. Temperature-related range degradation significantly affects BET viability in regions experiencing cold winters. To encourage technological improvements, policymakers could consider:

- » Establishing safety or performance standards requiring robust thermal management and mandating low-temperature life-cycle testing as part of vehicle type-approval processes;
- » Implementing certification programs that provide incentives to vehicle manufacturers for improved cold-weather performance, such as low-temperature range retention; and
- » Mandating progressively more stringent energy consumption standards for BETs to incentivize efficiency improvements that reduce battery weight and can provide adequate range during winter conditions.

CONCLUSION

This analysis demonstrated that under specific operational conditions, BETs are technologically and economically viable in long-haul logistics, including routes exceeding 400 km. Drawing on real-world data from cross-provincial auto parts transport in China's Yangtze River Delta, we found that with strategically placed high-power chargers, it is feasible for BETs to complete 900 km daily round-trip operations, with substantial TCO savings of 19% compared with diesel trucks.

However, barriers remain that constrain broader deployment. Infrastructure gaps—specifically the limited availability of 240+ kW chargers along the freight route—directly impacted operational efficiency, extending trip durations and reducing vehicle utility. Payload constraints resulting from battery weight created competitive disadvantages compared with diesel trucks. Cold-weather performance degradation further limited BET efficiency and viability.

Addressing these constraints requires targeted policy interventions. Our analysis suggests four priority areas: expanding pilot programs and deployment targets into long-haul operations, accelerating the development of efficient refueling infrastructure, adjusting weight regulations to address payload limitations, and establishing performance standards to drive improvements in cold-weather performance. Coordinated policy efforts in these targeted areas can help China expand the use of ZE-MHDVs into long-haul transport, moving from scattered pilots to systematic deployment and accelerating the pace toward achieving its zero-emission targets.

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