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Total cost of ownership parity between battery electric trucks and diesel trucks in India

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EXECUTIVE SUMMARY

Medium- and heavy-duty trucks play a critical role in India's economy. They are also a major source of greenhouse gas emissions. While they constitute only 3% of the on-road vehicle fleet in India, they contribute 44% of the well-to-wheel CO_2 emissions from road transport. Looking ahead, the adoption of zero-emission trucks—including battery electric trucks (BETs) and fuel-cell electric trucks—is critical to India's pursuit of its Paris Agreement commitments and to achieving its goal of net-zero emissions by 2070. While the Government of India has provided growing support for the electrification of other vehicle segments, the truck segment could benefit from additional policy support in the form of fuel-economy regulations and incentives.

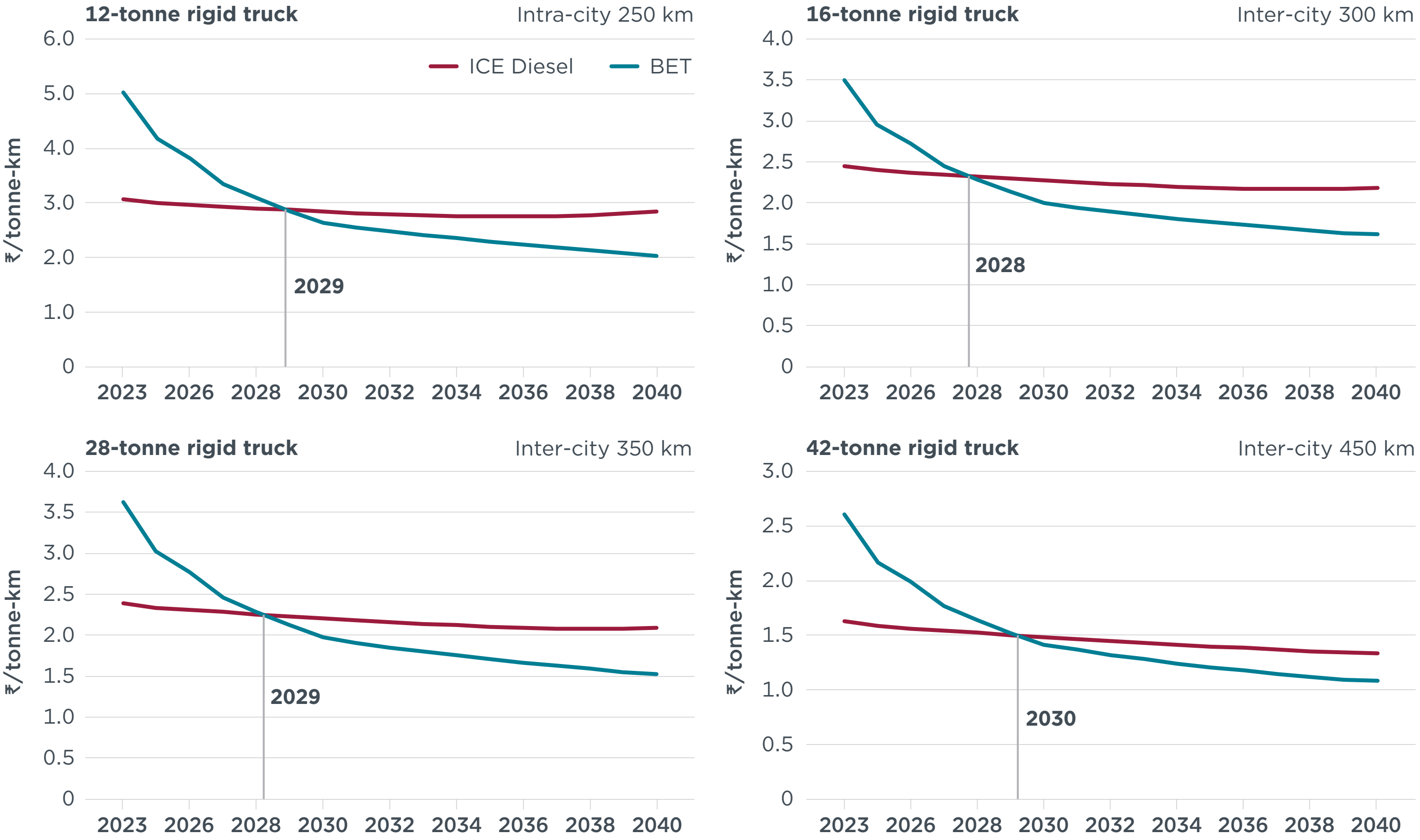
The zero-emission truck market in India remains at an early stage. A handful of manufacturers have introduced BET models and several plan to pilot BETs, but electric vehicle (EV) penetration among trucks continues to lag that of other segments. As India transitions to electric trucks, assessing total cost of ownership (TCO)—which considers both upfront and operational costs—will be critical to evaluate the cost-effectiveness of BETs and design policies to support their widespread adoption.

In this context, this study compares the TCO of internal combustion engine (ICE) diesel trucks and BETs in four segments—the 12-tonne, 16-tonne, 28-tonne, and 42-tonne rigid truck—that have accounted for approximately 70% of the Indian truck market in recent years. Drawing on primary data and interviews with seven fleet operators on use cases, driving patterns, and operating costs, we use vehicle simulation tools to estimate the fuel consumption of diesel trucks and BETs operating on test cycles developed using real-world activity and we project vehicle fuel economy improvement over time, considering expected technology development. Additionally, we use primary cost data on EV components obtained from an EY-Parthenon study commissioned by the International Council on Clean Transportation to determine the upfront costs of BETs in India and project them through 2040. Accounting for a wide range of cost components—including financing, resale values, fuel, maintenance, insurance, road taxes, and toll fees—we then project the TCO up to 2040 based on expected changes in fuel consumption and battery prices. This analysis reached five key findings:

1. **Based on bottom-up cost estimation, the upfront costs of BETs are 4–6 times those of diesel trucks in model year (MY) 2023 and are projected to fall by MY 2040 to 1.2–1.4 times the cost for the 12-tonne, 16-tonne, and 28-tonne trucks and 2 times the cost for 42-tonne trucks.** This estimated cost gap in MY 2023 is higher than that for BETs currently deployed in India, which are 2–3 times more expensive than diesel counterparts upfront. Deployed BETs are primarily used in pilot applications with a more limited range than the diverse operations in which diesel trucks are currently employed. The BETs analyzed in this report, therefore, more accurately represent real-world operations and performance demands. Declining battery prices and fuel economy improvements that lead to smaller battery sizes are the primary factors contributing to the projected gradual decline in the upfront cost of BETs; incremental costs associated with the deployment of fuel economy improvement technologies increase the upfront cost of diesel trucks over time.
2. **BETs are expected to reach TCO parity with diesel trucks in this decade without direct incentives, but policy support can help drive down costs.** In our projections, the expected decline in battery costs (65% between 2023 and 2040), coupled with lower energy costs due to fuel economy improvements, allow BETs to reach TCO parity with diesel trucks within the next 5 years (see Figure ES1). For high volume and low weight applications, where payload impact is irrelevant, TCO parity can be achieved by 2027. However, a robust policy ecosystem including fuel economy regulations and incentives is critical to driving down costs.

Figure ES1

Summary of TCO parity between BETs and diesel trucks



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3. **Stringent fuel consumption regulations can encourage the adoption of BETs and improve their cost-effectiveness compared with diesel trucks.** Such regulations would necessitate the deployment of fuel consumption improvement technologies that could increase the upfront cost of diesel trucks by 2030 (by 62%–89% for 12-tonne, 16-tonne, and 28-tonne trucks) compared with the business-as-usual scenario. As a result, the TCO savings offered by BETs in 2030 increase from a projected 7%–12% in a business-as-usual scenario to 20%–26% in a scenario with stringent fuel consumption regulations.
4. **Incentives such as purchase subsidies, interest rate subventions, road tax and toll waivers, and gross vehicle weight (GVW) relaxation for BETs result in TCO parity between MY 2023 BETs and diesel trucks in the 12-tonne, 16-tonne, and 28-tonne segments and nearly close the TCO gap for 42-tonne trucks.** We consider a purchase subsidy of ₹20,000/kWh (capped at ₹50 lakhs), equal to that provided for the purchase of electric buses under the second phase of the Faster Adoption and Manufacturing of Electric Vehicles (FAME) scheme. Additionally, we consider a 5% interest rate subvention, in line with Delhi's state-level EV policy; a 100% road tax waiver, as adopted by most Indian states for EVs; a 100% toll waiver, as implemented in Germany; and a GVW relaxation of 2 tonnes, in line with European Union regulations. These incentives substantially bridge the gap in TCO between diesel trucks and BETs (see Figure ES2).

Figure ES2

Impact of policies on the TCO of 12-, 16-, 28-, and 42-tonne BETs in MY 2023

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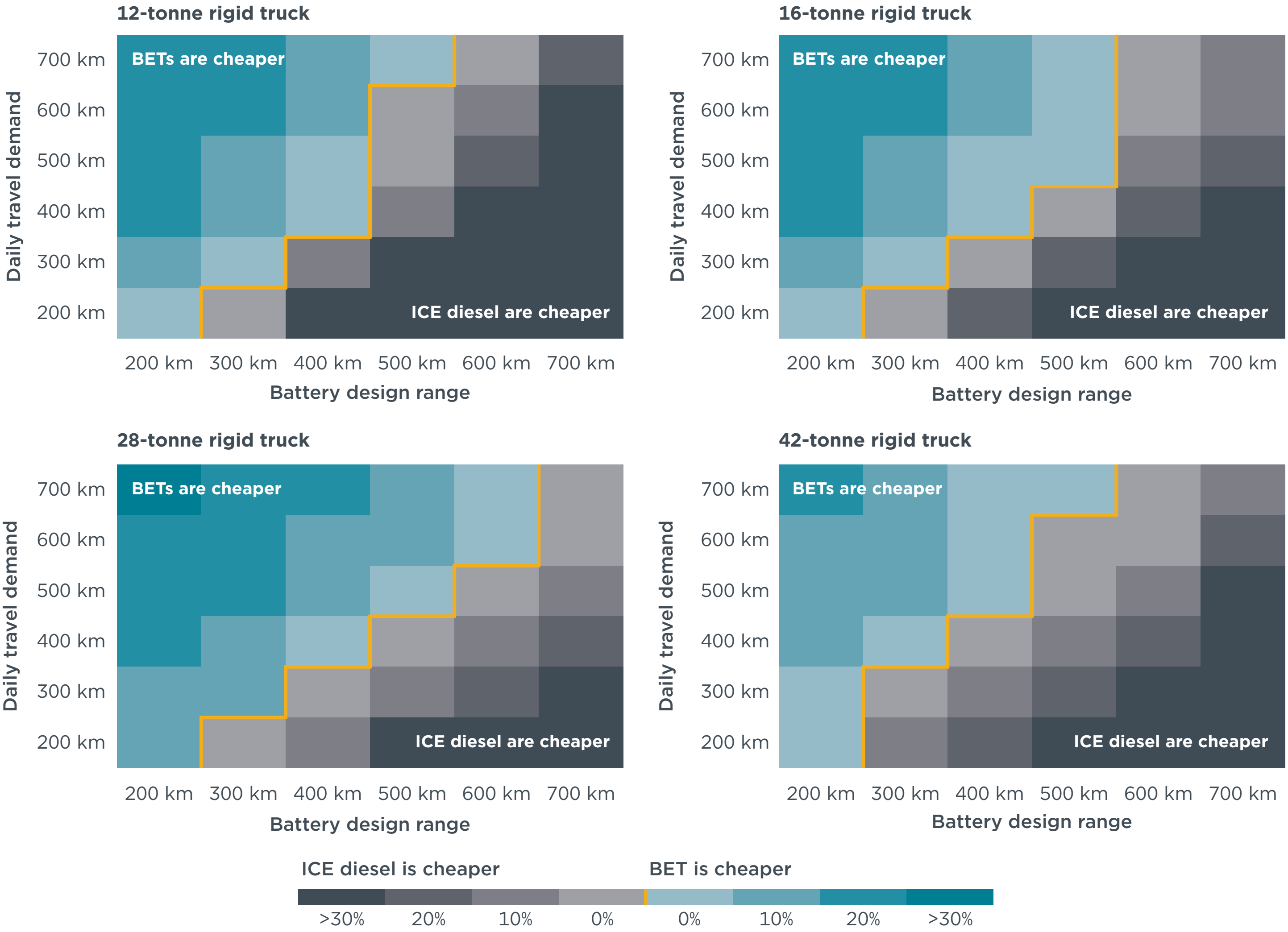
5. **By MY 2030, BETs are estimated to have a lower TCO than their diesel counterparts for all daily driving distances from 200–700 km; however, a robust network of charging infrastructure would maximize the TCO savings of BETs.** The battery electric powertrain is about 65% more fuel efficient than the diesel powertrain. Accordingly, BET energy costs are much lower than those of diesel trucks. While higher daily driving range requirements lead to higher battery design ranges and upfront costs, they are offset by lower energy expenses. Fuel cost is a major contributor to the TCO of diesel trucks; higher driving ranges increase those expenses, resulting in a higher TCO for diesel trucks relative to BETs. The TCO savings for BETs can be maximized by the optimal sizing of batteries such that battery range is smaller than daily travel demand and en-route charging meets additional distance demand.

Figure ES3

Sensitivity of battery range and annual daily driving range on TCO of MY 2030 trucks



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INTRODUCTION

Road transport is the lynchpin of India's economy. About 70% of freight in India is transported by road, a much higher share than in other major markets like the United States (37%), China (43%), and the European Union (EU, 45%) (NITI Aayog et al., 2021). According to a 2023 government assessment, India's aggregated logistics costs were roughly 8%–9% of gross domestic product in 2021–2022, and they greatly depend on fuel prices and other road transport costs (Munjal & Pohit, 2023). In 2021, the road transport sector consumed about 158 million metric tonnes of oil (65% of total oil demand in India); diesel trucks consumed 41% of that total (Ministry of Petroleum and Natural Gas, 2022, 2024; Singh & Yadav, 2024).

Medium- and heavy-duty trucks[1] are responsible for most of India's road freight transportation. The country has about 4.6 million trucks on the road; that number that is expected to grow 1.4 times between 2020 and 2050, reflecting India's increasing population, urbanization, and e-commerce (Singh & Yadav, 2024). While medium- and heavy-duty trucks account for just 3% of India's vehicle fleet, their contribution to overall CO_2 emissions from road transport is disproportionately high, at about 44% as of 2021 (Singh & Yadav, 2024). In this context, the adoption of zero-emission trucks (ZETs)—including battery electric trucks (BETs) and fuel-cell electric trucks—is expected to play a key role in India's efforts to meet its commitments under the Paris Agreement and achieve net zero emissions by 2070. Recent research by the International Council on Clean Transportation (ICCT) found that India would need to achieve 100% ZET sales no later than 2050 to meet its goal of net-zero emissions by 2070 (Singh & Yadav, 2024); to meet its Paris Agreement commitment, the target must be even sooner, by 2045 (Sen & Miller, 2023).

ICCT researchers estimate that the life-cycle greenhouse gas (GHG) emissions of BETs produced in India are about 17%–29% lower than their diesel truck counterparts when fueled by grid-average electricity; when powered with dedicated renewable electricity, their GHG reductions are 78%–83% greater (Yadav et al., 2024). Further, BETs are 65% more efficient than diesel trucks, resulting in lower fuel consumption and operating costs. Since ZETs emit no pollution, they are an important intervention for controlling air pollution in Indian cities. Indeed, on-road diesel vehicles accounted for about 60% of the transportation emissions-related public health burden in New Delhi (Miller et al., 2019). The Supreme Court's January 2024 decision directing the Union Government to design a policy to replace diesel trucks given rising air pollution underscores the urgency of ZET adoption to foster a clean, pollution-free environment (Tripathi, 2024).

About 80% of India's trucking sector consists of small operators who own fewer than 10 trucks; upfront price is generally their most important consideration when they purchase a vehicle. For the remaining 20%, fuel economy, and, by extension, fuel costs, are among the most important purchasing considerations (The Energy and Resources Institute, 2015). In this regard, it is important to weigh both upfront and operational costs to assess BET sales and uptake. As India transitions to electric trucks, assessing total cost of ownership (TCO)—which encompasses the costs of truck acquisition, electricity and fuel prices, maintenance, and road tolls, taxes, and other operating costs—is thus critical to evaluate the cost-effectiveness of BETs compared to diesel trucks and to design policies to support their adoption.

This study compares the TCO of battery electric and diesel trucks in India through 2040. It assesses representative vehicles from four truck segments: a 12-tonne, 16-tonne, 28-tonne, and 42-tonne rigid trucks. We apply vehicle simulation tools to

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[1] Medium-duty trucks are trucks in the N2 category, with a gross vehicle weight (GVW) between 3.5 tonnes and 12 tonnes. Heavy-duty trucks are in the N3 category, with a GVW above 12 tonnes.

estimate the fuel consumption of BETs and diesel trucks, assuming fuel economy improvements over time. We subsequently use data on the primary cost of electric vehicle (EV) components obtained from an ICCT-commissioned study to project the upfront costs of BETs through 2040, which we compare to the cost of diesel vehicles accounting for projected price increases due to the introduction of fuel-efficiency technology packages. We then estimate the TCO for BETs and diesel vehicles through 2040, considering projected changes in fuel consumption and battery prices and a range of operational cost components, including financing, resale value, fuel, maintenance, insurance, road tax, and toll fees. This study aims to answer the following research questions:

- What are the upfront costs of BETs in the Indian market and how will they evolve by 2040?
- How does the TCO of BETs compare with that of diesel trucks today? When will TCO parity be achieved across various segments?
- What daily distances and battery ranges make business sense for BET adoption?
- How sensitive is the TCO parity year to changes in fuel and electricity prices?
- What is the impact of incentives in improving the TCO of the BETs?

The following section covers the policy landscape for BETs in India. We then explain the methodology and assumptions of this study, before presenting the results of our TCO analysis and examining the impact of different policy measures on TCO. We conclude by discussing key findings and policy recommendations.

POLICY CONTEXT

Globally, China is leading the transition to ZETs, which accounted for about 7% of truck sales in the country in 2023; the EU follows with 1.6% (Ananda et al., 2024; Jin & Mao, 2023). China, the EU, and the United States have introduced ambitious ZET policies, involving a combination of demand incentives and regulations (Xie & Rodríguez, 2021). With the support of such policies, BETs in all three markets are near cost competitiveness with their diesel counterparts on a TCO basis (Basma et al., 2021; Mao et al., 2021; Basma et al., 2023).

In India, over the past decade, most policies to curb CO_2 emissions from road transport have focused on passenger and light-duty vehicles. These include demand incentives for EVs and chargers under the Faster Adoption and Manufacturing of Electric Vehicles (FAME) program, launched in 2015; the introduction of state-level EV promotion policies; and the adoption of regulations such as the corporate average fuel economy standards for passenger cars, launched in 2017. These policies have kickstarted the EV ecosystem for two- and three wheelers, passenger cars, and buses in India, with a 6.5% EV penetration rate among total sales across these classes in 2023–24 (Ministry of Road Transport and Highways [MoRTH] 2024). Meanwhile, in 2023, India began implementing the first phase of fuel consumption standards for heavy-duty vehicles (HDVs) (MoRTH, 2022). There are no policies in place to support electric truck uptake.

BATTERY ELECTRIC TRUCKS IN INDIA

The market for BETs in India remains in its nascent stages. Two legacy truck manufacturers, Tata Motors and Ashok Leyland, have launched truck models with a gross vehicle weight (GVW) ranging from 12–55 tonnes. Smaller domestic firms IPLTech Electric, Tresa Motors, and Olectra have also entered the market, as has BYD, headquartered in China (Express Mobility, 2023; Rautela, 2023). Table 1 lists BET models available on the Indian market as of July 2024.

Table 1
BET models in the Indian market as of July 2024

Make	Model	Body	GVW	Battery capacity	Motor power	Range	References
Ashok Leyland	Boss 1218 HB	Rigid	12 tonnes	284 kWh	140 kW peak	300–350 km	Truck Junction, 2023
Ashok Leyland	Boss 14T	Rigid	14 tonnes	201.5 kWh	120 kW continuous, 240 kW peak	230 km	Truck Junction, 2024b
Ashok Leyland	AVTR 55T 4X2	Tractor-trailer	55 tonnes	301.5 kWh	220 kW continuous, 330 kW peak	180 km	Truck Junction, 2024a
BYD	Q1R	Tractor-trailer	42 tonnes	217 kWh	180 kW peak	100 km	BYD, 2021
IPLT Electric	Rhino 5536e	Tractor-trailer	55 tonnes	258 kWh	268 kW peak	185 km	IPLT Electric, 2021
Olectra	Meghaetron	Rigid	28 tonnes	NA	180 kW continuous	120–150 km	Olectra, 2023
Tata Motors	Ultra T.7	Rigid	7.5 tonnes	62.5 kWh	220 kW peak	>100 km	Tata Motors, 2021
Tata Motors	Ultra E.9	Rigid	9 tonnes	110–148 kWh	250 kW continuous	120–150 km	Tata Motors, 2023a
Tata Motors	Prima E.28K	Rigid	28 tonnes	150–400 kWh	245 kW peak	15–200 km	Tata Motors, 2023b
Tresa Motors	Model V0.2 (to be launched)	Rigid	18 tonnes	200 kWh		600 km	Tresa Motors, 2024

Meanwhile, several companies in India have piloted or announced plans to pilot electric trucks in specific use cases. Table 2 lists a representative selection of such initiatives.

Table 2
Deployment (and planned deployment) of electric trucks in India

Operator	Truck model	Number of trucks	Details	References
Adani Group	BYD Q1R	400	Trucks are reportedly planned for operation at ports of Ennore, Katupalli, Hazira, and Mundra.	Hampel, 2023
Amazon	Volvo-Eicher	1,000	Partnership between Amazon and Volvo-Eicher to deploy 1,000 electric trucks across various payload categories for Amazon's delivery operations, with an initial deployment of 50 trucks in major cities like Delhi, Manesar, and Gurugram. Trucks will be deployed through Amazon's service partners.	VECV, 2023
Dalmia Cement	IPLTech Electric	22	Trucks will transport raw material from Rourkela to Rajgangpur for cement manufacturing. Two of 22 trucks were deployed as of 2021 (latest public information).	Dalmia Cement, 2021
Hindustan Zinc	IPLTech Electric Rhino 5536e	10	Trucks are to be deployed through Inland EV Green Services Pvt. Ltd., a logistics service provider, to transport concrete.	PTI, 2023
JSW Cement	IPLTech Electric	5 (deployed)	5 electric trucks transport raw materials for manufacturing in Andhra Pradesh and Karnataka.	ETAuto, 2023
Tata Steel	NA	27	15 electric trucks to be deployed at a Jamshedpur plant and 12 at a Sahibabad plant to transport finished steel between the plant and its stockyard.	Tata Steel, 2021
UltraTech Cement	NA	500	Trucks deployed in 2024 to transport clinker from UltraTech's cement manufacturing unit in Madhya Pradesh to its grinding unit in Maharashtra. The company has pledged to deploy 500 electric trucks by 2025.	UltraTech Cement, 2024

METHODOLOGY AND DATA SOURCES

USE CASES

We analyze four different rigid truck segments with their corresponding use cases to assess the feasibility of deploying zero-emission technologies in the real world. The trucks in these segments account for a major proportion of market sales in India. Between fiscal years (FYs) 2019–20 and 2021–22, they accounted for an average of 70% of new truck sales.[2] Each use case is characterized by its origin and destination, daily distance traveled, drive cycle, and typical time spent at rest stops. Use case details were obtained from consultation with seven fleet operators. These operators each owned more than 10 trucks and, at the time of consultation, were not piloting any electric trucks; while the use cases examined in this analysis do not represent current BET applications in India, they cover a variety of truck applications and driving cycles.

The use cases assessed in this study comprise 1-day trips, generally starting from one depot location and traveling along a well-established route to end at another depot location in another city. The exception is 12-tonne rigid trucks which operate intra-city and return to the same depot at the end of the day. During inter-city operation, drivers typically halted at rest stops for 1–2 hours during the day. We conduct our TCO analysis from a commercial first-user perspective, assuming an initial ownership period of 7 years. Table 3 details this study's use cases.

Table 3
Use cases examined in this analysis

Body type	GVW	Origin	Destination	Daily distance traveled	Resting time
Rigid truck	12 tonnes	Pune	Pune	250 km	1–2 hours
	16 tonnes	Jamnagar	Ahmedabad	300 km	1–2 hours
	28 tonnes	Vapi	Ahmedabad	350 km	1–2 hours
	42 tonnes	Kolkata	Ranchi	450 km	1–2 hours

VEHICLE TECHNICAL SPECIFICATIONS

We consider the best-selling diesel truck models in India in the four segments based on the ICCT's market analysis of HDV sales in India in FY 2019–20 and FY 2020–21 (Sathiamoorthy et al., 2021). We obtained detailed specifications of these vehicles for model year (MY) 2023 from publicly available sources (Ashok Leyland, 2022a, 2022b; Tata Motors, 2022a, 2022b). Table 4 summarizes these specifications.

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[2] The fiscal year in India runs from April 1 to March 30.

Table 4
Diesel vehicle technical specifications

Parameter	Unit	12-tonne rigid truck	16-tonne rigid truck	28-tonne rigid truck	42-tonne rigid truck
Axle configuration	—	4x2	4x2	6x2	10x2
Model	—	Tata 1212	Ashok Leyland 1615 HE	Tata Signa 2818	Ashok Leyland 4220
Maximum engine power	kW	92	111.8	140	149
Maximum engine torque	Nm	390 Nm @1,000–2,200 rpm	450 Nm@1,250–2,000 rpm	850 Nm@1,000–1,700 rpm	700 Nm@1,200–2,000 rpm
Number of tires	—	6	6	10	14
Tire rolling resistance coefficient	kg/tonne	8.8			
Aerodynamic drag coefficient	—	0.7			

Assumed BET specifications are presented in Table 5. Based on examples globally, we assume battery ranges of 250 km for the 12- and 16-tonne rigid trucks and 350 km for the 28- and 42-tonne trucks (CALSTART, 2024). Batteries are sized to accommodate these ranges in one charge; for additional energy, we account for en-route direct current (DC) fast charging of 240 kW on highways at rest stops. Trucks are equipped with lithium iron phosphate (LFP) battery packs based on the recent prototypes and models introduced in India (Hampel, 2023; Olectra, 2023; Tata Motors, 2023b). The LFP battery has a cycle life of 3,000 cycles (Nykvist & Olsson, 2021). Based on assumed utilization and charging cycles, the BETs considered in this analysis would thus not require battery replacement in their initial ownership period. The motor is sized to give the same amount of power as that of an engine in the diesel truck, and the power is assumed to remain constant for the projected model years.

Table 5
BET technical specifications

Parameter	Unit	12-tonne rigid truck	16-tonne rigid truck	28-tonne rigid truck	42-tonne rigid truck
Axle configuration	—	4x2	4x2	6x2	10x2
Motor power	kW	92	111.8	140	149
EV range	km	250	250	350	350
Battery size	kWh	213	241	552	705
Number of tires	—	6	6	10	14
Battery chemistry	—	Lithium iron phosphate			
Tire rolling resistance coefficient	kg/tonne	8.8			
Aerodynamic drag coefficient	—	0.7			

For both diesel trucks and BETs, we assume a coefficient of tire rolling resistance of 8.8 kg/tonne and a coefficient of aerodynamic drag of 0.7 in MY 2023 vehicles (Gopal et al., 2017). These coefficients are crucial in accounting for energy losses due to tire deformation and the inertia of air resisting the vehicle's movement, respectively. Considering the December 2023 notification of new rules requiring that truck cabins manufactured from October 2025 be fitted with air conditioners, we assume an air conditioning load of 2 kW for all models in this study (MoRTH, 2023a).

FUEL ECONOMY

We modeled BETs for each segment based on the vehicle specifications listed in Table 4. Applying the same methodology of a previous ICCT analysis (Yadav et al., 2023), we developed duty cycles using real-world data on driving patterns and fuel consumption obtained from a data logger plugged into the onboard diagnostic (OBD) port of the four reference diesel trucks over 2 months of operation, representing about 10,000 km of driving. We assumed 100% loading to account for cases of occasional overloading, this means our results are conservative. We then used the vehicle simulation software Amesim (Simcenter, 2022) to estimate the fuel economy of internal combustion engine (ICE) diesel trucks and BETs (see Table 6).

Table 6
Simulated truck fuel economy

Powertrain	12-tonne	16-tonne	28-tonne	42-tonne
ICE diesel (L/100 km)	19.6	21.7	38.9	40.6
BET (kWh/km)	0.68	0.77	1.26	1.61

Fuel consumption regulations require manufacturers to adopt fuel consumption improvement technologies to meet consumption targets. We assume a 2% nominal improvement in fuel economy year-on-year for diesel trucks under business-as-usual conditions. We thus assume a 14% fuel economy improvement is reached by MY 2030 and 34% is reached by MY 2040. For context, in 2024, the EU revised its CO_2 reduction targets for trucks to 43% by 2030, 64% by 2035, and 90% by 2040; these are the most ambitious standards in the world (Mulholland, 2024).

We assume both diesel trucks and BETs will benefit from technological improvements that improve their fuel efficiency over time. In the case of diesel trucks, we use the technology packages developed in Yadav et al. (2023), which consider technological advancements in engines, rolling resistance, and aerodynamics, among others. For BETs, we assume the deployment of road-load improvements to aerodynamics and rolling resistance included in the technology packages listed in Table 7. We assume technology package TP1 will be deployed in 2025, TP2 in 2030, and TP3 in 2035. The technologies in TP1, TP2, and TP3 are already available commercially in global markets.

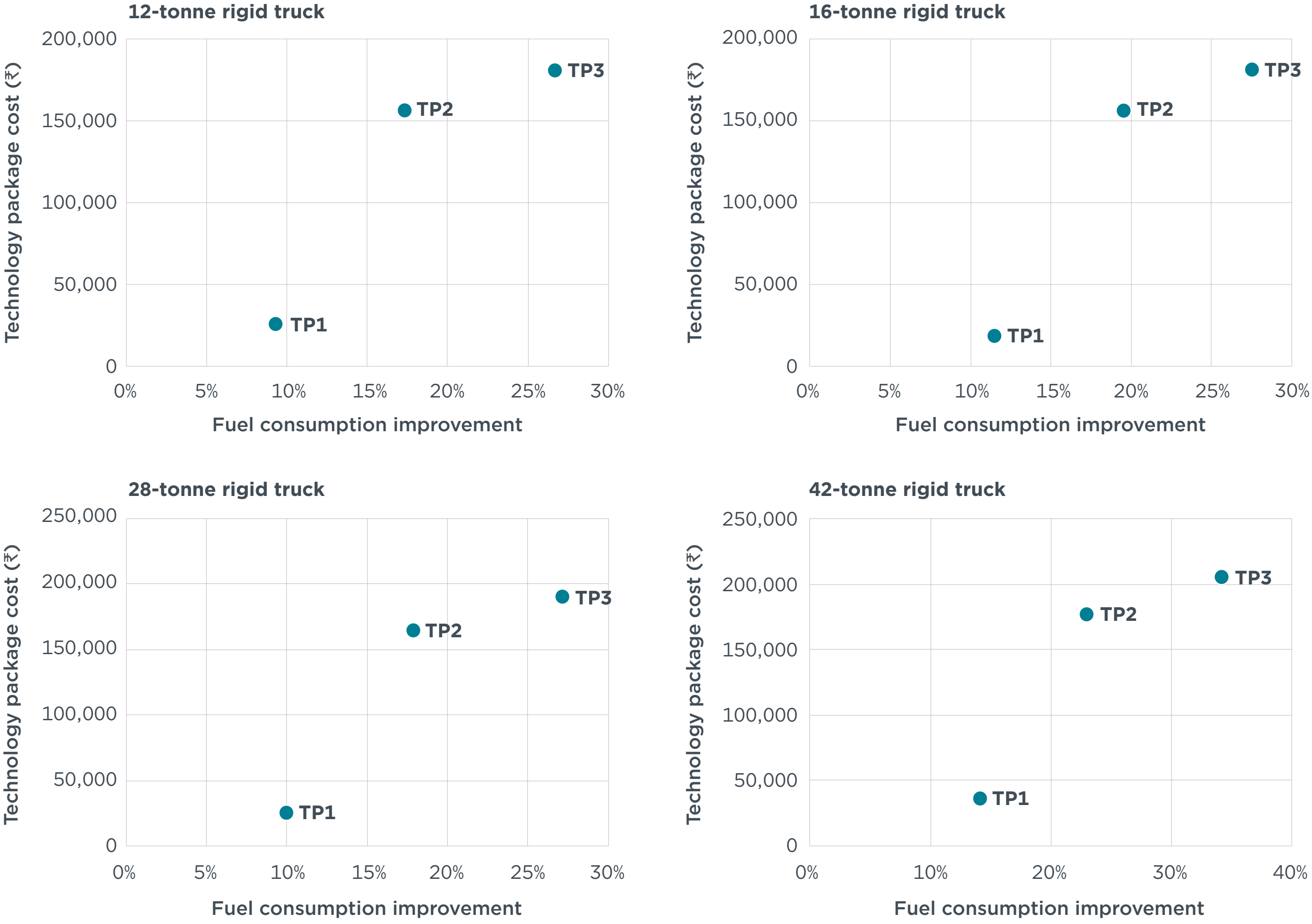
Table 7
Technology packages for all four BET segments

	Baseline	TP1	TP2	TP3
Tire rolling resistance				
Baseline (8.8 kg/tonne)	●			
Level 1 (7 kg/tonne)		●		
Level 2 (6.2 kg/tonne)			●	
Level 3 (4.9 kg/tonne)				●
Aerodynamic coefficient				
Baseline (0.7)	●	●		
Level 1 (0.62)			●	
Level 2 (0.55)				●

We simulate fuel consumption improvements for BETs in Amesim, using technology costs from Yadav et al. after accounting for 5.6% inflation between 2022 and 2023 (MoSPI, 2024; Yadav et al., 2023). Figure 1 shows fuel consumption improvements and technology costs for BETs under the three technology packages. Advancing from the baseline to TP3 results in fuel efficiency gains of up to 34% (in the case of the 42-tonne truck) from 2023–2035. Upfront cost projections for diesel trucks and BETs account for these incremental costs associated with improvements in fuel consumption technology.

Figure 1

Technology cost curves for BETs



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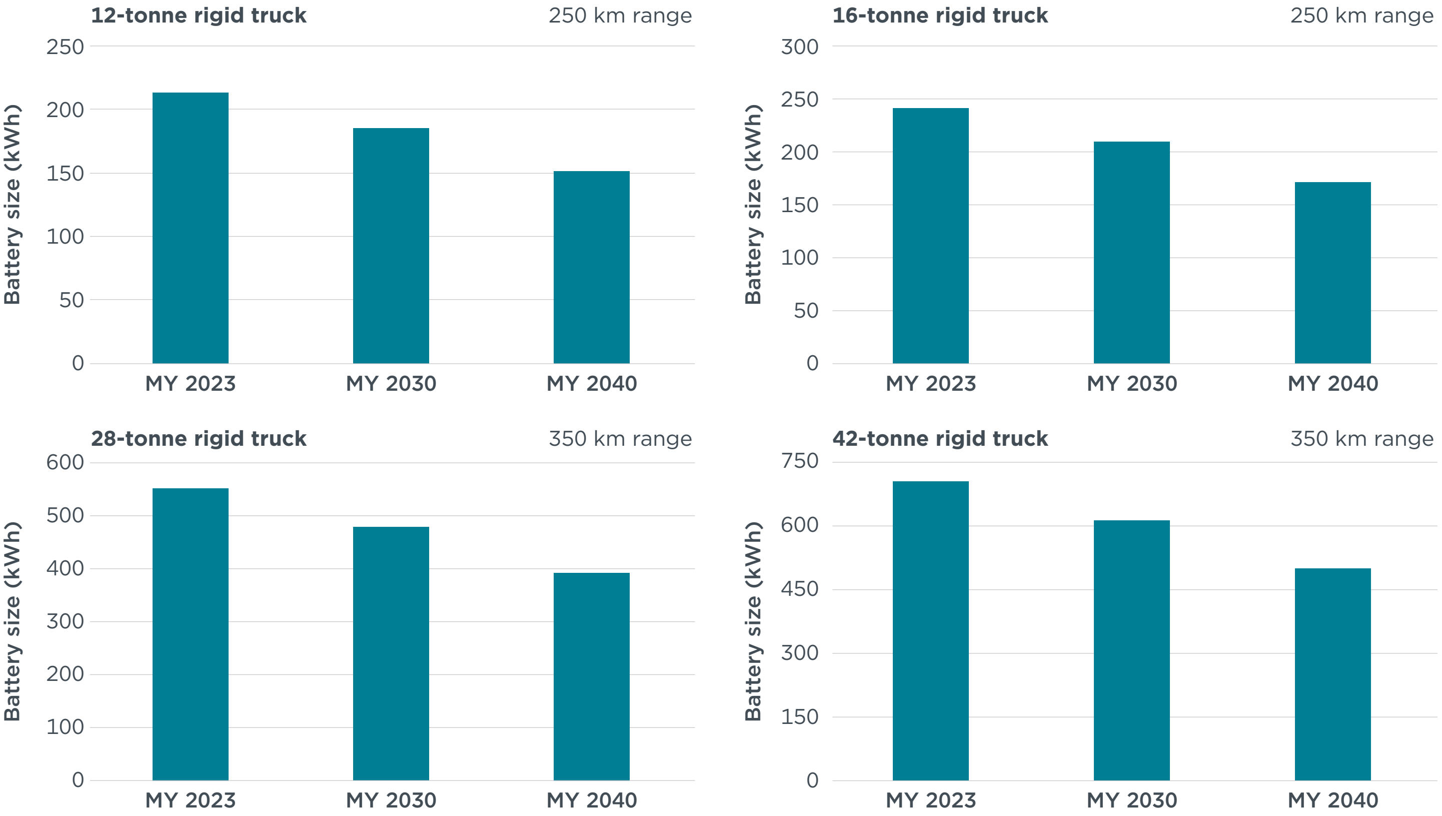
BATTERY SIZE AND PAYLOAD OF BETS

Fuel economy improvement affects both battery size and payload capacity. We assume BET batteries are sized for a constant range of 250 km for 12- and 16-tonne rigid trucks and 350 km for 28- and 42-tonne rigid trucks. With improved fuel economy, the battery size required for these ranges will be smaller than in MY 2023. Figure 2 shows the evolution of battery sizes for the four truck types in MY 2023, 2030, and 2040.

Figure 2
Evolution of battery sizes for constant ranges in MY 2023, 2030, and 2040



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We estimate the payload of BETs, considering weight factors as a function of energy and power, based on a study by EY-Parthenon commissioned by the ICCT assessing costs and weights of EV components in the Indian market. The energy density of the battery pack is 115 Wh/kg in the base year 2023 (EY-Parthenon, 2023). We assume that pack-level energy density improves over the years according to the LFP energy density improvement curve from a previous ICCT report (Mao et al., 2021), such that the battery pack density increases to 236 Wh/kg by 2040. This results in a lighter battery for a truck in MY 2040 for the same range. Table 8 presents the power and energy density factors for BETs and diesel trucks in this study.

Table 8
Power and energy density factors for BET and diesel truck components

Component	2023	2040
Battery electric truck		
Battery	115 Wh/kg	236 Wh/kg
Motor[3]	0.61 kW/kg	
Power electronics	4 kW/kg	
Diesel truck		
Engine system	0.17 kW/kg	
Transmission system	2.95 Nm/kg	

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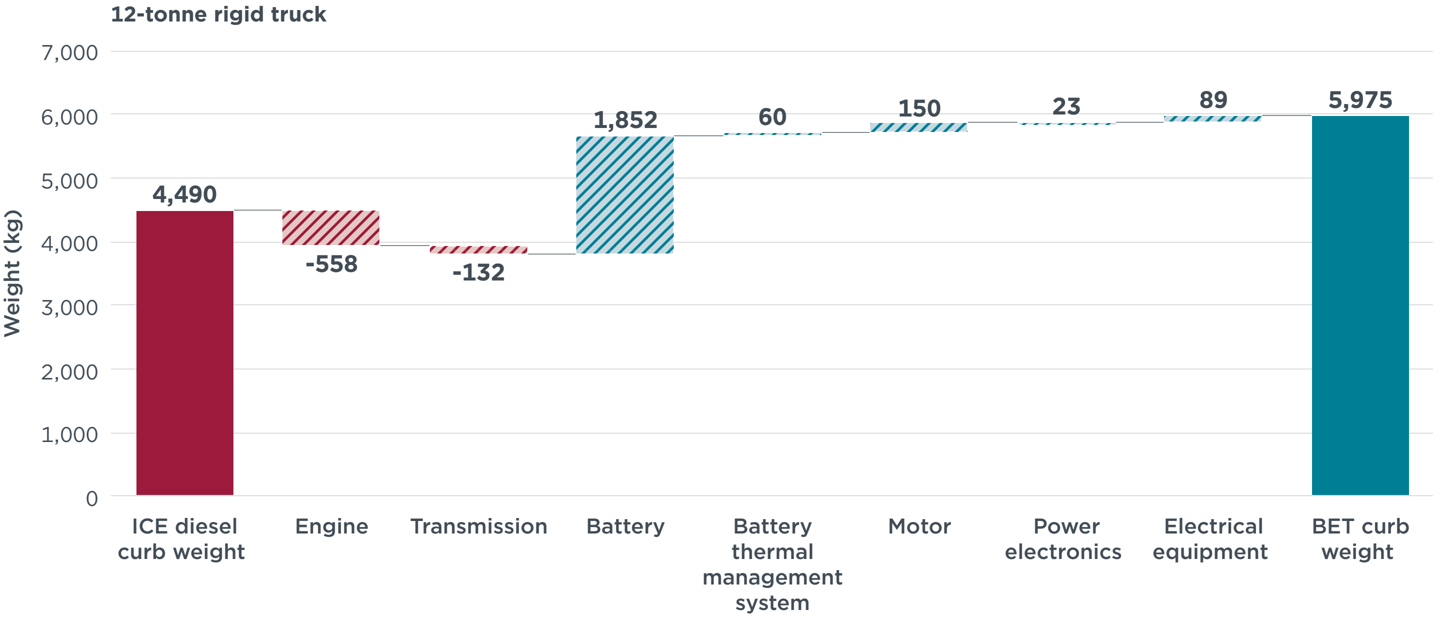
[3] Power density includes the motor control unit and associated thermal management system for the motor.

The improvement in battery energy densities combined with fuel economy improvement lead to smaller and lighter batteries and vehicles over the years. For instance, to meet a 250 km range, the MY 2023 12-tonne BET uses a 213 kWh battery that weighs 1,852 kg, while the MY 2040 vehicle uses a battery 29% smaller (in kWh) and 65% lighter. Figure 3 shows the weight build-up of the 12-tonne BET truck compared to that of a diesel truck. Weight build-ups for the other three trucks are presented in the Appendix (see Figure A1).

Figure 3

Weight build-up of a 12-tonne rigid truck in MY 2023



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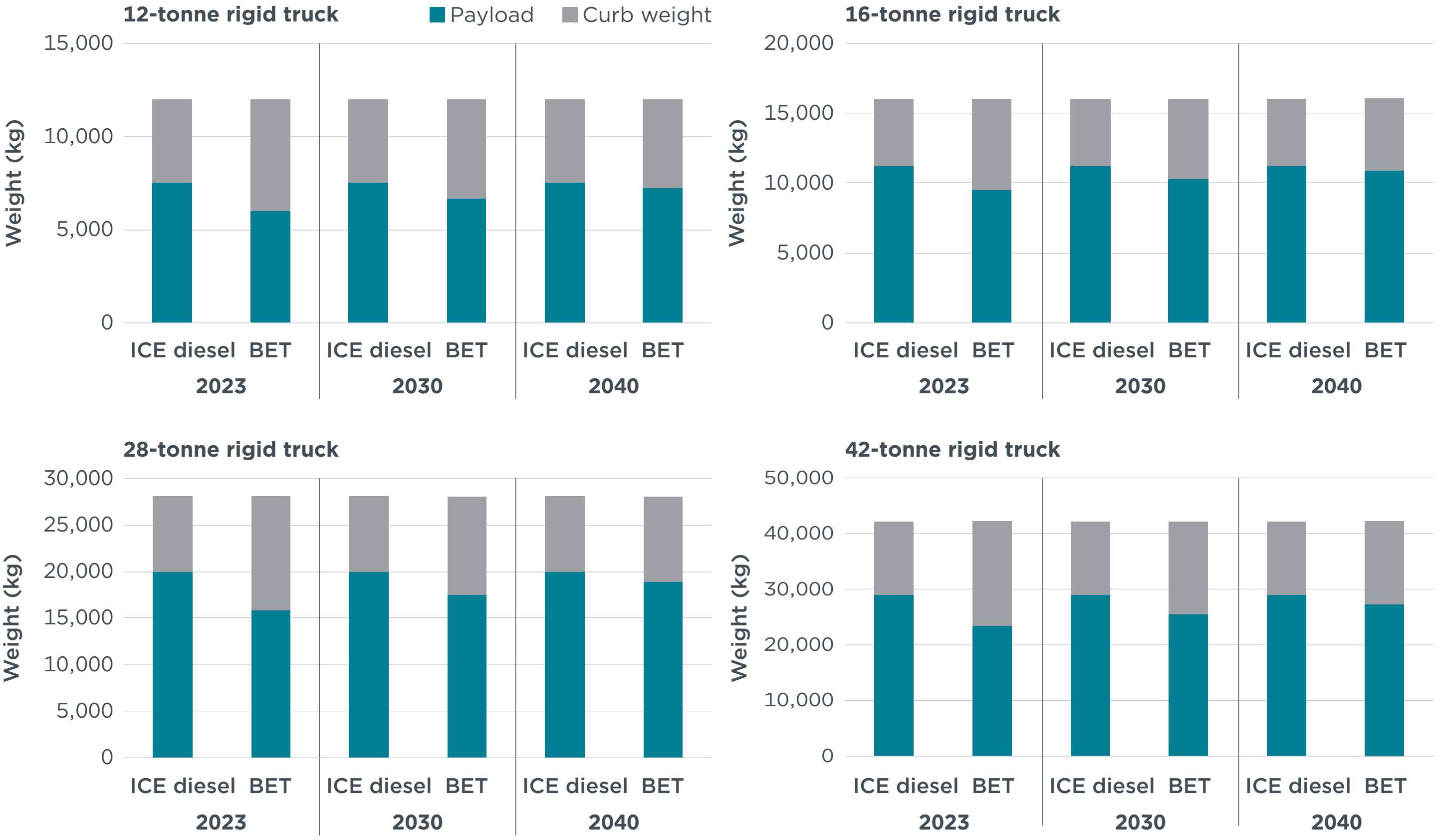
Assuming BETs comply with the same truck axle regulations as diesel trucks, meaning their GVW remains the same, we find that battery energy density improvements result in reductions in payload capacity loss. As shown in Figure 4, while BETs face a payload capacity loss of 15%–20% in 2023, this falls to 3%–6% by 2040. The United States and EU have relaxed weights and dimension rules for ZETs, increasing the maximum weight authorized by 1 ton (2,000 lb, or roughly 907.2 kg) and 2 tonnes (2,000 kg), respectively, to account for the payload loss due to heavier batteries (European Parliament, 2024; Federal Highway Administration, 2019). If India were to adopt a regulation like the EU's, the payload capacity loss in MY 2023 would fall to 11% for the 28-tonne BET and 13% for the 42-tonne BET, and would be eliminated in the 12-tonne and the 16-tonne BETs. We analyze how this payload penalty impacts the TCO in rupee per tonne-kilometer terms in the results section.

Figure 4
Payload capacity of BETs in MY 2023, 2030, and 2040



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UPFRONT COSTS

To calculate upfront cost for diesel vehicles, we use publicly available market data for the base year MY 2023. The upfront cost of these vehicles is projected to increase with the incorporation of advanced fuel-efficiency technology packages under business-as-usual fuel consumption norms. For this analysis, we assume a nominal improvement in fuel consumption of 2% per year, such that diesel trucks are 14% more efficient by 2030 and 34% more efficient by 2040 compared to the 2023 baseline; we use the cost curves for fuel efficient ICE technologies developed in Yadav et al. (2023) after adjusting them for inflation for 2023. As an exploratory exercise, we also analyze the TCO impacts of more stringent fuel consumption regulations in a high-ambition scenario.

To develop the upfront cost for BETs for the different segments, we use primary data on the Indian market in 2022 and convert to 2023 prices using an inflation rate of 5.6% (EY-Parthenon, 2023; MoSPI, 2024). Table 9 presents a sample cost build-up for the MY 2023 12-tonne BET, listing the scaling factors used; similar build-ups for the other trucks considered in this analysis are presented in Tables A1, A2, and A3 of the Appendix. On top of direct manufacturing costs, we use an indirect cost multiplier (ICM), which accounts for the operating expenses that manufacturers spend each day, administrative expenses, depreciation and amortization, and research and development costs, and which varies with the complexity of the associated technology. We assume an ICM for the diesel truck of 1.3; for the electric trucks, it is 1.43 until 2030, after which it falls to the same level as that of a diesel truck. We also apply a goods and service tax (GST) of 28% for the diesel truck, while assuming that EVs continue to receive a preferential GST rate of 5% throughout the analysis period (Press Information Bureau [PIB], 2019). Finally, we assume a dealer margin (profit to the seller) of 3%.

Table 9

Bottom-up cost build-up of 12-tonne BET for MY 2023

System	Scaling parameter	Unit	Cost per unit	12-tonne truck	
				Specifications	Cost
Powertrain					
Battery pack	kWh rating of battery	INR/kWh	₹19,546	213 kWh	₹4,163,260
Motor	kW rating of motor	INR/kW	₹5,280	92 kW	₹485,760
Battery thermal management system	kW rating of the system	INR/kW	₹29,700	8 kW	₹237,600
Motor thermal management	kW rating of the motor	INR/kW	₹132	92 kW	₹12,144
Body and chassis					
Ladder frame chassis	Weight of the frame	INR/kg	₹186	674 kg	₹125,277
Truck load body	Weight of the structure	INR/kg	₹141	674 kg	₹94,961
Cabin	—	—	—	—	₹116,160
Drivetrain					
Braking system	Diameter and number of brake drums	INR/mm	₹77	410 mm	₹126,720
Front axle	Rating in tonne	INR/tonne	₹6,160	4 t	₹27,697
Rear axle	Rating in tonne	INR/tonne	₹5,280	7 t	₹39,567
Tires	Diameter and number of wheel rims	INR/inch	₹905	20 in	₹126,720
Power steering	Front axle rating in tonne	INR/tonne	₹31,173	4 t	₹140,162
Front suspension	Front axle rating in tonne	INR/tonne	₹3,520	4 t	₹15,827
Rear suspension	Rear axle rating in tonne	INR/tonne	₹2,640	7 t	₹19,784
Driveshaft	Weight of the system	INR/kg	₹792	15 kg	₹11,870
Compressor	Pressure rating	INR/bar	₹9,504	10 bar	₹95,040
Electrical and electronic equipment					
Power electronics	kW rating of the motor	INR/kW	₹1,764	92 kW	₹162,269
Junction box	—	—	—	—	₹73,920
HV wiring harness	Weight of the wiring system	INR/kg	₹1,420	89 kg	₹126,658
LV wiring harness	Weight of the wiring system	INR/kg	₹1,056	30 kg	₹31,654
HVAC	kW rating	INR/kW	₹19,200	2 kW	₹38,400
Accessories	—	—	—	—	₹52,800
Direct manufacturing cost					**₹63,24,248**
Indirect cost multiplier			1.43	—	₹2,710,392
Ex-factory cost					**₹9,034,641**
Goods and service tax (GST)			5%	—	₹451,732
Dealer margin			3%	—	₹284,591
Ex-showroom price					**₹9,770,964**

The upfront cost of the BETs is projected up to 2040 based on the component cost projections developed in the EY-Parthenon study. Battery pack cost reductions substantially drive down the upfront cost of the BETs. Localization of cell production spurred by production-linked incentive schemes is expected to generate about 93 GWh of new production capacity by 2030, bringing down the cost by 16% by 2040 (EY-Parthenon, 2023; PIB, 2024), while higher production volumes and productivity gains would bring down the cost by another 49% over the same period (see Figure 5). The declining cost of motor and power electronics also reduces the upfront cost, albeit to a lesser degree. Motor and power electronics cost projections are shown in Figure 6.

Figure 5

Battery pack price projections

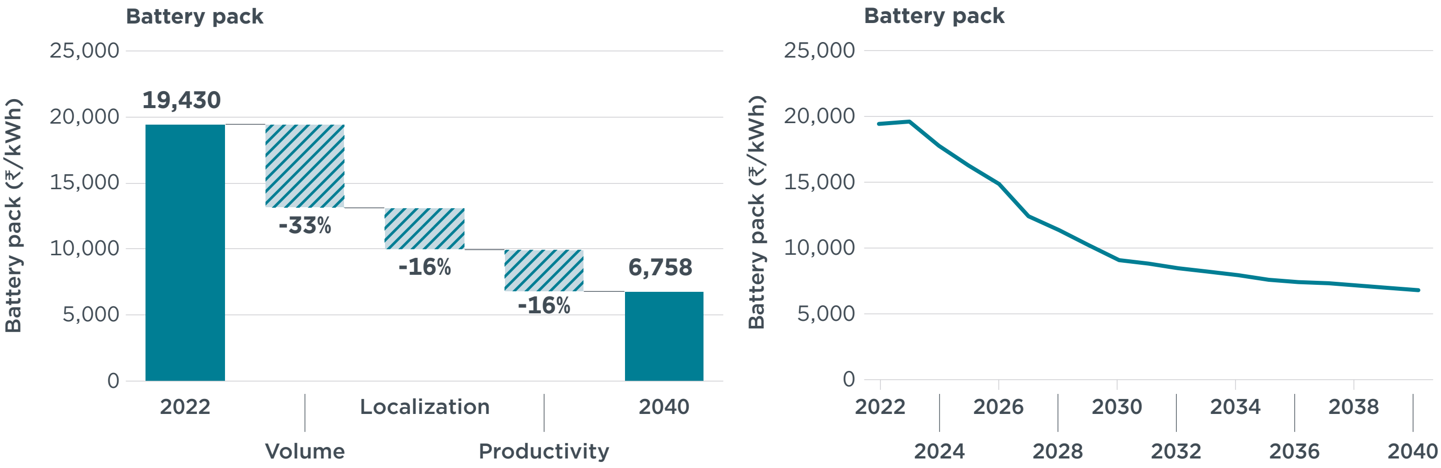

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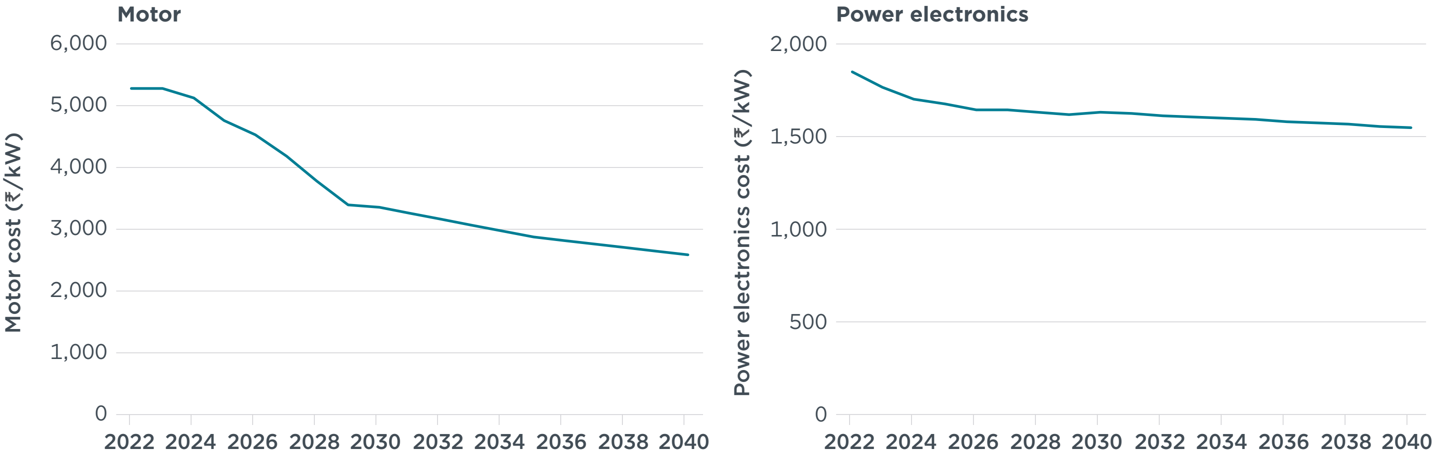
Figure 6

Motor and power electronics cost projections



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Through this bottom-up cost assessment, we find that the upfront cost of BETs in MY 2023 is about 4–6 times the cost of their diesel counterparts. We observe this ratio is higher than that for BETs currently in use in India, which are about 2–3 times the cost of diesel equivalents.[4] This is primarily because they are designed with smaller batteries

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[4] The purchase price of these trucks is not publicly available; we obtained this ratio through consultations with the original equipment manufacturers and fleet operators.

for pilots in short-range applications. We ground-truth the bottom-up cost assessment of BETs by simulating a 16-tonne BET with a battery size of 201 kWh and compare the cost to that of an actual 16-tonne BET with the same battery size that is currently being piloted in India. Since the vehicle is not presently available on the market, we ascertained its price through stakeholder consultations. We find that our estimate lies within 10% of the reported price of the actual vehicle.

Figure 7 shows the evolution of the upfront cost of BETs and diesel trucks across the four vehicle segments through MY 2040. With the declining battery costs, by 2040, the upfront cost of the BETs is between 1.2 and 1.4 times the cost of diesel counterparts for the 12-, 16-, and 28-tonne trucks and double the cost for the 42-tonne truck.

Figure 7

Upfront cost projections of BETs and diesel trucks assuming business-as-usual fuel consumption improvement

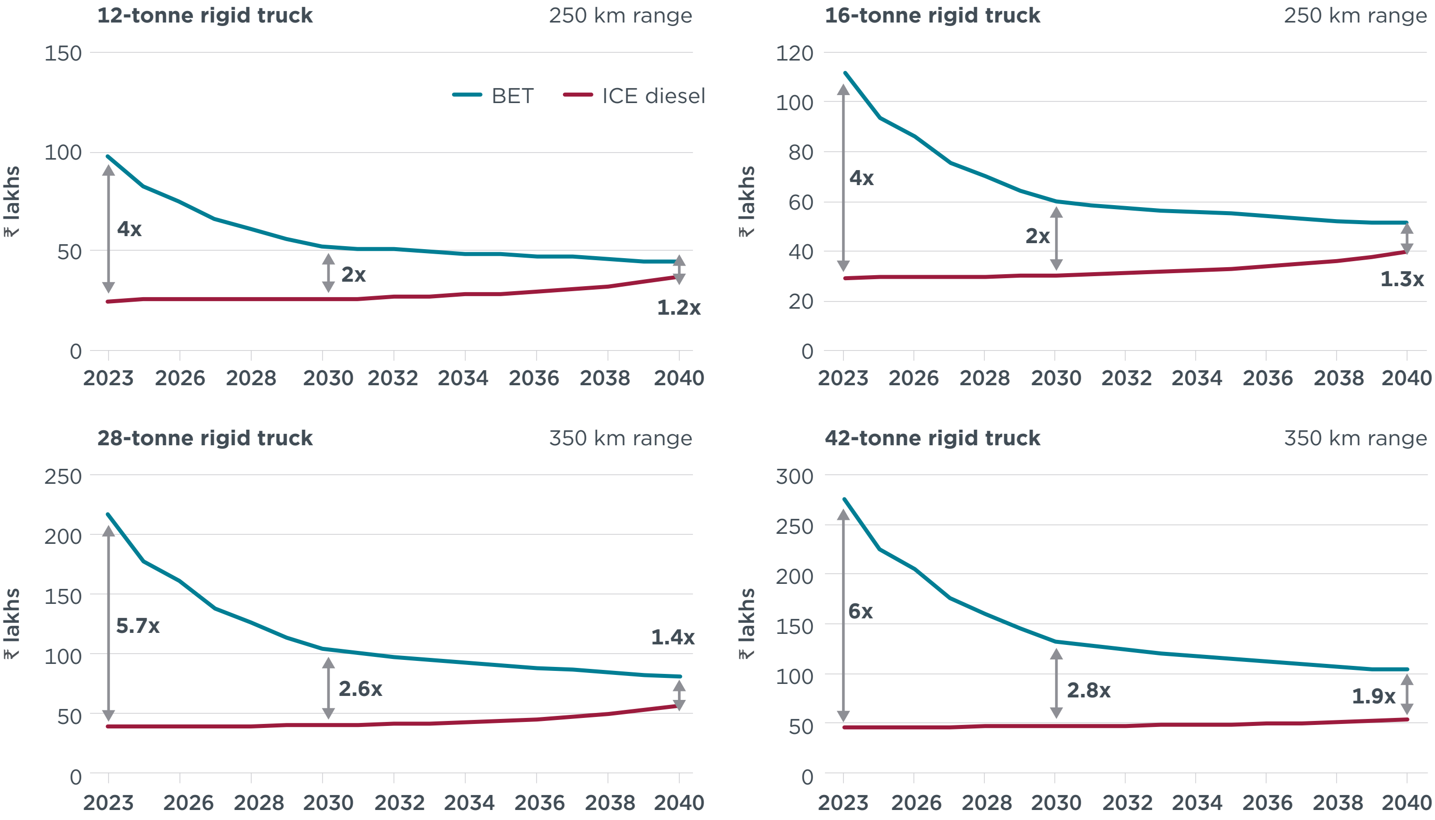

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Figure 8 shows the upfront cost build-up of BETs for a 12-tonne truck in MY 2023, 2030, and 2040. Similar upfront cost build-ups for the other three trucks are presented in the Appendix, in Figure A2. The battery is the single largest cost contributor to the upfront cost of the BET, accounting for about 42% of the total cost for 12- and 16-tonne BETs and about 50% for 28- and 42-tonne BETs in MY 2023. With declines in the cost of the battery, motor, and power electronics over time, the upfront cost of the BET falls between 2023 and 2040 by 55% for the 12-tonne truck, 54% for the 16-tonne truck, 63% for the 28-tonne truck, and 62% for the 42-tonne truck. Fuel economy improvement technologies grow to account for between 2%–6% of the upfront cost in 2040, depending on the segment.

Figure 8

Upfront cost build-up of the 12-tonne BET in MY 2023, 2030, and 2040

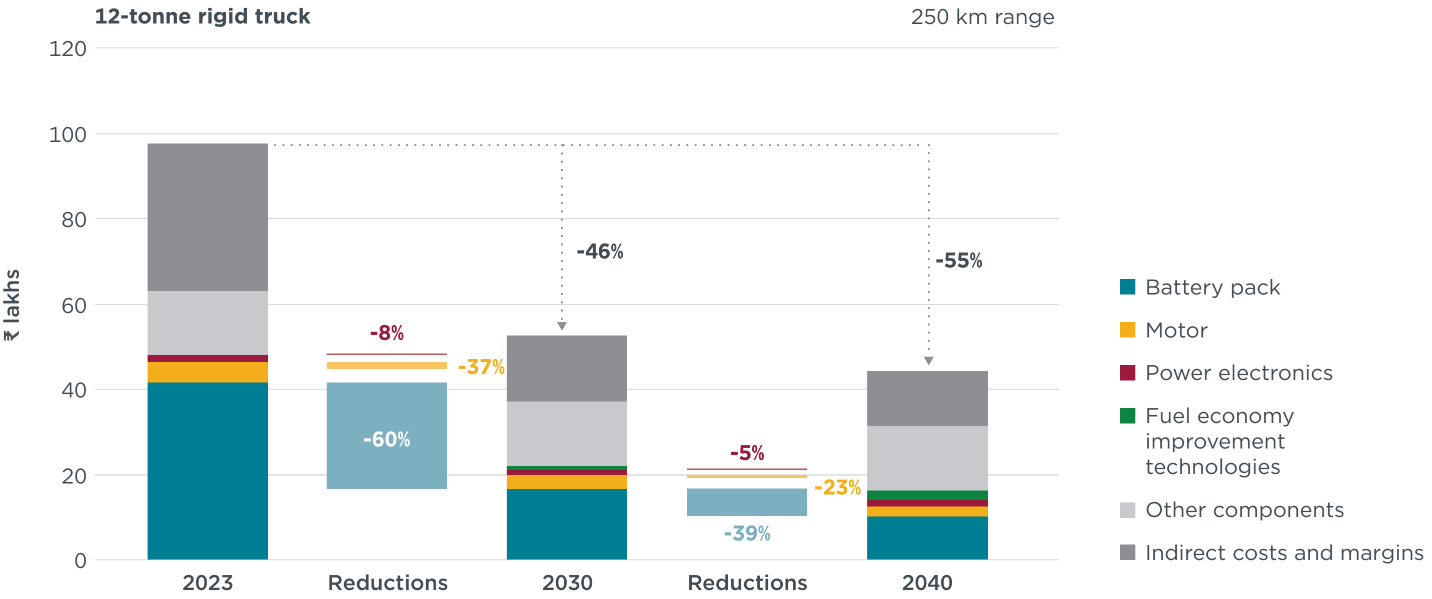

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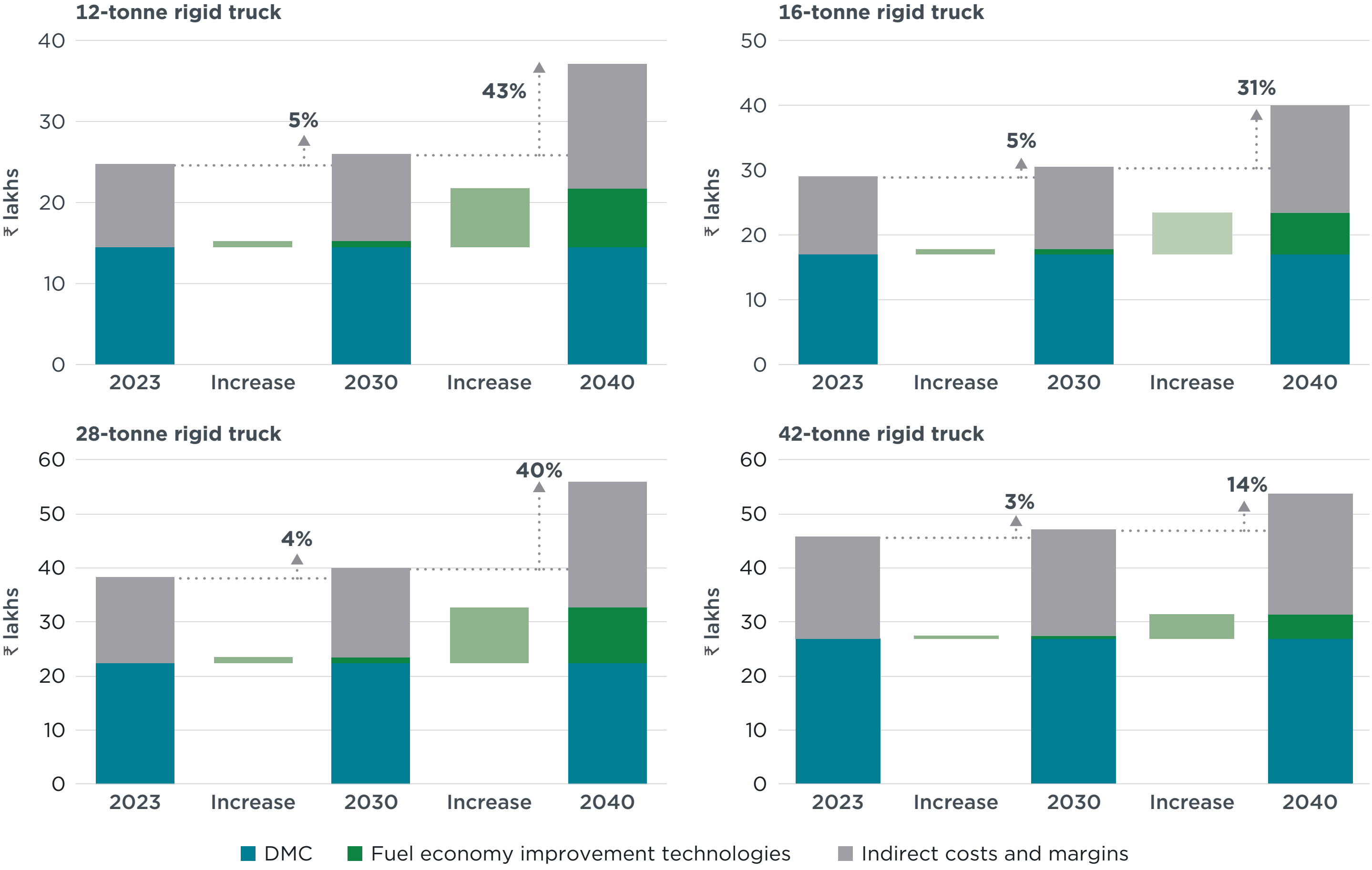
Figure 9 shows the upfront cost build-up for the four diesel trucks. Assuming business-as-usual fuel consumption regulations requiring 14% improvement by MY 2030 and 34% improvement by MY 2040 compared to 2023, OEMs incorporate fuel consumption improvement technologies that significantly increase the cost of diesel trucks. The incremental cost associated with these technologies grows at an increasing rate, accounting for 2% of the total upfront cost in MY 2030 and 16%–20% in MY 2040, depending on the segment. In total, the upfront cost of the diesel truck increases by 36%–48% between 2023 and 2040 for the 12-tonne, 16-tonne, and 28-tonne trucks. The increase is lower for the 42-tonne truck, the upfront cost of which increases by 17% between 2023 and 2040, due to the relatively lower incremental cost of fuel economy improvement technologies compared with the other three segments.

Figure 9

Upfront cost build-up of diesel trucks in MY 2023, 2030, and 2040 considering fuel consumption improvements of 14% by 2030 and 34% by 2040



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OPERATIONAL COSTS

This section details the various sources and assumptions used to calculate operational costs for the BETs and diesel trucks, including financing, insurance, fuel, maintenance costs, and taxes.

Truck financing, insurance, and residual value

Based on discussions with fleet operators, we assume that 80% of the cost of a truck is financed; the remaining 20% consists of the down payment. We assume a uniform 12% interest rate and a repayment period of 6 years uniformly for both diesel trucks and BETs. We use a discount rate of 4% throughout the analysis (Yadav et al., 2023).

We assume a 15-year life of trucks and a straight-line depreciation rate of 7% year-on-year for diesel trucks based on our interviews with fleet operators. We assume the same depreciation rate for the non-battery components of BETs. For the battery, we assume a 3,000-cycle life in 2023 that increases to 5,000 cycles by 2035 and remains constant thereafter (Nykvist & Olsson, 2021). We estimate the charging cycles required for the distances traveled in the use cases according to the designed EV ranges of each BET considered to arrive at the depreciated value of the batteries at the end of the first ownership period (i.e., the seventh year). We assume the battery's residual value at its end of life, defined as 80% capacity retention, will be 15% of its original price (Burke & Zhao, 2017). The residual values of the batteries at the end of the first ownership period for the different truck segments and model years are summarized in Table 10. The residual values of BETs and diesel trucks are presented in Table A4 in the Appendix.

Table 10
Residual value of batteries after 7 years of operation

Truck segments	MY 2023	MY 2030	MY 2040
12-tonne	50%	64%	70%
16-tonne	41%	57%	64%
28-tonne	50%	64%	70%
42-tonne	36%	54%	62%

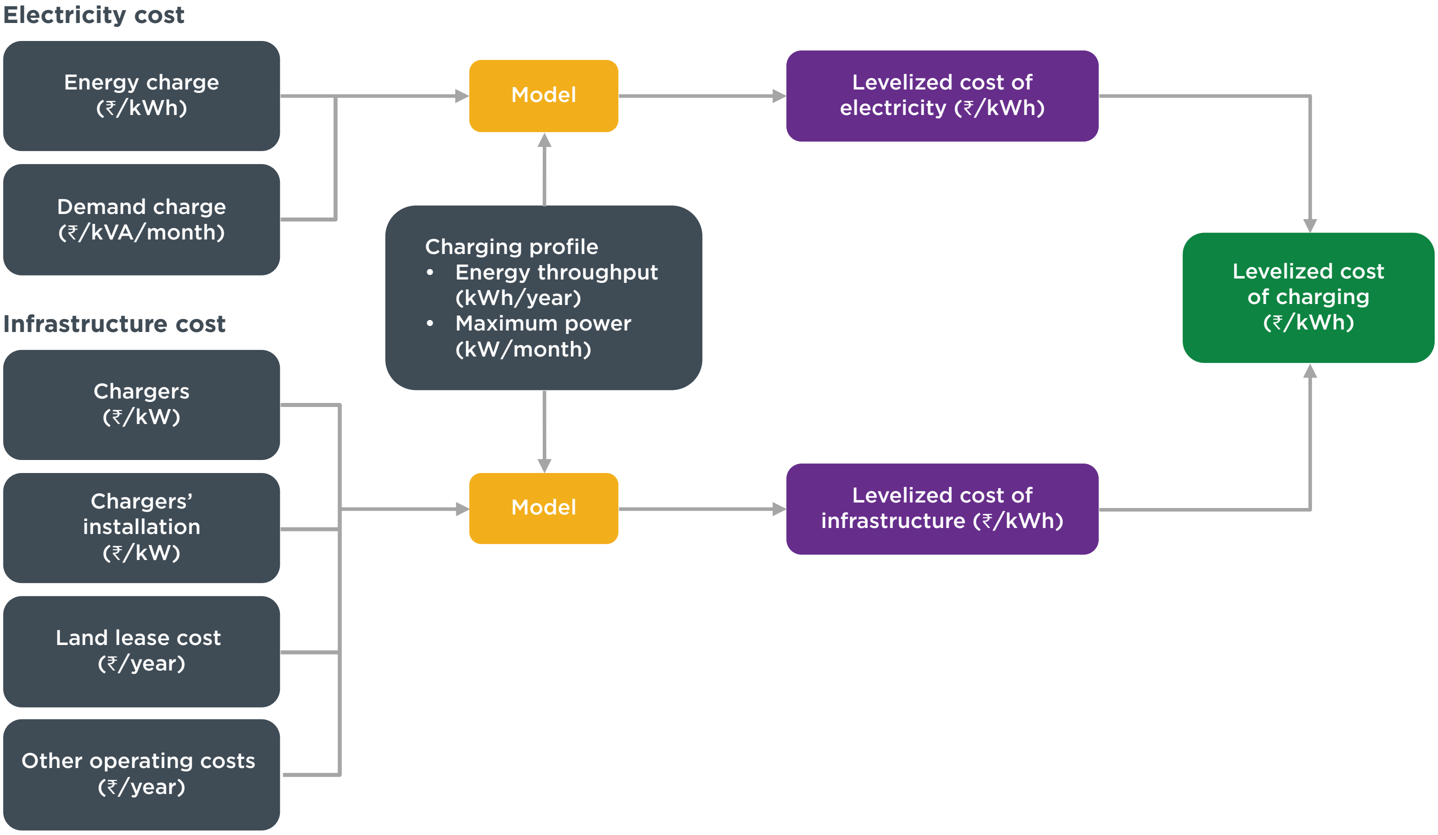
Fuel prices

We assume a diesel price of ₹93/L throughout the analysis period based on the average diesel price for India in 2023 (PPAC, 2023). We do not project diesel prices due to the immense uncertainty in fuel price projections; however, the results section below analyses the sensitivity of the TCO of diesel trucks and BETs to changes in diesel prices.

Charging cost

Charging cost comprises electricity cost and the cost of charging infrastructure. We account for both the capital expenditure and operational expenditure of the charging infrastructure to arrive a levelized cost of charging for the user (Basma et al., 2023). Figure 10 shows the framework used for estimating the charging cost.

Figure 10
Charging cost modeling framework



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This analysis considers two kinds of chargers: depot DC chargers of 100 kW used for overnight charging and en-route DC fast chargers of 240 kW for top-up charges at rest stops. Assumptions associated with the estimation of levelized charging costs are shown in Table 9. We assume the costs of additional grid upgrades required for the charging station upstream of the meter are borne by the utilities; therefore, they are not included in our charging cost calculation. We also assume charging stations have 10 chargers and estimate the area to be 450 m^2 based on the guidelines of parking requirements for trucks issued by the Indian Road Congress (IRC, 2015). Further, we estimate that about 9 m^2 of area is required per charger based on charger installation guidelines (IPLTech Electric, 2023). While charging stations may require more land for transformers and other ancillary equipment, we find that even if the land requirement is 5 times this assumption, the levelized cost of charging would increase by only 5%.

Table 11
Assumptions for EV charging stations

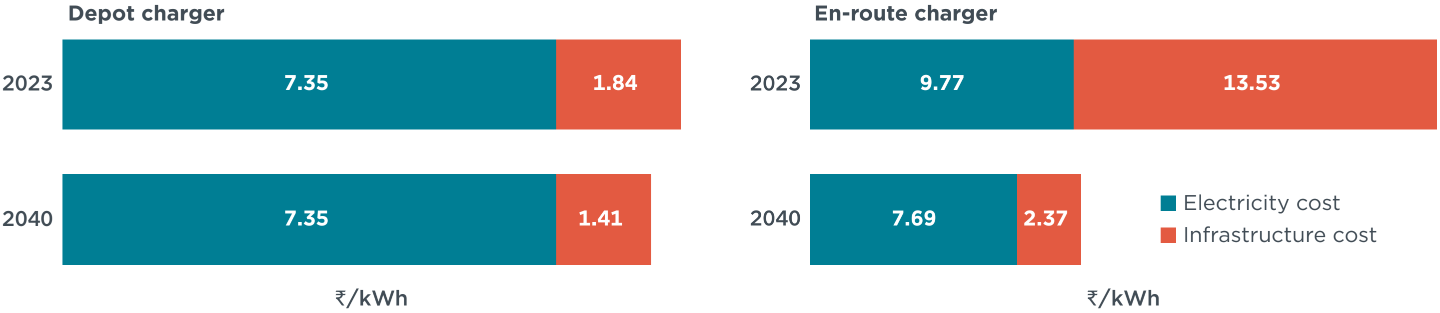
Parameters	Depot charger	En-route charger	Notes and references
Charging station characteristics			
Power output	100 kW	240 kW	—
Number of chargers at the station	10	10	
Charger availability	95%		
Number of weeks in use	52		
Numbers of days per week in use	6		
Utilization rate	33%	4% in 2023, 17% in 2040	
Charger efficiency	95%		
Internal rate of return	10%		
Station service life	15 years		
Electricity cost			
Energy charge	₹7/kWh		While EV tariffs vary from state to state in the areas considered in this analysis, we assume a uniform energy and demand charge for the simplicity of calculations.
Demand charge	₹100/kVA/month		
Infrastructure cost			
Hardware cost	₹24,500/kW in 2023 ₹18,130/kW in 2030		Abhyankar et al., 2022; Basma et al., 2021
Installation cost	20% of hardware cost		PSA, 2023
Operation expenditure	10% of capital expenditure		
Land lease cost	₹780/sq m/month or ₹35,100 per month in 2023, increasing by 5% annually		—

Although we expect lower utilization rates during the early years of operation, we assume charging station operators will average their expenses and profits over a station's lifetime. In the case of the 100 kW depot chargers, we assume 8 hours of charging every night. We find that the levelized charging cost to users at overnight depot chargers is ₹9.18/kWh in 2023 and falls to ₹8.76/kWh in 2040, primarily driven by declining hardware costs (see Figure 11).

For 240 kW en-route chargers, we assume a single 1-hour charging session at the charging station per day in 2023, increasing to 4 charging sessions per day in 2035 owing to the increasing market penetration of electric trucks. The charger utilization rate is assumed to follow a logarithmic growth function, with higher growth rates in the first few years that taper off with time. We find that the levelized cost of charging to the user at en-route charging stations is ₹23.30/kWh in 2023 and decreases to ₹10.06/kWh in 2040, driven by the declining hardware cost and increasing utilization rates. Figure 11 shows the evolution of levelized cost of charging between 2023 and 2040.

Figure 11

Levelized cost of charging to the user



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Electricity cost is about 80% the cost of levelized electricity cost to the user, showing the important role that preferential electricity rates can play in ensuring low levelized charging costs. Further, public investment in upgrades of grid distribution infrastructure by utilities and planning of charging station locations to ensure high utilization rates can help to keep charging rates at these high power charging stations affordable for users.

Other operating costs

Maintenance costs for diesel trucks were obtained from interviews with fleet operators. For BETs, we assume the maintenance cost is 30% lower compared to that of diesel trucks (Wang et al., 2022). We consider road taxes based on the states in which vehicles are registered. We also assume toll fees for the intercity movement considered in three of the four use cases (Commissionerate of Transport, n.d.; Department of Motor Vehicles, n.d.; MoRTH, 2023b). We use toll fees obtained from tolltax.in based on the number of axles and origin and destination cities (tolltax.in, 2023). We assume both diesel trucks and BETs are subject to the same road tax and toll fees. Table 12 details these other operating costs for the different trucks in this analysis.

Table 12

Other operating costs for diesel trucks and BETs

Parameter	Unit	12-tonne		16-tonne		28-tonne		42-tonne	
		ICE diesel	BET	ICE diesel	BET	ICE diesel	BET	ICE diesel	BET
Maintenance cost	INR/km	2	1.4	3	2.1	4	2.8	4	2.8
Road tax	INR/year	9,750		12,880		22,400		24,750	
Toll fees	INR/trip	—		700		2,875		2,795	

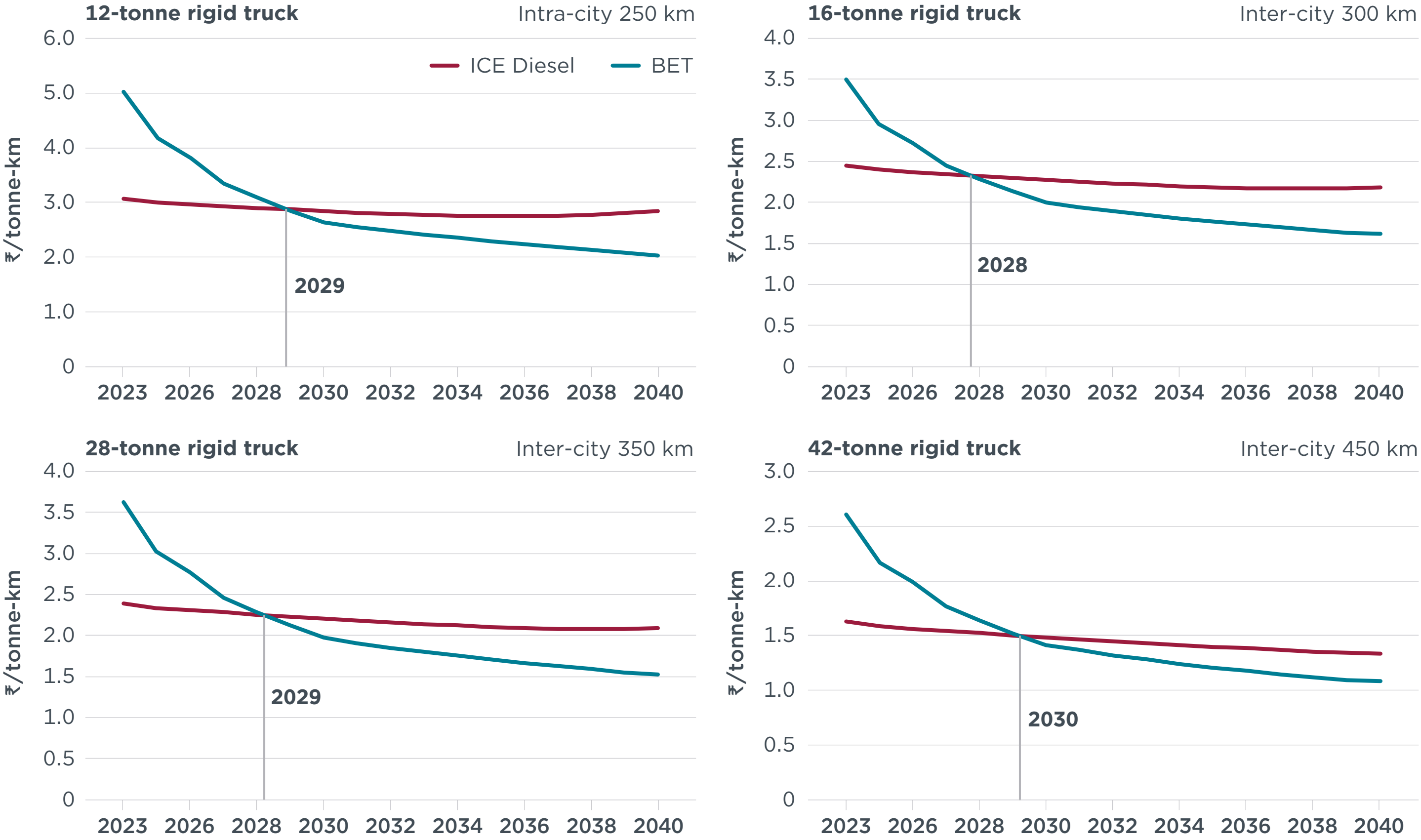
RESULTS AND DISCUSSION

TCO PARITY

We present the TCO in terms of INR/tonne-km to fully capture the effect of the payload penalty on the cost of operating a BET. We find that TCO parity occurs in the year 2028 for the 16-tonne truck, 2029 for the 12-tonne and 28-tonne trucks, and 2030 for the 42-tonne truck (see Figure 12). As discussed below, introducing new policies in the form of fuel economy regulations and fiscal incentives can hasten TCO parity.

Figure 12

TCO projections and cost parity of all four truck models



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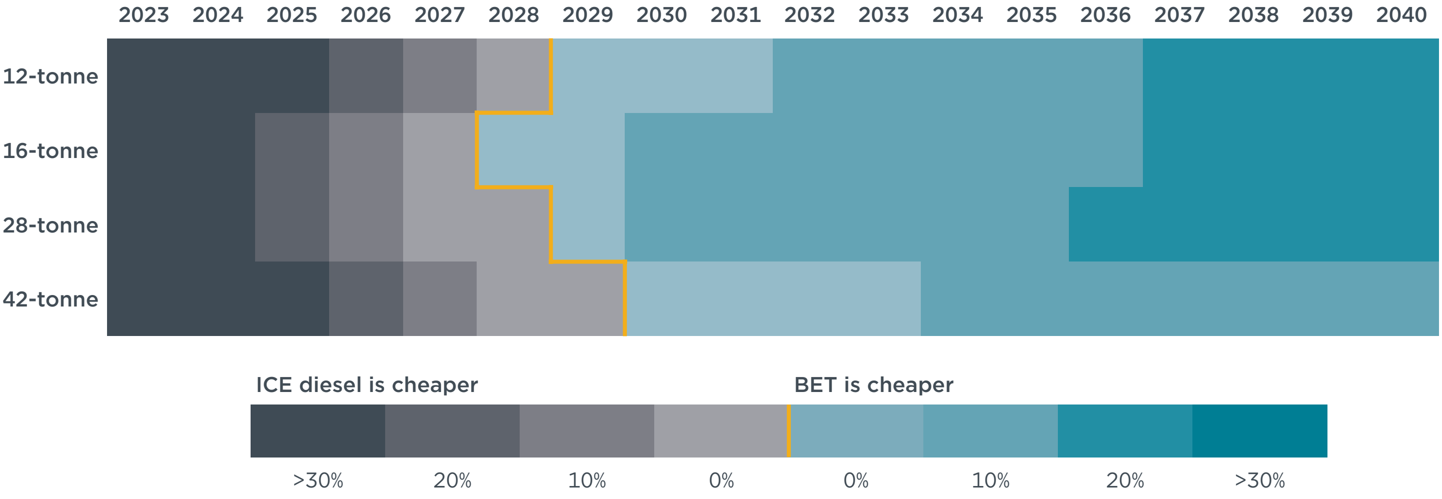
As Figure 12 shows, between 2038 and 2040, the TCO of the 12-tonne, 16-tonne, and 28-tonne diesel truck rises modestly, with the 12-tonne truck experiencing the highest increase at 3%. This is due to the costs of fuel economy technologies outweighing fuel savings. Conversely, the 42-tonne truck sees a decrease in TCO because its technology costs are relatively lower and offset by fuel savings.

The 7-year TCO of MY 2023 BETs is 1.6 times that of the diesel truck for the 12-tonne truck, 1.4 times for the 16-tonne truck, 1.5 times for the 28-tonne truck, and 1.6 times for the 42-tonne truck. With declining battery and other component prices and improvements in BET fuel economy, we find that between MY 2023 and MY 2040, the TCO of the BETs falls by more than half across all four segments, resulting in a 19%–29% lower TCO compared to diesel trucks. Figure 13 illustrates the TCO gaps between BETs and diesel trucks for different segments and model years.

Figure 13

TCO gap between ICE diesel trucks and BETs for different model years



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While most truck applications could be expected to use 100% a truck's payload capacity, there are certain use cases, such as the transport of parcels, fast-moving consumer goods, and minerals, in which trucks may reach volumetric capacity before they reach payload capacity (Climate Group, 2022). For such cases, the TCO in INR/km is a more relevant metric for the cost-effectiveness of BETs compared to diesel trucks. Figure 14 shows TCO parity in terms of INR/km. We find that, for such use cases, parity is shifted 2–3 years early.

Figure 14

TCO projections and cost parity of all four truck models

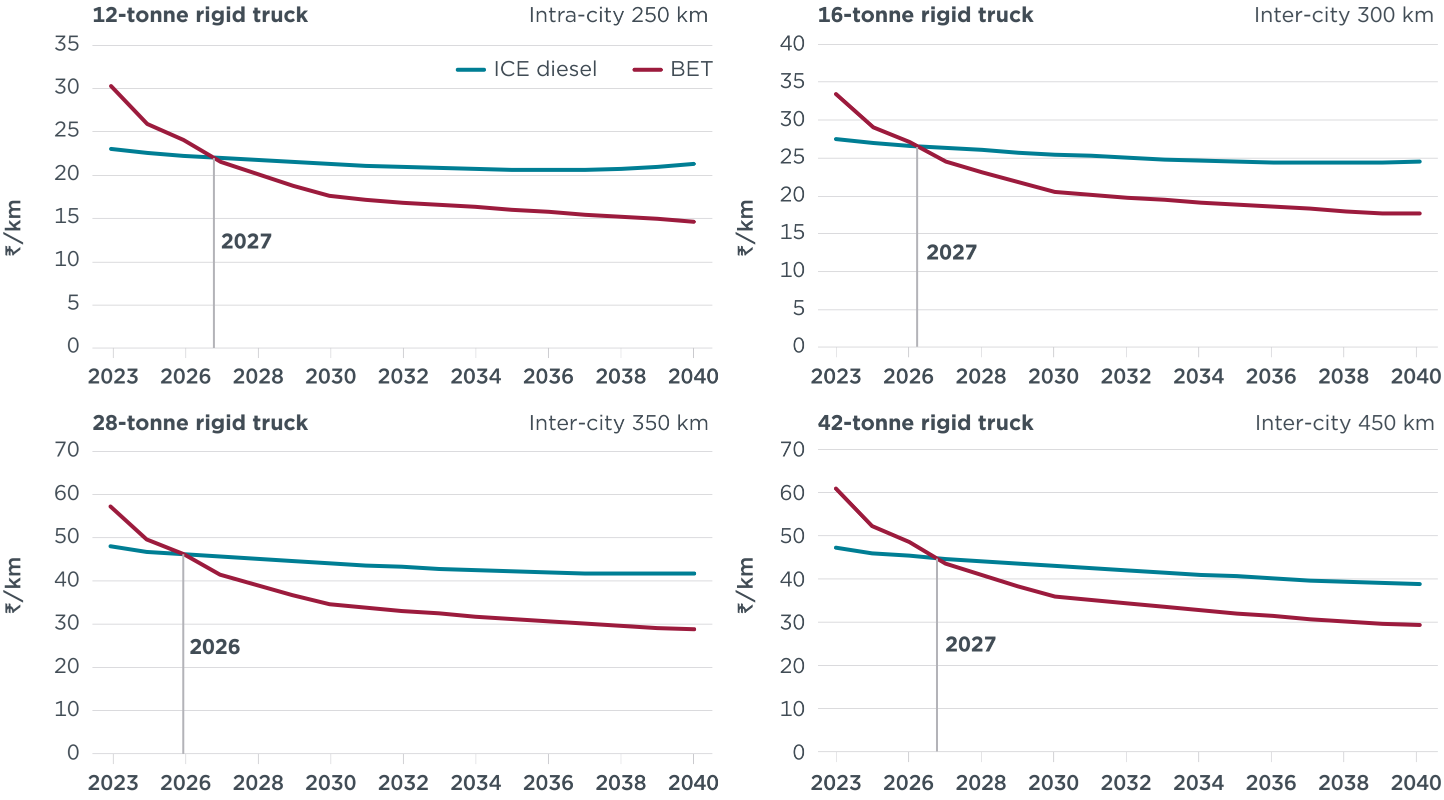

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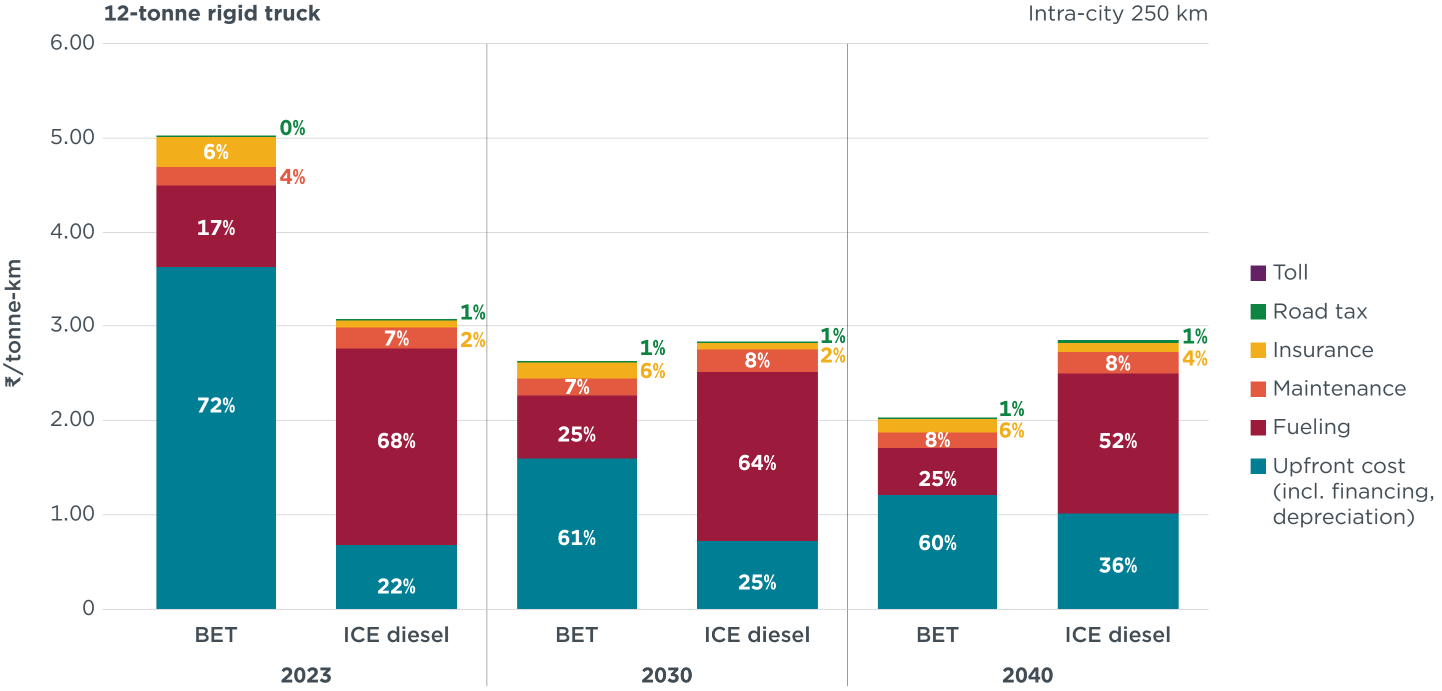
Figure 15 shows the breakdown of the TCO of the 12-tonne truck for MY 2023, 2030, and 2040. Breakdowns of the other three trucks are presented in Figure A3 in the Appendix. Fuel cost is the largest TCO contributor for the diesel trucks, accounting for 63%–69% of the total in MY 2023, depending on the segment. Even with a business-as-usual fuel economy improvement of 2% year-on-year in diesel trucks, fuel cost accounts for a much larger share of the TCO for diesel trucks than for BET counterparts through MY 2040. This is primarily because battery powertrain technology is about 65%[5] more efficient than diesel powertrain technology. In the case of BETs, the upfront cost is a major contributor (59%–72%, depending on the segment) to the TCO in MY 2023. The relative share of upfront costs in the overall TCO of BETs is highest for the 12-tonne truck, because its TCO does not include toll costs, as the truck is being used on intracity routes.

Figure 15

TCO breakdown and projections of the 12-tonne rigid truck



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[5] For the fuel economy of 19.6 L/100 km for the 12-tonne diesel truck, assuming 1L of Diesel contains 38 MJ ~ 10kWh, the energy consumption is 1.96 kWh/km compared to a BET with an energy consumption of 0.68 kWh/km.

SENSITIVITY ANALYSES

IMPACT OF DAILY DISTANCE TRAVEL DEMAND AND BATTERY RANGE

Generally, longer daily travel demand results in higher energy demand, which can be fulfilled through either bigger batteries on board or through en-route charging. Given that battery cost is a major contributor to the upfront cost of BETs, increasing battery size (and cost) significantly impacts TCO; larger batteries also lead to a higher payload penalty to the user.

Reducing battery size and depending on en-route charging to meet additional daily travel needs can thus lower the overall TCO for BETs. Figure 16 illustrates the sensitivity of TCO to daily distance travel demand and battery range in MY 2030. The x-axes show battery design range and the y-axes show the daily travel demand of the truck. The cells show the percentage TCO gap between the BET and equivalent diesel truck.

Figure 16

Sensitivity of TCO to battery range and annual daily driving range (₹/tonne-km) in MY 2030

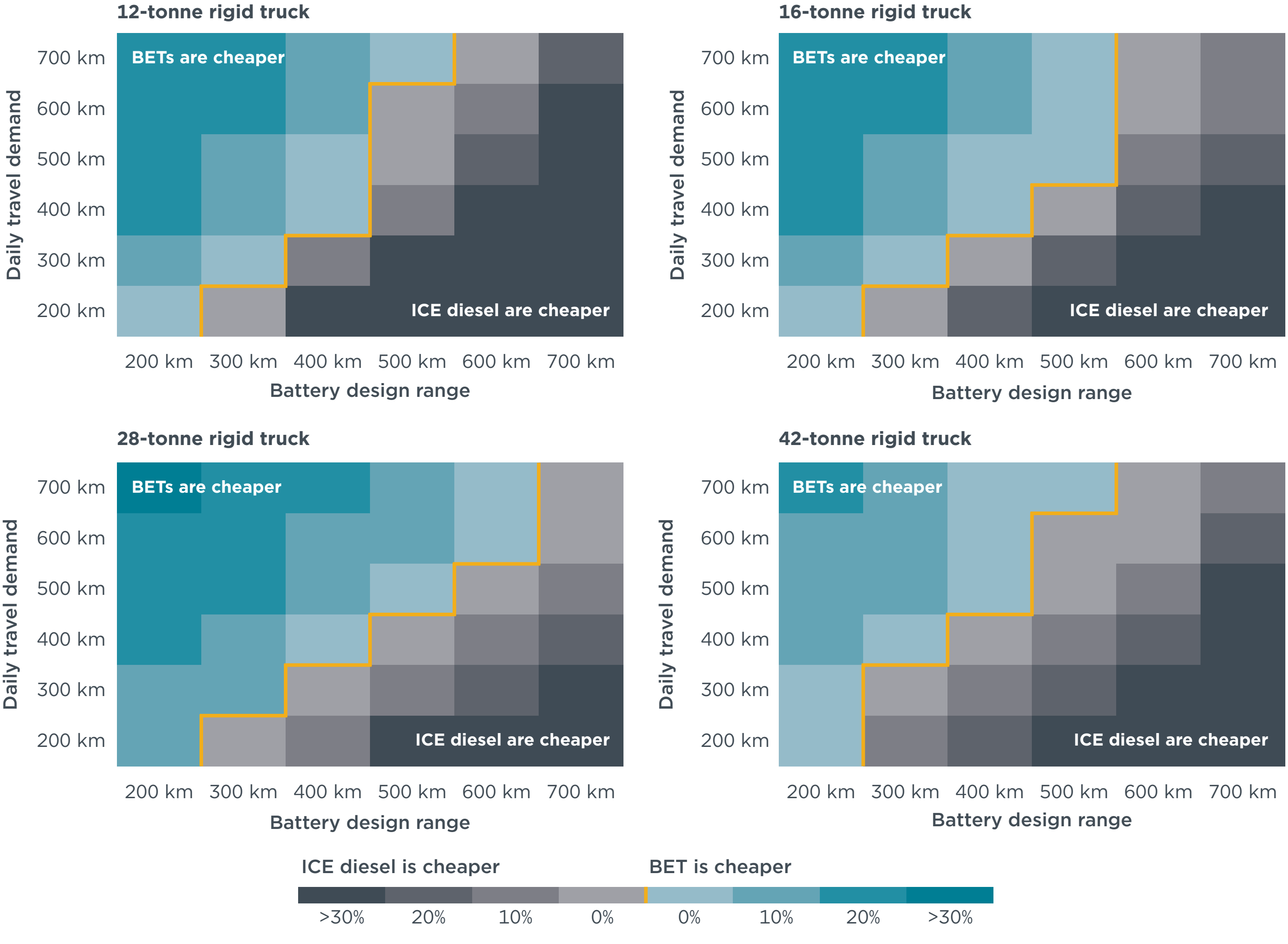

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Figure 16 illustrates the impacts of this trade-off under three conditions: when the battery is sized precisely to meet daily travel demands; when the battery design range is lower than daily travel demand (necessitating en-route charging); and when the battery design range exceeds daily travel demand. These conditions are analyzed in turn below.

Battery design range equal to daily travel demand. When batteries are sized to meet daily travel demand exactly, the TCO for MY 2030 BETs is lower than that of their diesel counterparts for daily travel demands ranging from 200 km to 400 km in the 12-tonne segment and 200 km to 500 km for the 16-tonne segment. In the case of the 28-tonne segment, the TCO of the BET is lower for a daily travel demand of between 200 km and 600 km. However, for the 42-tonne segment, designing battery range equal to daily travel demand only results in a lower TCO for BETs with a daily travel demand of 200 km.

Higher daily travel demand would result in a larger battery size, but at the same time BETs would benefit from greater fuel cost savings compared to diesel trucks. On the other hand, with lower daily travel demand, the fuel cost advantage of BETs over diesel trucks declines. These opposing mechanisms slightly impact the TCO parity year. Figure 17 explores this trade-off for a 12-tonne BET, considering 'low' and 'high' cases in which daily travel distances are 40% lower and higher, respectively, compared to the 'base' scenario that refers to the daily travel distance of the use-cases analyzed in this report. Similar graphs for the other three trucks are presented in Figure A4 in the Appendix. Table 13 summarizes the impact of these scenarios on the TCO parity year.

Figure 17

Impact of daily travel demand on upfront and fuel costs of 12-tonne BET for MY 2023 and 2030

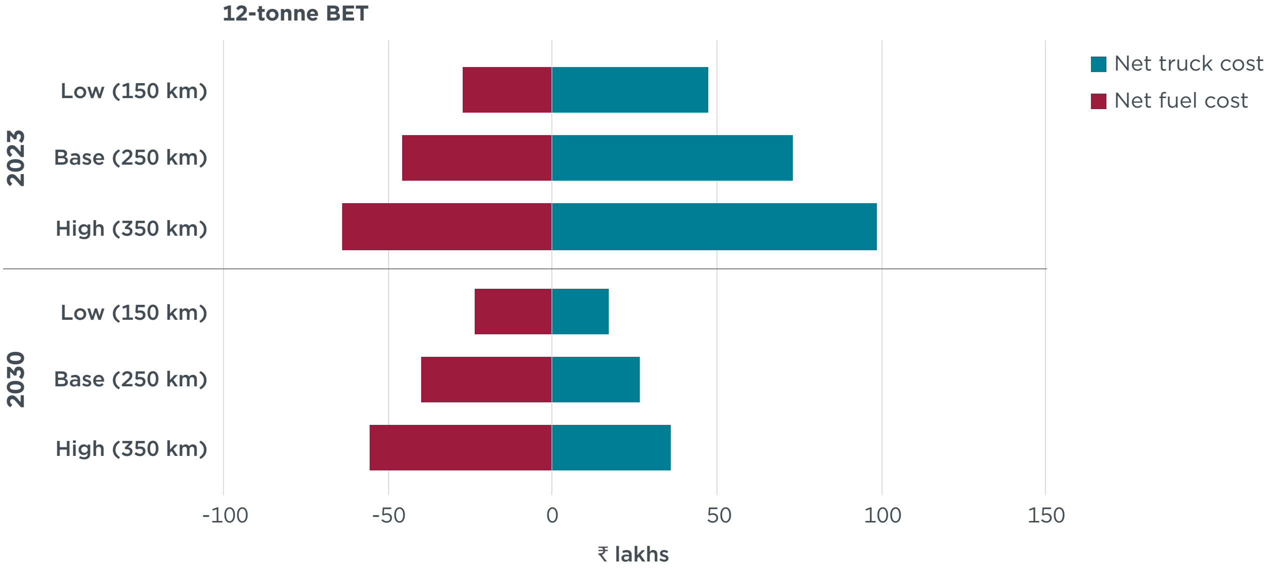

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Table 13

Impact of daily travel demand on TCO parity year, with batteries sized to fully meet daily travel needs

Segment	Low		Base		High	
	Daily travel demand and battery range	TCO parity year	Daily travel demand and battery range	TCO parity year	Daily travel demand and battery range	TCO parity year
12-tonne	150 km	2029	250 km	2029	350 km	2030
16-tonne	180 km	2029	300 km	2029	420 km	2030
28-tonne	210 km	2028	350 km	2029	490 km	2030
42-tonne	270 km	2030	450 km	2032	630 km	2034

Battery design range is lower than daily travel demand, requiring en-route charging. When the battery design range is lower than daily distance travel demand and remaining kilometers are added through en-route charging, the TCO of BETs will be lower than that of diesel trucks across all segments in MY 2030. This is because smaller batteries mean lower upfront costs, and the incremental cost of charging does not substantially outweigh the upfront cost savings. This highlights the importance of charging infrastructure for lowering the TCO of BETs.

Figure 18 compares the TCO of a 12-tonne BET with and without en-route charging in MY 2023 and 2030. With en-route charging, we assume battery size is 0.6 times the daily driving range for all the BETs analyzed in the report. A similar comparison for 16-tonne, 28-tonne, and 42-tonne BETs is included in Figure A5 in the Appendix. The impact of these two scenarios on the parity year is tabulated in Table 14.

Figure 18

Impact of en-route charging on upfront and fuel costs of a 12-tonne BET for MY 2023 and 2030

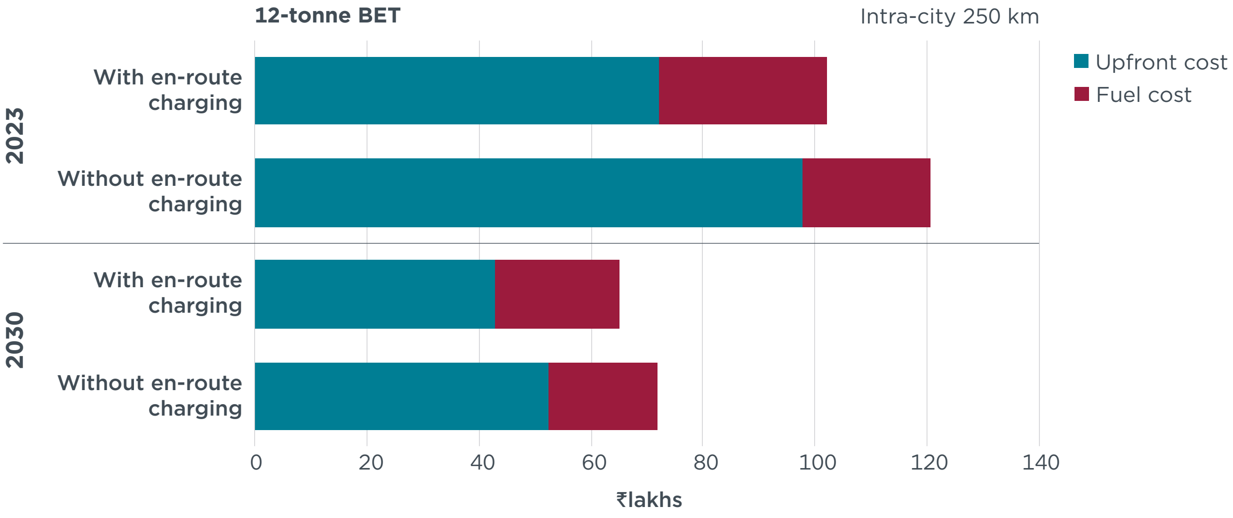

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Table 14

Impact of en-route charging on TCO parity year of BETs

Segment	Daily travel demand	With en-route charging		Base scenario assumed in the report		Without en-route charging	
		Battery range	TCO parity year	Battery range	TCO parity year	Battery range	TCO parity year
12-tonne	250 km	150 km	2027	250 km	2029	250 km	2029
16-tonne	300 km	180 km	2027	250 km	2028	300 km	2029
28-tonne	350 km	210 km	2026	350 km	2029	350 km	2029
42-tonne	450 km	270 km	2028	350 km	2030	450 km	2032

Based on interviews with operators, we assume drivers can take up to 2 hours of breaks per day to charge; we consider any additional downtime to be unfeasible. For instance, a 28-tonne BET in MY 2030, with a 400 km range, has a lower TCO than a diesel truck with a daily distance of 600 km; the installed battery meets 67% of the truck's daily energy requirement, and the driver adds the remaining 33% of the energy through a top-up charge from a 240 kW charger within an hour. On the other hand, although the TCO for a BET with a 200 km battery range and a 700 km driving range is lower than that of the diesel counterpart, this pairing results in more frequent charging stops, leading to downtime greater than 2 hours, which is not feasible.

Battery design range greater than daily travel demand. If there is high variability in vehicle activity, drivers may equip their trucks with oversized batteries to prepare for possibly longer-than-expected travel demands. As illustrated in Figure 16, there is no case in which the TCO of the BET equipped with a battery range 100 km longer than daily driving demand is lower than that of the diesel truck in MY 2030. This highlights the importance of the availability of a robust network of charging infrastructure to cater to trucks with highly variable daily travel demand.

Two forms of employment are common in the Indian trucking sector. In the first, drivers are employed by transport companies and work based on immediate assignment, with no fixed routes or schedules. In the second, drivers are engaged with logistics firms, usually transporting goods between two fixed locations, with a higher route and schedule predictability. While fixed route operations make an ideal application for BET deployment, by 2030, the BETs considered in this analysis can handle daily travel demands up to 700 km with optimal battery sizing, making them economically feasible alternatives to diesel trucks, assuming sufficiently available charging infrastructure.

IMPACT OF FUEL PRICES

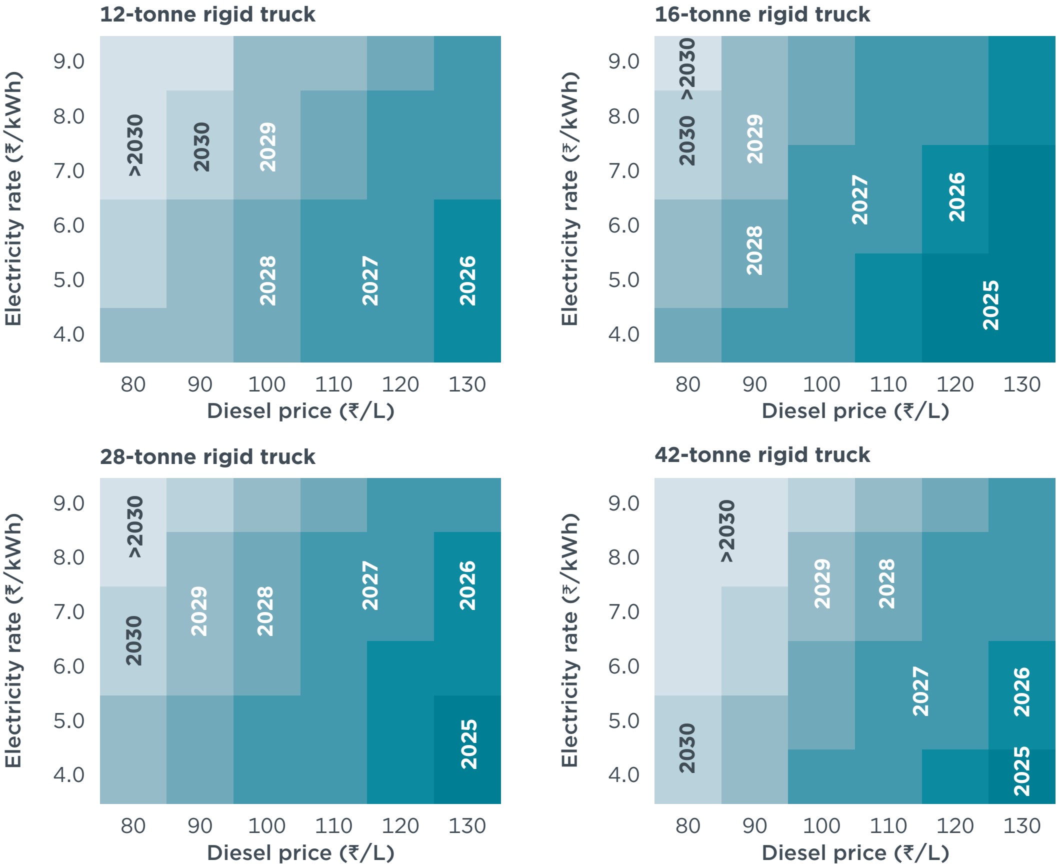
We next explore the sensitivity of the TCO to changes in diesel price and electricity rates for EV charging. Because fuel costs constitute about 66% of the overall TCO of diesel trucks in MY 2023, changes in diesel prices could have a particularly significant impact on the TCO parity year between BETs and diesel trucks. We use ₹130/L as our upper bound and the pre-pandemic price of ₹80/L as the lower bound of diesel prices.

Many Indian states have announced concessional electricity rates for EV charging stations. According to the Ministry of Power's Bureau of Energy Efficiency (2023), these electricity rates range from ₹4/kWh to ₹9/kWh. Ministry guidelines indicate that the tariff to be determined by the appropriate commission should not exceed the average cost of supply by more than 15% until March 2025 (PIB, 2023). We use an electricity rate range of ₹4–9/kWh for our sensitivity analysis. We assume that the fixed charges as part of the electricity rate for EV charging remain the same across all segments throughout the analysis period.

Figure 19 shows the sensitivity of the TCO parity year for the four segments to changes in diesel prices and electricity rates. We find that at diesel prices of ₹90–100/L (close to the price of ₹93/L assumed in the analysis above), BETs can achieve TCO parity with diesel trucks in this decade for electricity prices up to ₹7/kWh: the 16- and 28-tonne BET in 2029 and the 12- and 42-tonne BET in 2030. Assuming the same diesel price range, an electricity rate of ₹4/kWh shifts up the parity year by 1 year for the 12-, 28-, and 42-tonne BET and by 2 years for the 16-tonne BET, while a higher electricity rate of ₹9/kWh would lead to the 12-tonne and 42-tonne segments not reaching parity in this decade. This highlights the key role that states can play in increasing the attractiveness of BETs in the near term through preferential electricity rates for EV charging.

Figure 19

Sensitivity of diesel prices and electricity rates on the TCO (₹/tonne-km) parity year



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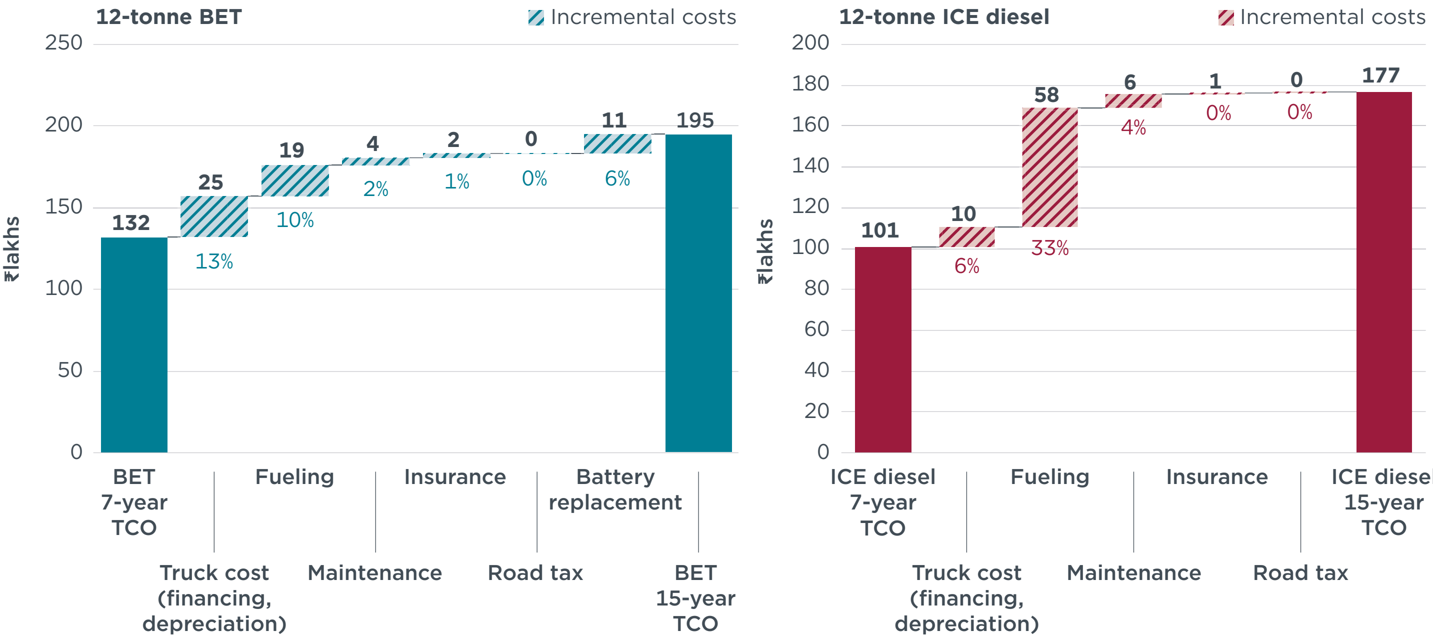
15-YEAR TCO ANALYSIS

The TCO analysis above, which assumes a 7-year first-user ownership period, excludes BET costs associated with battery replacement. We next explore a 15-year ownership period for the MY 2023 BETs considered in the analysis, wherein battery replacement costs are included in total lifetime costs. Considering declining battery prices (see Figure 5), the direct manufacturing cost of the battery in the replacement year is nearly 50%–60% lower than the cost of the battery in MY 2023. Our analysis accounts for the 18% GST rate at which replacement batteries are taxed in India as of June 2024. This is much higher than the tax rate for original vehicle-fitted batteries that is absorbed in the 5% preferential GST rate applied to the EV overall.

Figure 8 shows the TCO build-up of the 12-tonne truck in MY 2023; those for the remaining three trucks are included in Figure A6 in the Appendix. We find that the battery replacement cost accounts for only 6% of the 15-year TCO. Meanwhile, fuel costs comprise by far the largest share (close to one-third) of incremental costs for the diesel truck over the 15-year period. Ultimately, for the BET, the 15-year TCO is 32% higher than the 7-year TCO, while for the diesel truck, the 15-year TCO is 44% higher than the 7-year TCO.

Figure 20

15-year TCO evolution of a 12-tonne BET and diesel truck in MY 2023



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Since BETs have lower fuel costs than diesel trucks considering greater vehicle kilometers traveled over the 15 years, the TCO gap between BETs and diesel trucks in a 15-year TCO scenario is lower than the 7-year TCO scenario. As a result, the TCO parity year is earlier (see Table 15).

Table 15

TCO gap and parity year between a 7- and 15-year TCO

Segments	7-year TCO (₹/tonne-km)		15-year TCO (₹/tonne-km)	
	TCO gap between BET and ICE diesel in MY 2023	TCO parity year	TCO gap between BET and ICE diesel in MY 2023	TCO parity year
12-tonne	63%	2029	38%	2027
16-tonne	43%	2028	23%	2027
28-tonne	51%	2029	29%	2027
42-tonne	61%	2030	36%	2028

IMPACT OF STRINGENT FUEL CONSUMPTION REGULATIONS

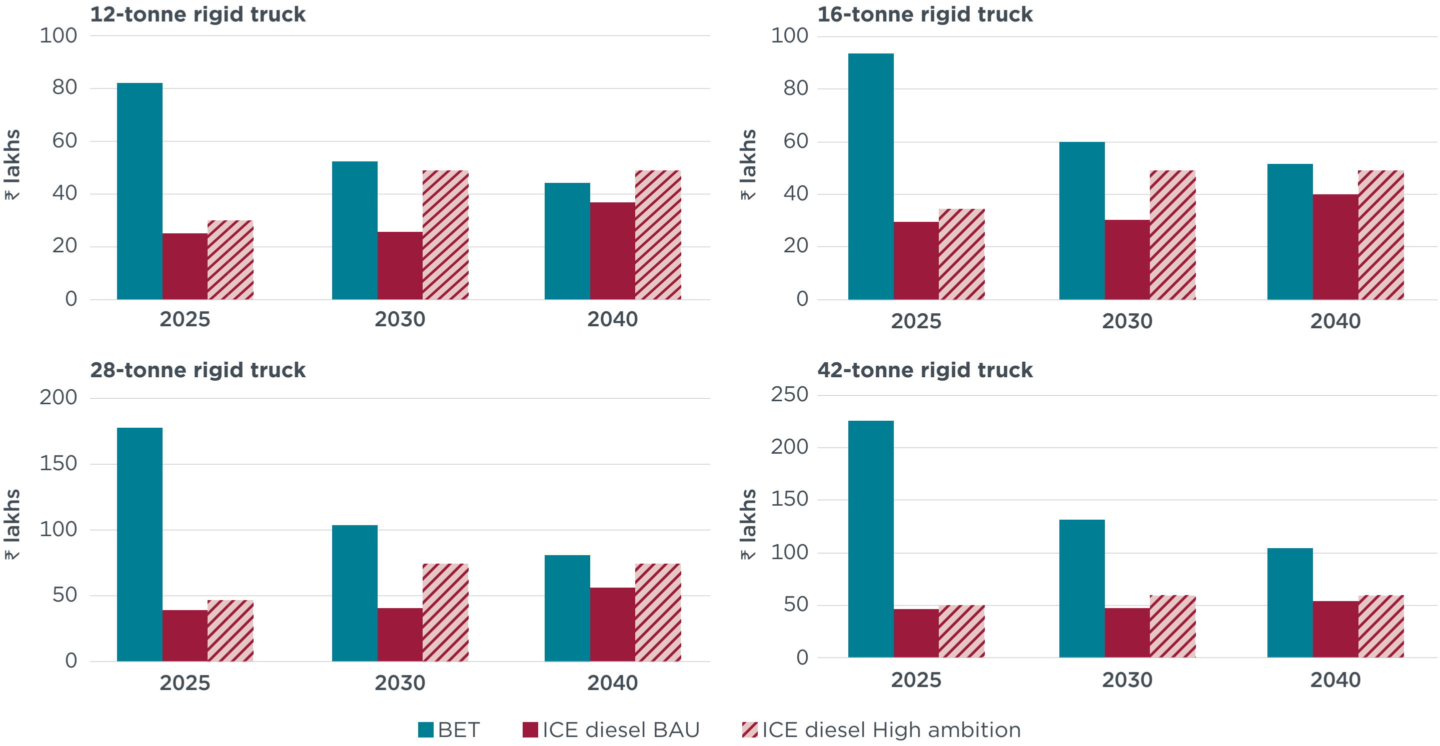
As noted above, the Ministry of Road Transport and Highways implemented the first phase of fuel consumption regulations in 2023 (MoRTH, 2022). This phase sets a baseline for fuel consumption but does not set stringency levels. As an exploratory exercise, we analyze the impact of hypothetical fuel consumption standards of increasing stringency on upfront cost and TCO. To align with India's climate goals to achieve net-zero emissions by 2070, we compare the business-as-usual case of 2% improvement per year with a high-ambition scenario in which ICE technologies reach their maximum fuel consumption improvement potential of 40% by 2030, in line with Yadav et al. (2023). Table 16 details fuel consumption improvement levels.

Table 16
Fuel consumption improvement scenarios

Year	Business-as-usual	High ambition
2025	4%	27%
2030	14%	40%
2040	34%	40%

We find that as fuel consumption standards are made more stringent, upfront costs of the diesel trucks increase substantially, reducing the gap between the BETs and their diesel counterparts. As seen in Figure 21, in MY 2023, upfront cost of the diesel truck in the high-ambition scenario is 16%–21% higher for the 12-tonne, 16-tonne, and 28-tonne trucks, and 8% higher for the 42-tonne truck, relative to business as usual. By 2040, we find that the upfront cost of the 12-tonne BET is 10% lower than that of the most fuel efficient diesel truck. However, in the case of the 16-tonne and 28-tonne BETs, the upfront costs are higher than those of the most fuel efficient diesel trucks, by 5% and 9% respectively. The upfront cost gap is still higher (at 75%) for the 42-tonne trucks due to the relatively lower incremental costs of fuel consumption improvement technologies.

Figure 21
Impact of stringent fuel consumption regulations on upfront cost



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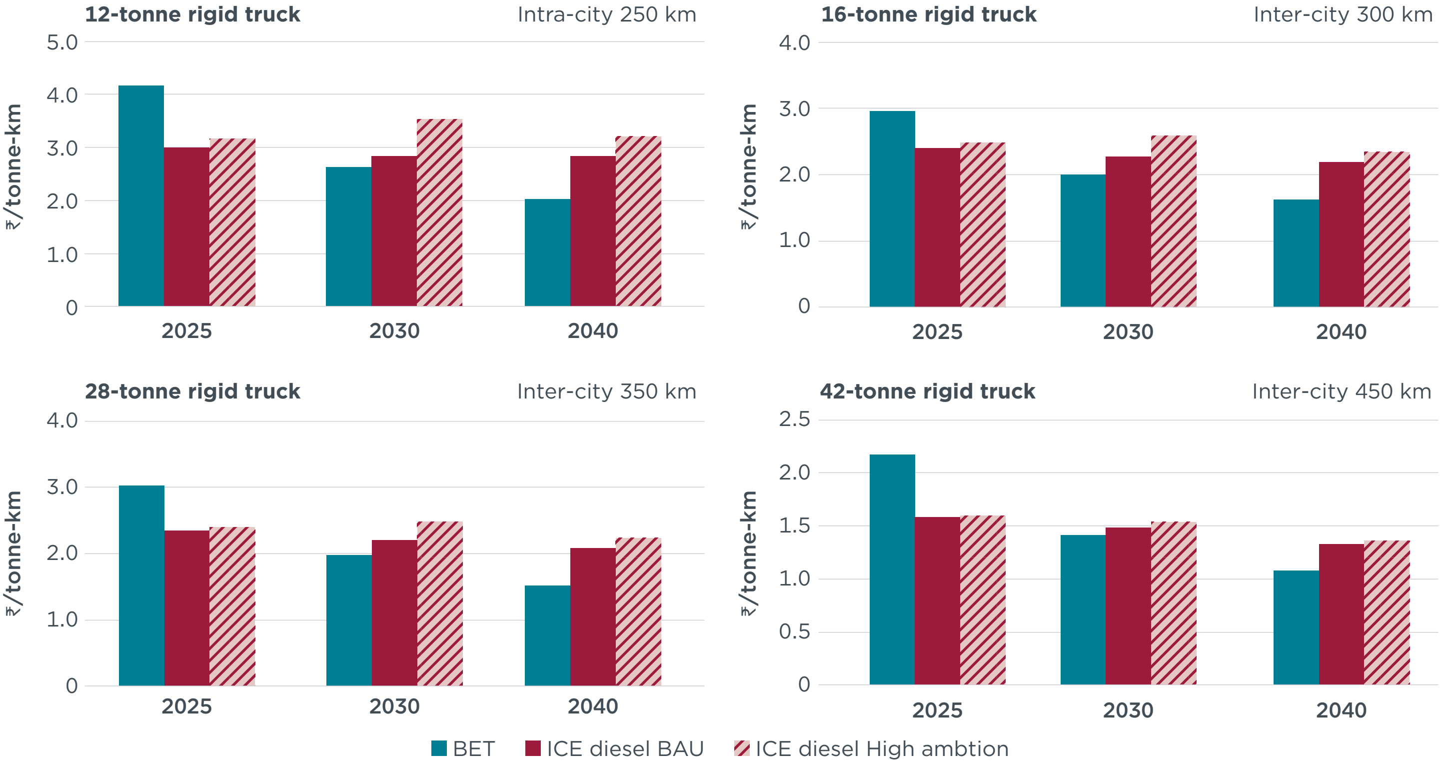
We also analyze the impact of stringent fuel consumption regulations on the TCO. As expected, the TCO of the MY 2040 diesel trucks is higher in the high-ambition scenario than in the business-as-usual case, by 7%–13% for the 12-, 16-, and 28-tonne trucks and 2% for the 42-tonne truck segment. This makes BETs even more attractive on a TCO basis than under the base case with business-as-usual fuel economy improvement assumptions (see Figure 22).

Figure 22
Impact of stringent fuel consumption regulation on TCO



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IMPACT OF INCENTIVES

Demand-side incentives have made electric two-wheelers and passenger cars more attractive in India (Dash et al., 2021; Rokadiya et al., 2021). India recently concluded the second phase of the Faster Adoption and Manufacturing of Electric Vehicles (FAME) program, a national demand incentive scheme for light-duty vehicles and passenger buses. Since battery electric trucks fell in the N2 and N3 categories, they were not included in this scheme. States have provided additional support on top of FAME II incentives, but battery electric trucks have not been covered thus far.

As an exploratory exercise, we examine the impact of different fiscal policies on the TCO of BETs and cost parity with diesel trucks. We consider a subsidy of ₹20,000/kWh with a cap of ₹50 lakhs, the same level as that made available for passenger buses in India under FAME II. We also consider 100% road tax waivers, which are applicable to EVs in multiple states in India, and a 5% interest rate subvention that was introduced in the Delhi EV policy (Kaur & Narla, 2023). Additionally, we consider 100% toll waivers for BETs on national highways. This is similar to the tolling fee waivers applicable for all the alternative fuel trucks in Germany (Bundesministerium für Digitales und Verkehr, 2023).

Further, we consider the non-fiscal incentive of GVW relaxation for BETs to abate the payload penalty resulting from heavier batteries. As noted above, the United States and the European Union have relaxed weights and dimension rules for zero-emission trucks, increasing the maximum authorized by 1 ton (2,000 pounds, or 907.2 kg) and 2 tonnes (2,000 kg), respectively, to account for the payload loss due to heavier batteries (European Parliament, 2024; Federal Highway Administration, 2019). We find that a relaxation of 2 tonnes significantly impacts the TCO of the trucks considered in this analysis, shifting the TCO parity year forward by 3 years for the 12-tonne BET and 2 years for the other three segments (see Table 17).

Table 17
Impact of payload penalty on TCO parity year

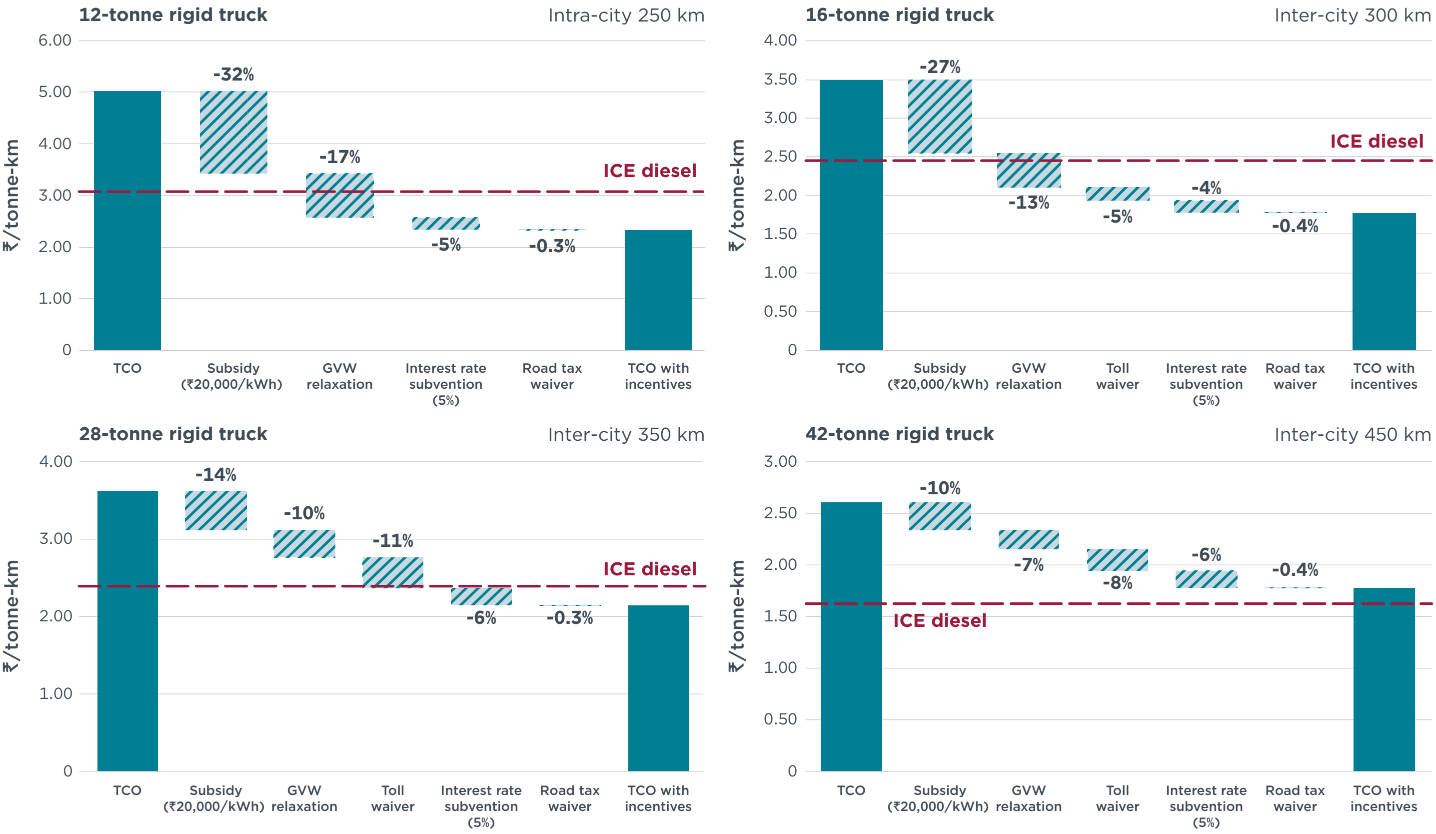
Segment	No GVW relaxation		GVW relaxation of 2 tonnes	
	Payload penalty compared to ICE diesel trucks in MY 2023	TCO parity year	Payload penalty compared to ICE diesel trucks in MY 2023	TCO parity year
12-tonne	20%	2029	0%	2026
16-tonne	15%	2028	0%	2026
28-tonne	21%	2029	11%	2027
42-tonne	20%	2030	13%	2028

We find that the subsidy of ₹20,000/kWh significantly impacts the TCO, lowering it by 27%–32% for the 12-tonne and 16-tonne BETs, reducing the TCO gap between the BET and the diesel truck to 11% for the 12-tonne truck and 4% for the 16-tonne truck in MY 2023. In the case of the 28-tonne and 42-tonne BETs, the battery subsidy of ₹20,000/kWh exceeds the hypothetical cap of ₹50 lakhs; the resulting TCO impact is limited to a 14% decrease for the 28-tonne truck and 10% decrease for the 42-tonne truck (see Figure 23).

Relaxation GVW regulations reduces the TCO of the BETs by between 7%–17% across the four truck segments studied, while the toll waiver reduces it by 5%–11%, interest rate subvention by 4%–6%, and the road tax waiver by another 0.4%. The cumulative impact of these policies makes the TCO of the BET lower than the TCO of the diesel truck by 24% for the 12-tonne truck, 28% for the 16-tonne truck, and 11% for the 28-tonne truck. For the 42-tonne truck, the TCO gap between the BET and the ICE diesel truck reduces significantly from 61% in MY 2023 to 9%.

Figure 23

Impact of policies on the TCO (₹/tonne-km) of all four BETs in MY 2023



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CONCLUSION AND POLICY RECOMMENDATIONS

This study evaluated the total cost of ownership of battery electric trucks and diesel trucks in four truck categories: the 12-tonne, 16-tonne, 28-tonne, and 42-tonne rigid truck, which have collectively accounted for 70% of total medium and heavy-duty truck sales in India in recent years. With primary cost data on EV components drawn from an ICCT-commissioned study by EY-Parthenon and real-world drive cycles collected from trucks running on-ground to simulate the fuel efficiency of BETs in Indian driving conditions, we compared the TCO of the two powertrain technologies from a first-user perspective. Based on this analysis, we arrive at five key findings:

1. **The upfront cost of simulated BETs in MY 2023 is about 4–6 times the cost of equivalent diesel models; in 2030, the upfront cost of the BETs is projected to be 2–3 times the cost of diesel trucks; by MY 2040, this ratio would further reduce to 1.2–1.4 for the 12-tonne, 16-tonne, and 28-tonne trucks, and 2 times for the 42-tonne truck.** The 2023 ratio is higher than that of the small number of BET models currently on the market in India, which are approximately 2–3 times more expensive than diesel counterparts; these models are currently deployed in limited-range pilot applications, while the simulated BETs in this study would be designed to cover the diverse range of operations in which diesel trucks are commonly employed. The projected reduction in upfront costs over time is driven by three primary factors. First, battery prices decline substantially between 2023 and 2040, due to assumed economies of scale, productivity gains, and policies promoting local production. Second, improvements in BET fuel economy reduces battery size. Finally, the deployment of fuel economy technologies in diesel trucks, driven by the adoption of fuel consumption regulations, increases the upfront cost of diesel vehicles year on year, gradually reducing the cost gap between BETs and diesel trucks. These estimates indicate that policies promoting local battery cell manufacturing and the implementation of stringent fuel consumption standards could help substantially reduce the cost differential between BET and diesel trucks in the near term.
2. **The 12-tonne, 16-tonne, 28-tonne, and 42-tonne rigid BETs are projected to reach TCO parity with diesel trucks in this decade**. For select use cases such as the shipment of high-volume, low-weight goods like parcels and fast-moving consumer goods, TCO parity by 2027 is possible. While capital investment for BETs is 4–6 times the cost for diesel trucks, their operating expenses are considerably lower. This is because a battery electric powertrain is 65% more fuel-efficient than a diesel powertrain, and associated BET maintenance costs are lower. Early deployment of electric trucks in these applications could help kickstart the development of India's BET ecosystem.
3. **Optimal battery sizing and adequate availability of EV charging infrastructure can provide substantial TCO savings.** Our analysis finds that equipping BETs with battery ranges that are shorter than daily driving range demand can lower the TCO of BETs compared with cases when the battery is sized exactly to meet daily travel demand. This is because smaller batteries mean lower upfront cost, and the incremental cost of charging does not significantly outweigh the upfront cost savings. This highlights the importance of charging infrastructure for a lower TCO, particularly for applications with variable daily driving distances (e.g., long-haul heavy trucks).
4. **BETs are projected to have a lower TCO than diesel trucks for daily traveling distances as high as 700 km in MY 2030.** While bigger batteries are required for higher daily travel demands, the resulting high upfront cost of the BETs is offset by the lower fueling expenses of the BETs compared to diesel trucks. Optimized

battery sizing, combined with adequate availability of en-route charging to meet daily travel demands, will help maximize TCO savings.

5. **With a longer assumed life of 15 years, the TCO of BETs is estimated to be level with that of diesel trucks by 2027 for the 12-tonne, 16-tonne, and 28-tonne BETs and 2028 for 42-tonne BETs.** Over a period of 15 years, BETs require a battery replacement that adds up to 6% to the overall TCO. However, this one-time battery replacement cost is offset by lower BET fuel expenses, resulting in operating expenses far lower than those of diesel trucks over the vehicle lifespan. Since BETs benefit from higher annual vehicle kilometers travelled over the 15 years owing to lower operating costs, the TCO gap between BETs and diesel trucks in a 15-year TCO analysis is smaller than in the 7-year TCO assessment, and the TCO parity year is shifted earlier by 2 years.

These findings support 5 policy recommendations:

1. **To promote BET uptake, the government could consider introducing stringent fuel consumption regulations, which could significantly increase the cost-effectiveness of BETs.** Deploying fuel efficient technologies to meet an ambitious fuel consumption regulatory scenario is projected to substantially increase the upfront cost of diesel trucks, by 62%–89% for 12-tonne, 16-tonne, and 28-tonne diesel trucks and 27% for the 42-tonne truck in MY 2030. Thus, on a TCO basis, while the diesel trucks in MY 2030 benefit from lower fuel costs due to fuel economy improvement technologies, the cost of these incremental technologies offset any potential fuel cost savings. As a result, the TCO of the BETs is even more attractive, 20%–37% lower depending on the truck type compared to 19%–29% lower assuming business-as-usual fuel economy improvement.
2. **Existing national and sub-national incentives could be extended to BETs to lower the TCO of BETs compared with diesel trucks.** Both national and state-level EV policies in India have focused on light-duty vehicles and buses. Targeting medium- and heavy-duty trucks with a ₹20,000/kWh purchase subsidy, interest rate subvention, road-tax waiver, and an additional toll fee waiver can reduce the TCO in MY 2023 by 25%–37%, bridging the gap in the TCO of BETs and diesel trucks substantially.
3. **Gross vehicle weight regulations could be relaxed for BETs (as they are in other markets) to help reduce the TCO gap between BETs and diesel trucks.** BETs in model year 2023 face a payload penalty of 15%–20%. If India relaxes GVW regulations for BETs by 2 tonnes, in line with policies in the EU, we find this payload loss is eliminated in the 12-tonne and 16-tonne BETs and reduces to 11%–13% for the 28-tonne and 42-tonne BETs. This positively impacts TCO, shifting the TCO parity year forward from 2028–2030 to 2026–2028.
4. **Enhancing the EV charging infrastructure network would help promote BETs.** We find that the TCO of BETs that rely on en-route charging is lower than the TCO of BETs with batteries designed to meet full daily travel demand. The impact is significant, such that the TCO parity year can be shifted up by 2–4 years across the different truck segments analyzed. The Ministry of Power has identified 25 national highways and expressways to be prioritized for setting up charging infrastructure (MoP, 2022). Additionally, it has also provided guidelines on power levels, standards, and distance between two charging stations for HDVs. The Ministry of Heavy Industries, meanwhile, has further provided ₹1,000 crore of funds to set up about 10,000 EV chargers in the country (Narde, 2023). Continuing to pursue these efforts, with the aim of ensuring adequate availability of high-power DC fast chargers suited for electric HDVs along freight corridors, could help lower the TCO of BETs for a broader range of applications and thereby spur the development of India’s BET ecosystem.

5. **States could provide preferential electricity rates for users and utilities to help maintain lower levelized costs of charging for users.** Many states have introduced preferential electricity rates for electricity supply to EV chargers, ranging between ₹4/kWh and ₹9kWh. Lower electricity rates can help shift the TCO parity year sooner. This highlights that states can play an important role in closing TCO gaps between BETs and diesel trucks and helping to kickstart India’s BET transition.

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APPENDIX

Figure A1

Weight build-up of 16-tonne, 28-tonne, and 42-tonne BET compared to the equivalent diesel truck

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Table A1

Upfront cost build-up of a 16-tonne rigid truck

System	Scaling parameter	Unit	Cost per unit	16-tonne truck	
				Specifications	Cost
Powertrain					
Battery pack	kWh rating of battery	INR/kWh	₹19,546	241 kWh	₹4,710,543
Motor	kW rating of motor	INR/kW	₹5,280	112 kW	₹591,360
Battery thermal management system	kW rating of the system	INR/kW	₹29,700	8 kW	₹237,600
Motor thermal management	kW rating of the motor	INR/kW	₹132	112 kW	₹14,784
Body and chassis					
Ladder frame chassis	Weight of the frame	INR/kg	₹186	900 kg	₹167,175
Truck load body	Weight of the structure	INR/kg	₹141	900 kg	₹126,720
Cabin	—	—	—	—	₹116,160
Drivetrain					
Braking system	Diameter and number of brake drums	INR/mm	₹77	410 mm	₹126,720
Front axle	Rating in tonne	INR/tonne	₹6,160	6 t	₹36,960
Rear axle	Rating in tonne	INR/tonne	₹5,280	10 t	₹52,800
Tires	Diameter and number of wheel rims	INR/inch	₹905	20 in	₹126,720
Power steering	Front axle rating in tonne	INR/tonne	₹31,173	6 t	₹187,039
Front suspension	Front axle rating in tonne	INR/tonne	₹3,520	6 t	₹21,120
Rear suspension	Rear axle rating in tonne	INR/tonne	₹2,640	10 t	₹26,400
Driveshaft	Weight of the system	INR/kg	₹792	20 kg	₹15,840
Compressor	Pressure rating	INR/bar	₹9,504	10 bar	₹95,040
Electrical and electronic equipment					
Power electronics	kW rating of the motor	INR/kW	₹1,764	112 kW	₹197,545
Junction box	—	—	—	—	₹73,920
HV wiring harness	Weight of the wiring system	INR/kg	₹1,420	119 kg	₹169,018
LV wiring harness	Weight of the wiring system	INR/kg	₹1,056	40 kg	₹42,240
HVAC	kW rating	INR/kW	₹19,200	2 kW	₹38,400
Accessories	—	—	—	—	₹52,800
Direct manufacturing cost					**₹7,226,903**
Indirect cost multiplier			1.43	—	₹3,097,244
Ex-factory cost					**₹10,324,148**
Goods and service tax (GST)			5%	—	₹516,207
Dealer margin			3%	—	₹325,211
Ex-showroom price					**₹11,165,566**

Table A2

Upfront cost build-up of a 28-tonne rigid truck

System	Scaling parameter	Unit	Cost per unit	28-tonne truck	
				Specifications	Cost
Powertrain					
Battery pack	kWh rating of battery	INR/kWh	₹19,546	552 kWh	₹10,789,293
Motor	kW rating of motor	INR/kW	₹5,280	140 kW	₹739,200
Battery thermal management system	kW rating of the system	INR/kW	₹29,700	8 kW	₹237,600
Motor thermal management	kW rating of the motor	INR/kW	₹132	140 kW	₹18,480
Body and chassis					
Ladder frame chassis	Weight of the frame	INR/kg	₹186	1,100 kg	₹204,325
Truck load body	Weight of the structure	INR/kg	₹141	1,100 kg	₹154,880
Cabin	—	—	—	—	₹127,776
Drivetrain					
Braking system	Diameter and number of brake drums	INR/mm	₹77	410 mm	₹190,081
Front axle	Rating in tonne	INR/tonne	₹6,160	7 t	₹43,120
Rear axle	Rating in tonne	INR/tonne	₹5,280	21 t	₹110,880
Tires	Diameter and number of wheel rims	INR/inch	₹905	20 in	₹181,028
Power steering	Front axle rating in tonne	INR/tonne	₹31,173	7 t	₹218,212
Front suspension	Front axle rating in tonne	INR/tonne	₹3,520	7 t	₹24,640
Rear suspension	Rear axle rating in tonne	INR/tonne	₹2,640	21 t	₹55,440
Driveshaft	Weight of the system	INR/kg	₹792	67 kg	₹53,064
Compressor	Pressure rating	INR/bar	₹9,504	10 bar	₹95,040
Electrical and electronic equipment					
Power electronics	kW rating of the motor	INR/kW	₹1,764	140 kW	₹246,931
Junction box	—	—	—	—	₹73,920
HV wiring harness	Weight of the wiring system	INR/kg	₹1,420	208 kg	₹295,782
LV wiring harness	Weight of the wiring system	INR/kg	₹1,056	70 kg	₹73,920
HVAC	kW rating	INR/kW	₹19,200	2 kW	₹38,400
Accessories	—	—	—	—	₹52,800
				Direct manufacturing cost	**₹14,024,811**
Indirect cost multiplier			1.43	—	₹60,10,633
				Ex-factory cost	**₹20,035,445**
Goods and service tax (GST)			5%	—	₹1,001,772
Dealer margin			3%	—	₹631,117
				Ex-showroom price	**₹21,668,33**

Table A3

Upfront cost build-up of a 42-tonne rigid truck

System	Scaling parameter	Unit	Cost per unit	42-tonne truck	
				Specifications	Cost
Powertrain					
Battery pack	kWh rating of battery	INR/kWh	₹19,546	705 kWh	₹13,779,804
Motor	kW rating of motor	INR/kW	₹5,280	149 kW	₹786,720
Battery thermal management system	kW rating of the system	INR/kW	₹29,700	8 kW	₹237,600
Motor thermal management	kW rating of the motor	INR/kW	₹132	149 kW	₹19,668
Body and chassis					
Ladder frame chassis	Weight of the frame	INR/kg	₹186	1,194 kg	₹221,727
Truck load body	Weight of the structure	INR/kg	₹141	1,194 kg	₹168,071
Cabin	—	—	—	—	₹190,080
Drivetrain					
Braking system	Diameter and number of brake drums	INR/mm	₹77	410 mm	₹316,801
Front axle	Rating in tonne	INR/tonne	₹6,160	14 t	₹82,240
Rear axle	Rating in tonne	INR/tonne	₹5,280	21 t	₹110,880
Tires	Diameter and number of wheel rims	INR/inch	₹905	20 in	₹253,439
Power steering	Front axle rating in tonne	INR/tonne	₹31,173	14 t	₹436,424
Front suspension	Front axle rating in tonne	INR/tonne	₹3,520	14 t	₹49,280
Rear suspension	Rear axle rating in tonne	INR/tonne	₹2,640	21 t	₹55,440
Driveshaft	Weight of the system	INR/kg	₹792	68 kg	₹53,923
Compressor	Pressure rating	INR/bar	₹9,504	10 bar	₹95,040
Electrical and electronic equipment					
Power electronics	kW rating of the motor	INR/kW	₹1,764	149 kW	₹262,805
Junction box	—	—	—	—	₹73,920
HV wiring harness	Weight of the wiring system	INR/kg	₹1,420	312 kg	₹443,672
LV wiring harness	Weight of the wiring system	INR/kg	₹1,056	105 kg	₹110,880
HVAC	kW rating	INR/kW	₹19,200	2 kW	₹38,400
Accessories	—	—	—	—	₹52,800
				Direct manufacturing cost	**₹17,843,613**
Indirect cost multiplier			1.43	—	₹7,647,263
				Ex-factory cost	**₹20,035,445**
Goods and service tax (GST)			5%	—	₹1,274,544
Dealer margin			3%	—	₹802,963
				Ex-showroom price	**₹27,568,382**

Figure A2

Upfront cost build-up of 16-tonne, 28-tonne, and 42-tonne BET in MY 2023, 2030, and 2040

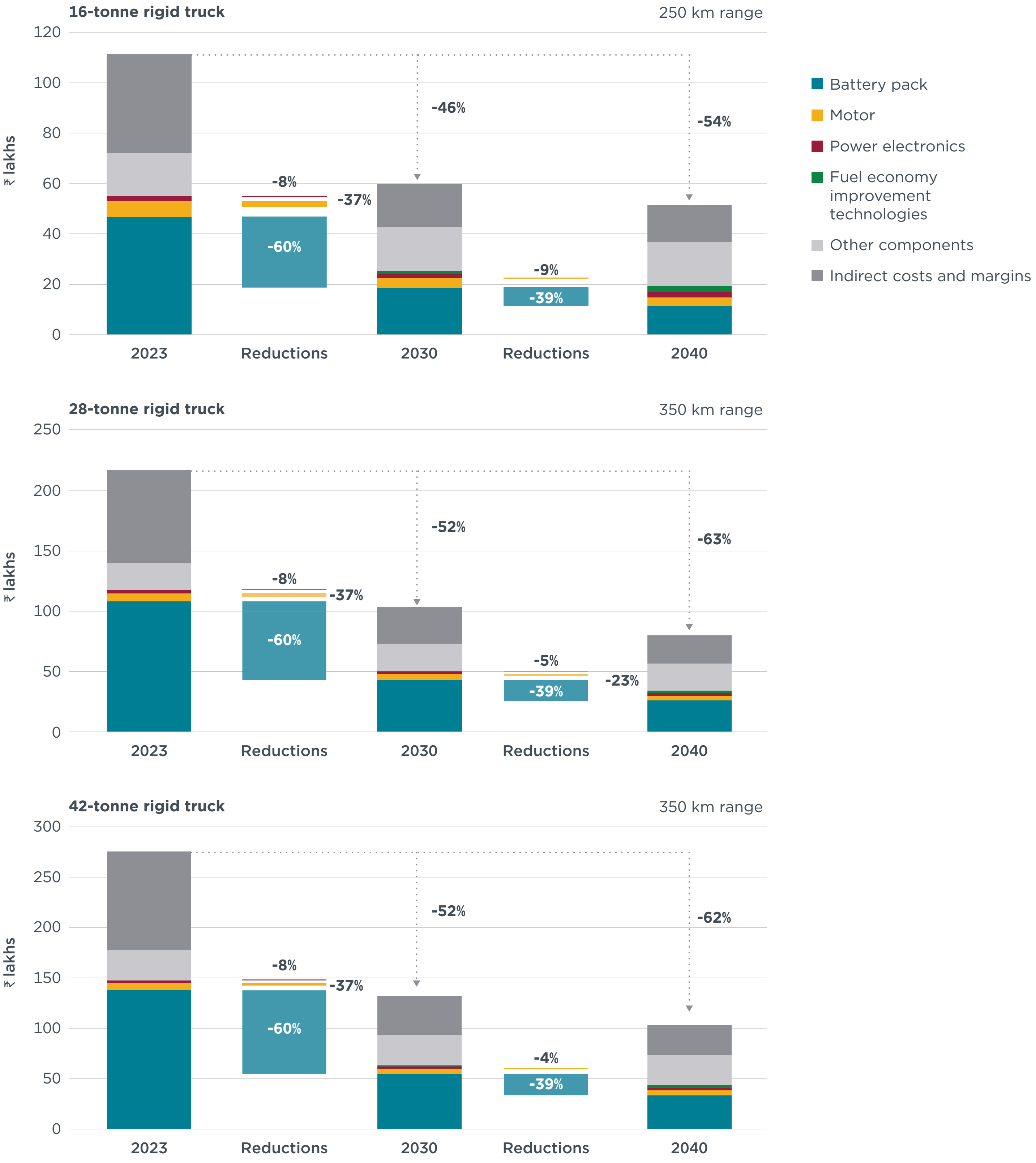

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Table A4

Residual value of diesel and BETs at the end of the seventh year (first ownership) in MY 2023, 2030, and 2040

Truck segment	Technology	MY 2023		MY 2030		MY 2040	
12-tonne	Diesel	₹10 lakhs	53%	₹10.5 lakhs	53%	₹15 lakhs	53%
	Battery electric	₹32.2 lakhs	33%	₹21.7 lakhs	41%	₹19.6 lakhs	44%
16-tonne	Diesel	₹11.8 lakhs	53%	₹12.3 lakhs	53%	₹16.2 lakhs	53%
	Battery electric	₹35.3 lakhs	32%	₹24 lakhs	40%	₹22.4 lakhs	43%
28-tonne	Diesel	₹15.5 lakhs	53%	₹16.2 lakhs	53%	₹22.7 lakhs	53%
	Battery electric	₹68.7 lakhs	32%	₹43.2 lakhs	42%	₹36.9 lakhs	46%
42-tonne	Diesel	₹18.6 lakhs	53%	₹19.1 lakhs	53%	₹21.8 lakhs	53%
	Battery electric	₹80.6 lakhs	29%	₹52 lakhs	39%	₹45.8 lakhs	44%

Figure A3

TCO breakdown of 16-tonne, 28-tonne, and 42-tonne diesel trucks and BETs for MY 2023, 2030, and 2040

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Figure A4

Impact of daily driving range on upfront and fuel costs of BETs for MY 2023 and 2030

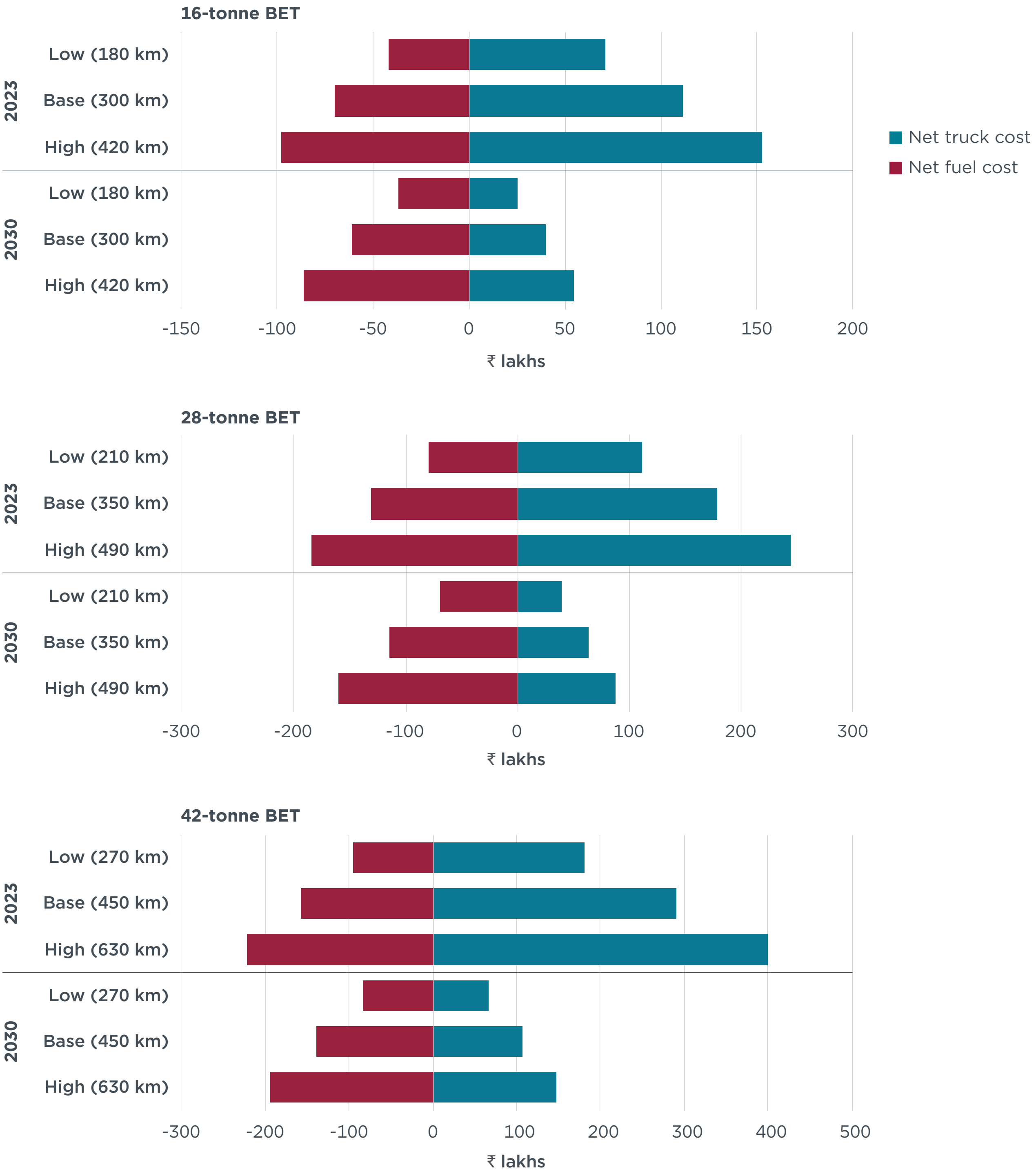

Figure A5

Impact of en-route charging on upfront and fuel costs of BETs for MY 2023 and 2030

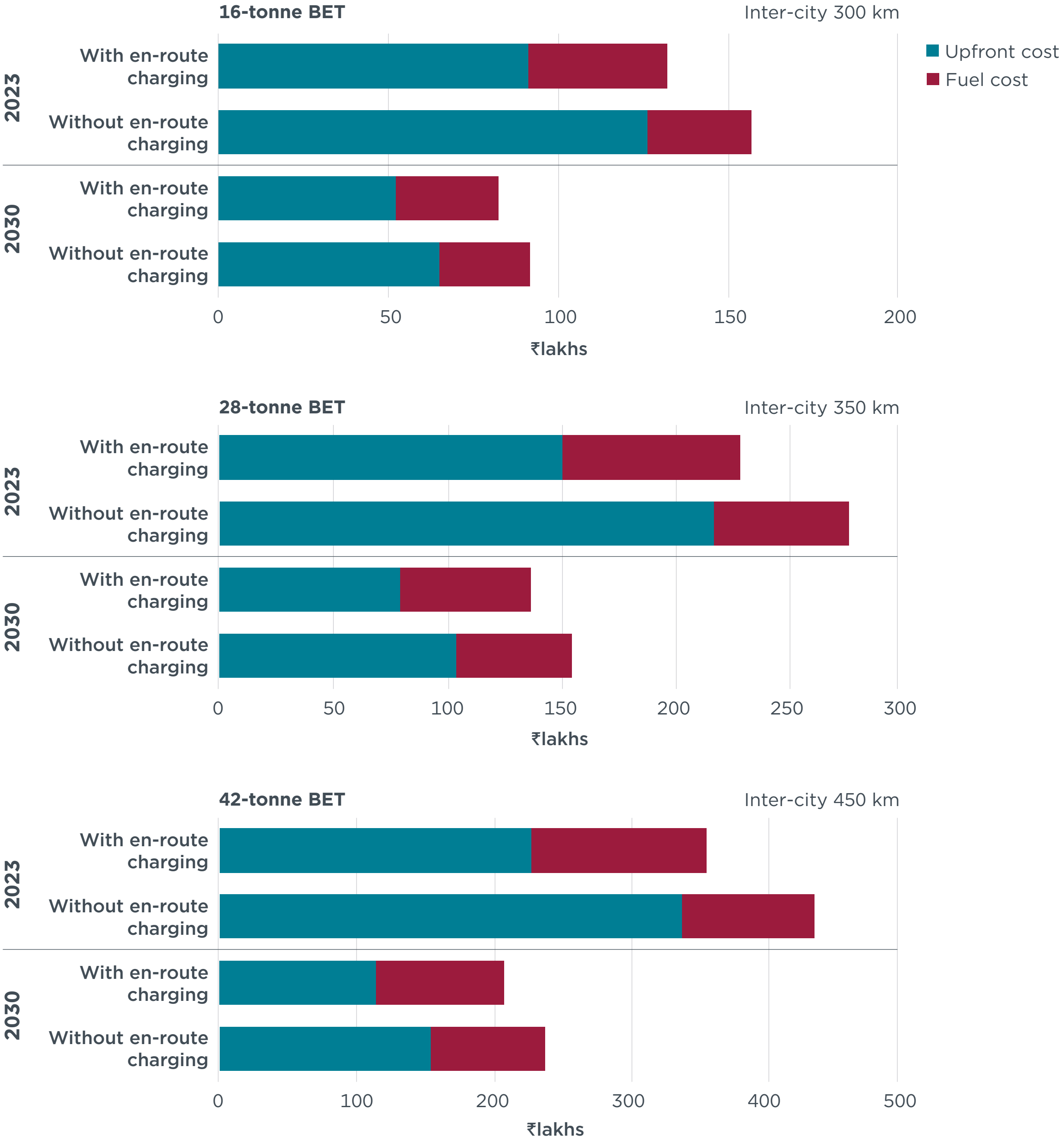

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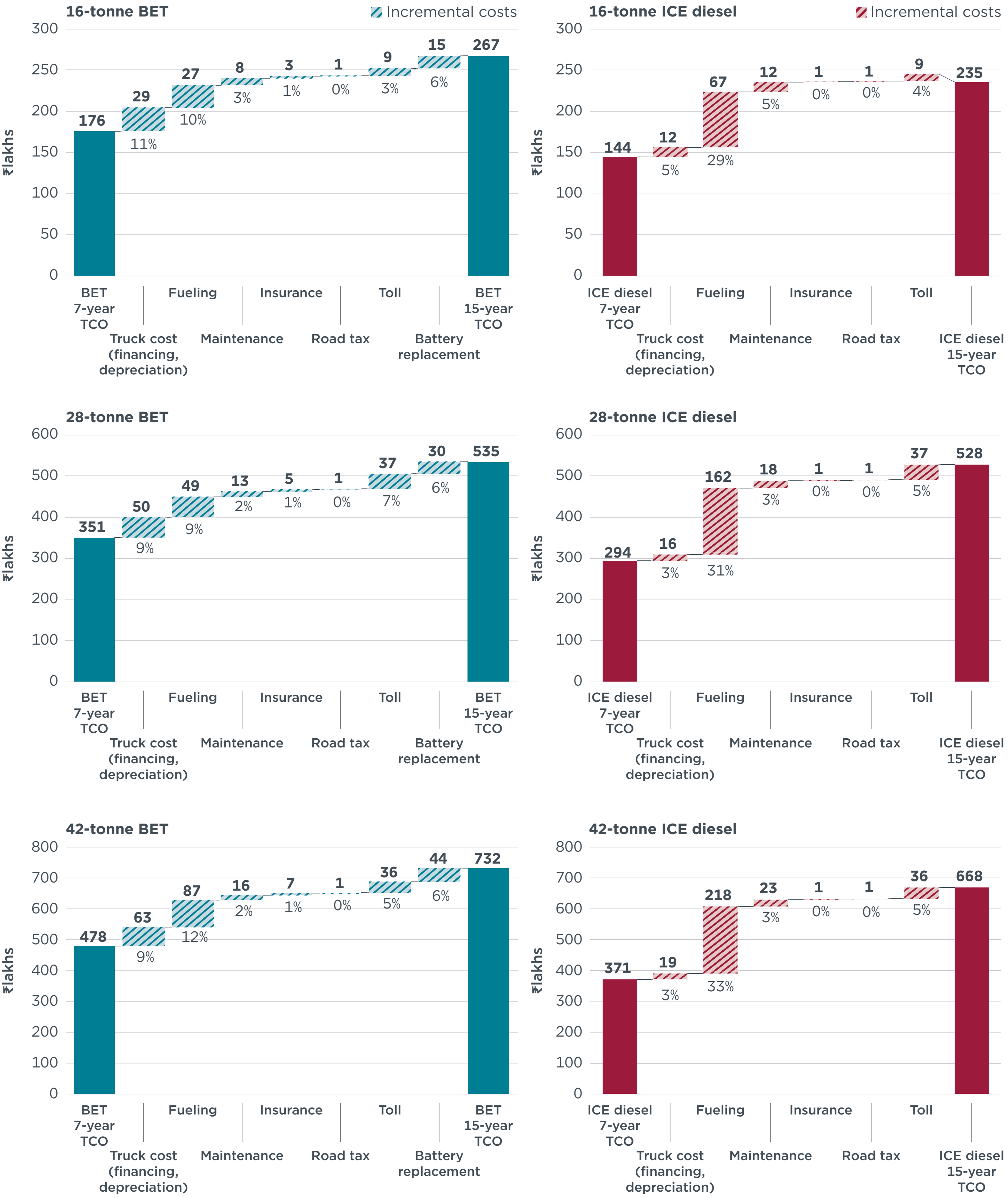
Figure A6

15-year TCO evolution of 16-tonne, 28-tonne, and 42-tonne BETs and diesel trucks in MY 2023



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