Centre of Excellence for Zero Emission Trucking

CoEZET

IIT MADRAS

Indian Institute of Technology Madras

Assessment of Maintenance and Repair Costs of Battery Electric Trucks

April 2025

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EXECUTIVE SUMMARY

Scope:

This assessment aims to evaluate and compare the Maintenance and Repair Costs (MRC) of Battery Electric Trucks (BETs) and Internal Combustion Engine Trucks (ICETs) or diesel trucks over their lifespans under similar conditions. It aims to analyse BETs maintenance and repair, noting the factors influencing cost variations, such as vehicle type, age, mileage, energy consumption, and driving conditions.

Methodology:

- Created an organized data collection framework for ICET and BETs.
- Grouped the truck segments based on their rated (Gross Vehicle Weight) and their usages. Tipper, Tractor, Multi Axle Vehicles and Intermediate Commercial Vehicles contribute to more than 85% of truck sales in a year. Thus, one truck model from each category has been selected for the assessment.
- Identified major aggregates in both ICETs and BETs for 14T and 35T rigid trucks, 28T tipper, and 55T tractor category.
- Performed cost calculations considering average lifespan of vehicle to be 8 years and running of 1,00,000 lakh kms/ year for 14T rigid truck, 80,000 km/ year for 35T rigid truck &55T Tractor, and 3,000 hours of operation / year for 28T tipper.
    - Maintenance and repair strategies of electric buses (e-Buses) is taken as a supplementary reference for approximating BET maintenance.

Conclusion:

The assessment, for the given considerations, indicates cost savings across all studied segments: 14T Haulage (-11%), 35T Haulage (-16%), 55T Tractor (-21%), and 28T Tipper (-2%) compared to ICE trucks. Factors such as battery capacity, battery chemistry (LFP), life cycles (4,000), operational distances, and energy consumption significantly influence maintenance and repair costs. With ongoing technological advancements and economies of scale reducing expenses, BETs are well-positioned to become increasingly accessible and cost-efficient.

1. Introduction

The Centre of Excellence for Zero Emission Trucking (CoEZET) has been established at the Department of Engineering Design, Indian Institute of Technology Madras (IITM), with the objective of accelerating the deployment of Zero Emission Trucks (ZET) in India in Medium & Heavy-Duty range with GVW of 12 Tons and above. CoEZET's vision is to become a nodal resource for Zero Emission Trucking solutions for all the related stakeholders in India.

With the advent of Battery Electric Trucks (BETs), Zero Emission Trucks (ZETs) represent a transformative shift in the transportation industry, offering a sustainable alternative to traditional Internal Combustion Engine (ICE) powered trucks. BETs have begun steadily gaining traction all over the world, and India is a huge potential market. For effective penetration of BETs, it is important to understand the impact of Maintenance and Repair Cost (MRC) of BETs compared to Internal Combustion Engine (ICE) trucks.

Tata Motors Ltd, Ashok Leyland Ltd, and VECV collectively hold over 95% of the >12T GVW category of ICE truck market in India.

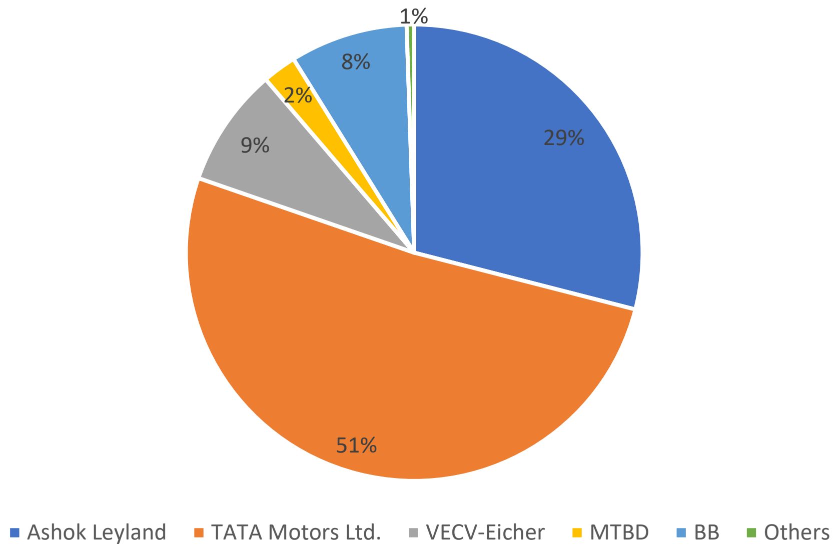

Figure 1: ICE Truck Market Share in 2023-24 (GVW>18.5T)

From figure 1, it is observed that TATA Motors and Ashok Leyland are continued to be most favoured brands in Medium and Heavy-Duty trucks. Customers tend to remain loyal to their brand of choice and will be more comfortable switching to a BET offered by a trusted brand. These major OEMs are poised to enter the electric truck market due to their R&D capabilities, strategic partnerships, and the lucrative prospects of entering a growing BET market. Component manufacturers like BOSCH, who manufacture fuel injection systems and various other parts to these top-tier OEMs, will also play a crucial role in developing BET components.

Further to split up of major manufacturers, analysis of segment split within ICETs >12T GVW is done to understand the segments that are to be considered for the MRC analysis.

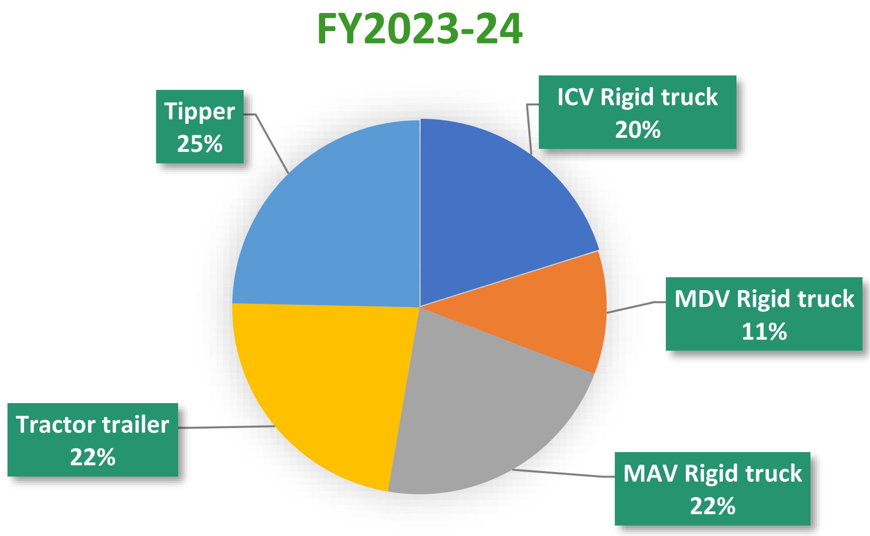

Figure 2: Segment split of truck in India

The above figure 2 shows that Tipper contributes 25%, Multi-Axle Vehicle (MAV) & Tractor Trailer contributes 22% each, Medium Duty Vehicle (MDV) 11% and Intermediate Commercial Vehicle (ICV) contributes 20% of Total Industry Volume (TIV).

As a representative sample, we have considered the 14T Rigid ICV truck, 28T Tipper, 35T Rigid MAV truck and 55T Tractor Trailer for the MRC analysis because of their extensive usage, popularity among a broad customer base, and the current availability of these segments as BETs.

2. Methodology

To comprehend BETs maintenance and repair cost (MRC), and make a realistic comparison with the ICE trucks, it is essential to have a thorough understanding of ICE maintenance & repair strategies.

- A detailed ICET maintenance and repair data including part identities, part quantities and part prices for all major aggregates and sub-components was collected through various stakeholder consultations and on-site visits.
- The resulting aggregates list was segregated into common ICET & BET aggregates, diesel-specific aggregates, and electric powertrain-specific aggregates.
- Following this breakdown of ICET data, OEMs and their respective industry R&D professionals, and e-Bus operators were consulted to seek out verified data for BET aggregates and subsystems.
- A BET aggregates list was compiled with BET-specific components and a cost-comparison analysis of four GVW categories (14T, 28T, 35T, and 55T) was performed.
- Sensitivity experimentation with these values was performed and approximations for different levels of annual running were produced.

2.1 General Considerations

Following general considerations were made for analysing the MRC of BETs.

1. Rated Capacity of motor 120 kW for 14T truck and a higher rated motor (200 – 250kW) for 28T Tipper, 35T truck and 55T Tractor Trailer.
2. Battery cost per kWh and battery life is based on consultations with OEMs/distributors. Battery cost drop and chemistry price comparison (LFP vs. NMC) are based on the figures from Bloomberg's NEF ZEV Investor Factbook.
3. Battery life LFP is considered based on consultation with OEMs as 4000 cycles until 80% State of Health (SOH) level.
4. As per CoEZET estimates, the average application scenario for running per year for each of the segments:
5. 14T Trucks in parcel and FMCG transportation → 100,000 Km.
6. 28T Tipper in on-road application → 300 days a year at 10 hours per day.
7. 35T Truck & 55T Tractor in transporting cement and steel → 80,000km.
8. Lifetimes are approximate. As per use components will have an assumed lifetime of 8 years for the purposes of calculation. Truck lifetime parts will assume a mileage of 8,00,000km for 14T GVW truck, 6,40,000km for 35T GVW truck & 55T GVW Tractor and 24,000 hours for Tipper.
9. Where a component's lifetime was not clearly detailed, the warranty period and B10 life served as guidance for the educated assumption of its lifetime.
10. E-Powertrain subsystems are expected to be carryovers from equivalent GVW e-bus subsystems. For BETs larger than the equivalent available e-buses, their subsystems have been assumed to scale up to meet the increased power demand as estimated from equivalent diesel trucks.
11. Tyre cost is not included in the analysis as it varies widely based on operating conditions and driving behaviour.
12. The energy consumption varies for different GVW vehicles for different scenarios and can be changed in the Excel templates.

2.2 Calculation Methodology

Table 2 below shows the list of major aggregates that are specific to ICET that are changed in BET and aggregates that are common or retained with minor changes between ICET and BET.

List of Aggregates		
Getting replaced in ICE trucks	Getting added for BETs	Retained from ICE trucks
Engine	Battery Pack & Cooling system	Power Steering
Cooling System	Traction Motor	Axles
CRS Fuel system	DC-DC Converter	Brakes
EATS system	Wiring Harness	Suspension
Clutch	Charging inlet connector	Cabin & AC
Gear Box	Power Distribution Unit	24V Electricals
Propeller Shaft	Auxiliary System Motors	

Table 1: Grouping of aggregates

Aggregates like axle, brakes, suspension, chassis, etc. will remain unchanged between ICET and BET. The MRC of diesel-specific aggregates like engine, clutch, gearbox, exhaust system, etc. is removed from the total MRC of an ICE truck, leaving a base vehicle MRC. MRC of electric powertrain aggregates is added to the base vehicle MRC to create an educated inference of the BET MRC. This is the aggregate understanding that is applied to calculate the maintenance and repair cost for BETs. Figure 3 below shows the calculation methodology followed for arriving MRC for BETs.

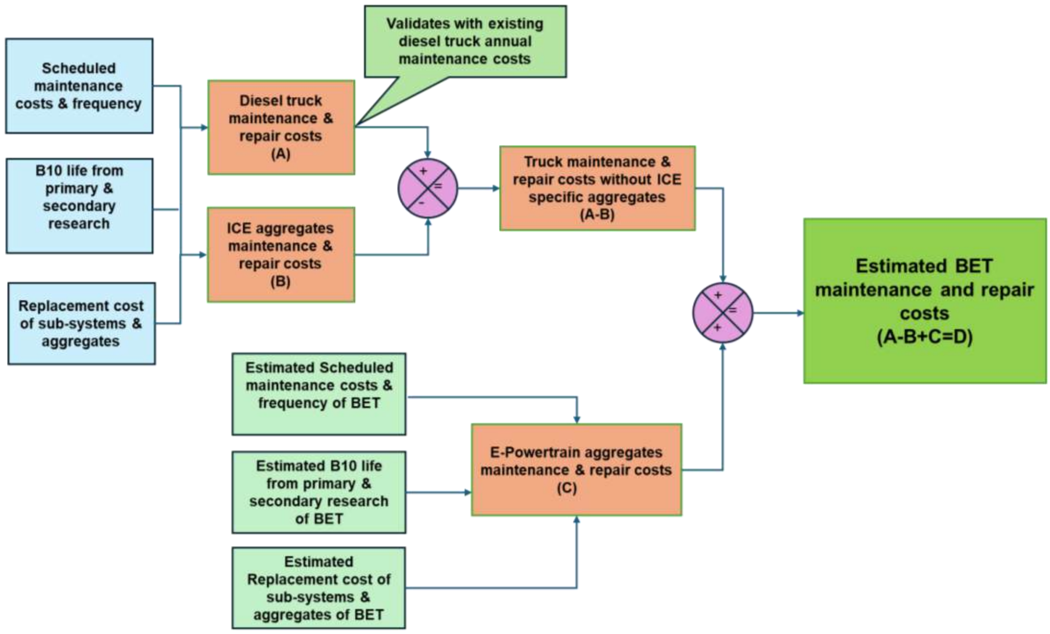

Figure 3: Calculation Methodology Flowchart

3. Data Collection Framework

Questionnaires were filled with information from fleet operators and personnel from authorized workshops. Those for fleet operators focused on the costs of operating a truck fleet. For authorized workshops, the questions addressed maintenance, repair, replacement cost, and frequency details and OEM strategy for maintenance and repair.

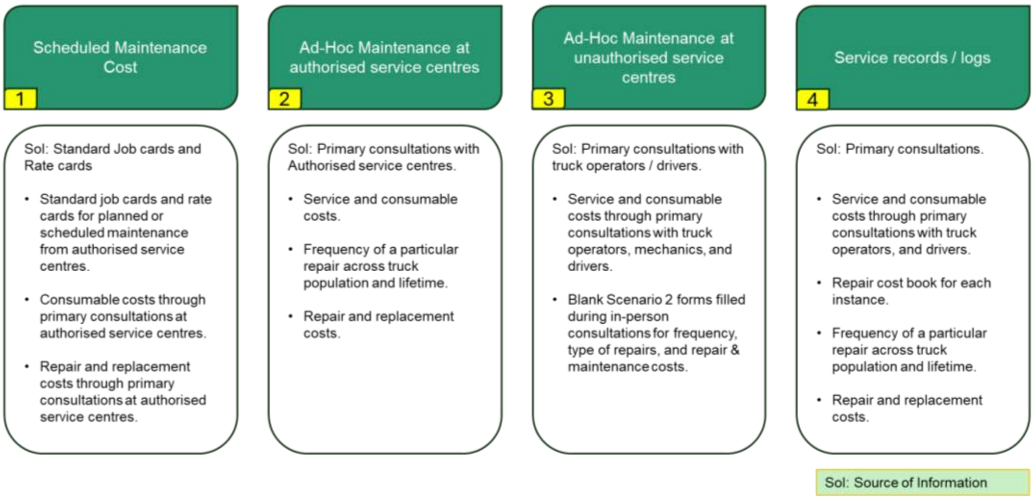

Figure 4: Data Collection Framework for ICE Trucks

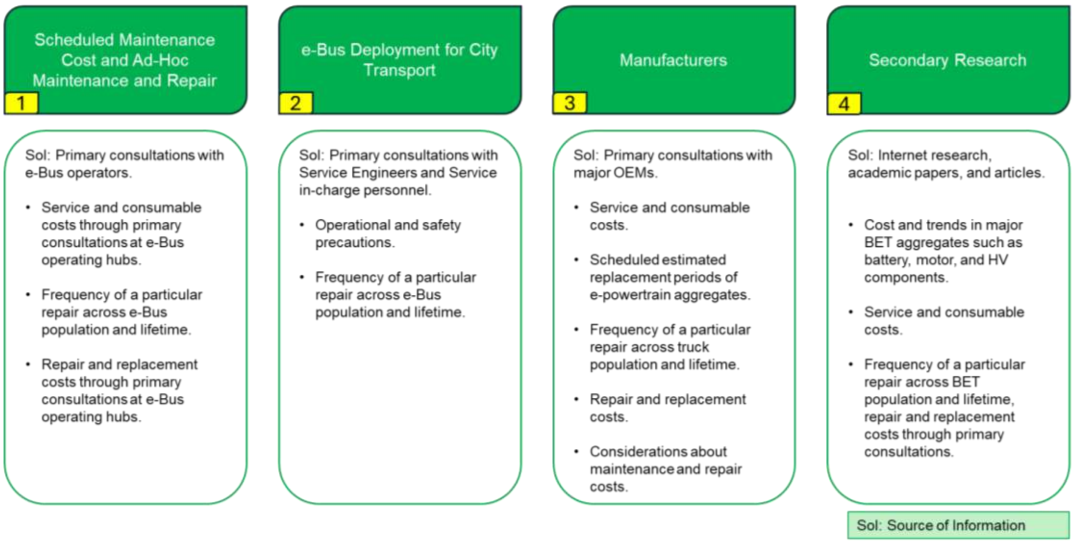

Figure 5: Data Collection Framework for BETs

Figure 4 and Figure 5 shows Data collection framework for ICE and BET respectively. For ICE trucks, B10 life, scheduled maintenance cost, and part replacement cost were gathered through primary consultations at authorized and unauthorized service centers, standard job/rate cards, and service records of garages. Estimated BET maintenance cost, part replacement cost, frequency of repairs, and B10 life was calculated and analyzed from the inputs from e-Bus operators and drivers, manufacturers, and secondary research.

4. Maintenance and Repair Cost Analysis

We assume that the maintenance and repair services are carried out authorised location and by authorised person. If the preventive maintenance is carried as per schedule suggested by manufacturer enroute breakdown and related repairs are avoided.

Parts that are replaced during preventive/scheduled maintenance. Timely replacement of basic vehicle consumables will prevent breakdowns and maintain smooth operation. This is usually scheduled based on either time or mileage [1] (or time/hours for tippers).

Consumables considered: Lubricants and parts such as engine oil, transmission oil, chassis lube, steering oil, engine coolant, brake linings, brake drums, oil filters etc.

[1] *An Overview of Fleet Maintenance and Operating Cost: Key Components and Methods*

5. Results and Conclusions

5.1 Results

The total maintenance and repair cost for ICETs and BETs are compared in table 3 below. This comparison highlights several factors influencing maintenance and repair costs across different truck categories.

Truck Category	Final MRC (₹ / km) / *(₹ / hr)		BET Advantage	Key Considerations
	ICET	BET		
14T Truck	**2.99**	**2.66**	⇩ **- 0.33 (11%)**	Battery Chemistry: LFP (4000 cycle life) Battery Capacity: 200 kWh for 14T and 300 kWh for 35T, 55T Trucks and 28T Tipper. Life of truck: 8 years Operations per annum: 14T Truck – 1,00,000 km 35T & 55T Truck – 80,000 km 28T Tipper – 3000 hours
35T Truck	**3.89**	**3.28**	⇩ **- 0.61 (16%)**	
55T Tractor	**2.89**	**2.28**	⇩ **- 0.61 (21%)**	
28T Tipper	**329**	**322**	⇩ **-6.69 (2%) -**	

Table 2: Final Maintenance and Repair Costs

BETs show cost savings across all studied segments: 14T Haulage (-11%), 35T Haulage (-16%), 55T Tractor (-21%), and 28T Tipper (-2%) when compared to ICE trucks. Key specifications like battery capacity, chemistry (LFP), life cycles (4,000), operational distances and energy consumption contribute to the maintenance and repair costs of BETs. The analysis, conducted over an 8-year truck lifespan, reveals how maintenance and repair dynamics shift with the adoption of BET technology, offering sustainability-focused advantages for many truck types.

5.2 Conclusions

While Battery Electric Trucks (BETs) present notable advantages in terms of reduced environmental impact and operational efficiency, their maintenance and repair costs require careful consideration. However, as technological advancements and economies of scale continue to drive down costs, BETs are poised to become more accessible and cost-effective. Ultimately, evaluating the long-term benefits against initial investments underscores their potential to redefine sustainable transportation.

- Cost of consumables for BETs is less than diesel ICETs, however, the cost of part replacement is higher for BETs. Initially, the approach to maintenance and repair for major BET components will have to be replacement-based. As technology matures and becomes more widely adopted, the emphasis will move from replacing components to repairing and optimizing them, leading to more cost-effective and sustainable maintenance practices.
- Major MRC for BETs is related to battery packs, and other HV electrical components costs account for the majority of electric truck maintenance expenses. However, this is expected to benefit BETs in the future, thanks to the establishment of a local supply chain and their increased mainstream adoption. Going forward MRC for BETs will come down due to mass production and localization.

Annexure: 1

Sample Calculation for 55 T Tractor Trailer

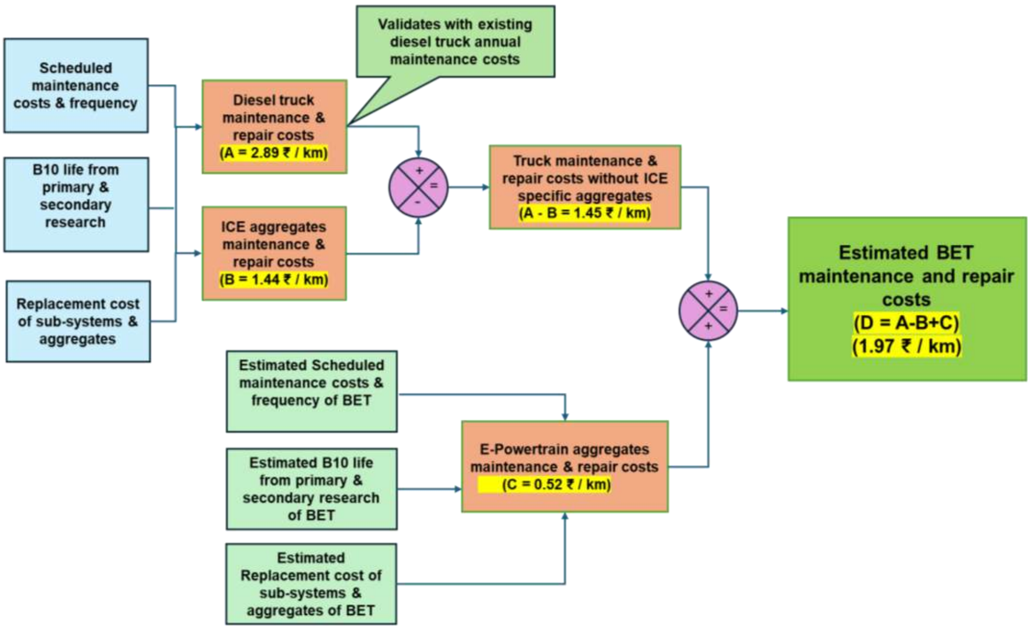

Figure 6: Maintenance and Repair Costs for 55T Tractor Trailer

Annexure: 2

Maintenance and Repair Cost assessment for BET Vs ICE truck comparison (excluding tyres)						
Sl. No.	Parameter	Units	14T Haulage	35T Haulage	55T Tractor	28T Tipper
1	Distance operated	km (hours) / annum	1,00,000	80,000	80,000	3,000
2	Life of truck for analysis	years	8	8	8	8
3	Total distance considered	km	8,00,000	6,40,000	6,40,000	24,000
4	Battery chemistry		LFP	LFP	LFP	LFP
5	Battery life	cycles	4,000	4,000	4,000	4,000
6	Battery capacity	kWh	200	300	300	300
7	Usable battery capacity @ 80% DOD	kWh	160	240	240	240
8	Average energy consumption considered	kWh / km (kWh / hr)	1.00	1.20	1.45	2.00
9	Battery life expected	km (hours)	6,40,000	8,00,000	6,62,069	19,200
10	Battery life expected	Years	6.40	10.00	8.28	6.40
11	Maintenance and repair cost of ICE truck	Rs. / km (Rs. / hr)	2.99	3.89	2.89	328.89
12	Maintenance and repair cost of BET	Rs. / km (Rs. / hr)	2.66	3.28	2.28	322.20
13	Cost increase (saving) at truck level	Rs.	-0.33	-0.61	-0.60	-6.69
14	Cost increase (saving) at truck level	%	-11%	-16%	-21%	-2%

	Input cells
	Cost increase
	Cost saving

Table 3: Estimated Maintenance and Repair Costs

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