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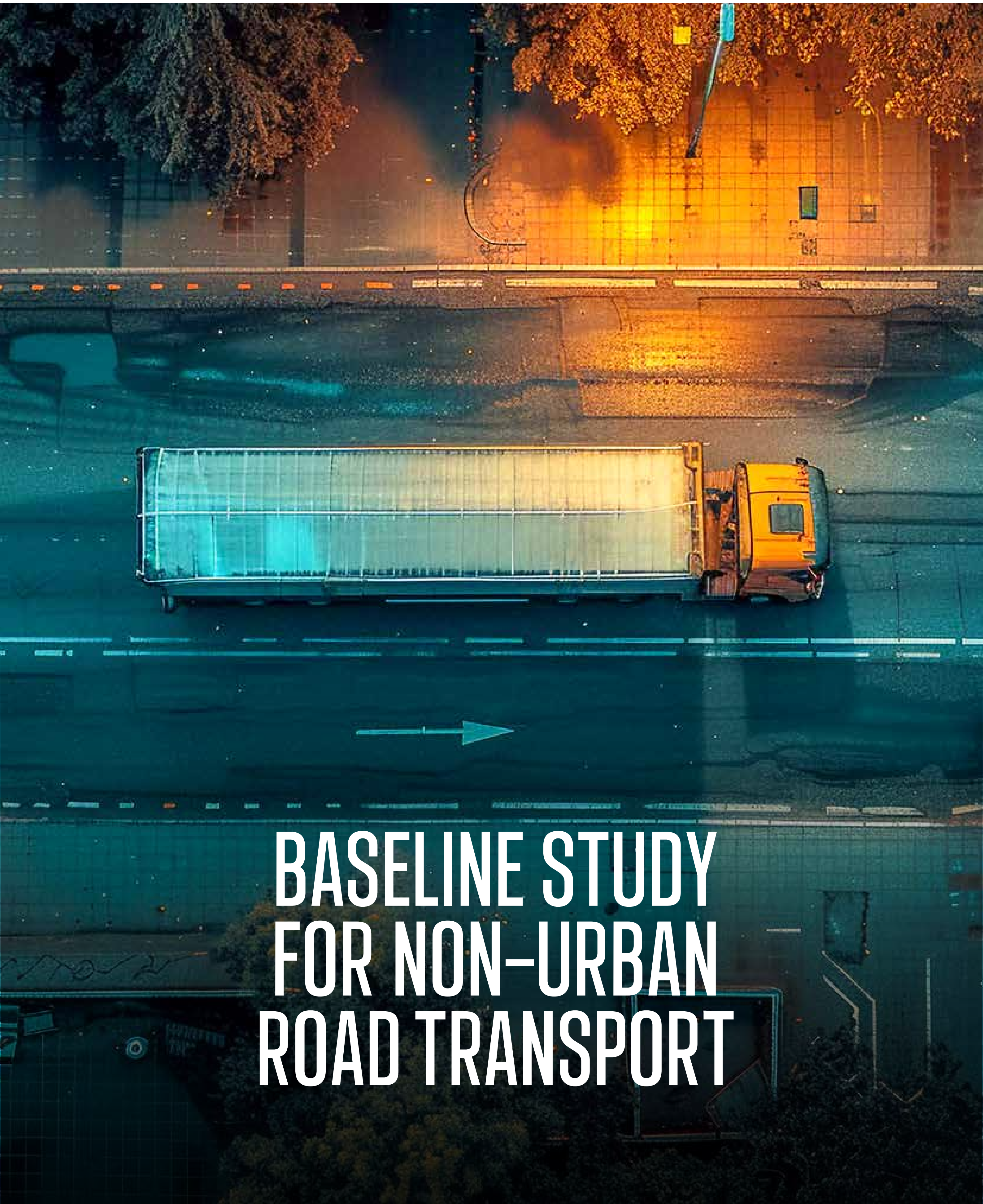

BASELINE STUDY FOR NON-URBAN ROAD TRANSPORT

Baseline Study for Non-Urban Road Transport

Prepared by:
Transport and Urban Governance Division,
The Energy and Resources Institute (TERI)

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Suggested citation: TERI. (2024). *Baseline Study for Non-Urban Road Transport*. The Energy and Resources Institute. New Delhi, India: TERI.

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Published by

The Energy and Resources Institute, 2024

THE ENERGY AND RESOURCES INSTITUTE
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Acknowledgements

TERI would like to extend its deepest gratitude to the sectoral experts for participating in the discussions and providing their valuable inputs during the course of this study under the project titled 'Baseline Study for Non-Urban Road Transport' in India.

We acknowledge the support of Mr Dinesh Gupta (Transport Research Wing, Ministry of Road Transport and Highways), and Mr Dinesh Kumar (Transport Research Wing, Ministry of Road Transport and Highways) for sparing their valuable time to share key insights on the topics that were helpful in shaping the report.

Our sincere thanks to Mr Abhishek A Gupta (All India Transporters Welfare Association), Mr Naveen Kumar Gupta (All India Motor Transport Congress), Mr Aviral Yadav (International Council on Clean Transportation) for their insightful contribution on the topic. TERI would like to express its gratitude to the Smart Freight Centre (SFC) for reviewing this report and providing their constructive feedback.

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List of Abbreviations

3PL	Third Party Logistics
ADB	Asian Development Bank
AIMTC	All India Motor Transport Congress
AIS	Automotive Indian Standard
AITWA	All India Transporters Welfare Association
ARAI	Automotive Research Association of India
BEE	Bureau of Energy Efficiency
BTKM	Billion Ton-Kilometers
CSFC	Constant Speed Fuel Consumption
DC	Designated Consumers
DEF	Distance-based Emission Factor
EU	European Union
FMCG	Fast Moving Consumer Goods
GHG	Greenhouse Gas
GLEC	Global Logistics Emission Council
GPS	Global Positioning System
GST	Goods and Services Tax
GVW	Gross Vehicular Weight
HDV	Heavy-Duty Vehicles
IEA	International Energy Agency
kmph	Kilometer per hour
LCV	Light Commercial Vehicles
MHDV	Medium and Heavy-Duty Vehicles
MoRTH	Ministry of Road Transport and Highways
MT	Million Ton
NTDPC	National Transport Development Policy Committee
OEM	Original Equipment Manufacturer
PAT	Perform, Achieve and Trade
PCRA	Petroleum Conservation Research Association
PLVB	Programa de Logística Verde Brasil
PPAC	Petroleum Planning and Analysis Cell
SEC	Specific Energy Consumption
SEF	Specific Emission Factor
SIAM	Society of Indian Automobile Manufacturers
TERI	The Energy and Resources Institute
TKM	Ton-Kilometer
TTW	Tank-to-wheel
UNFCCC	United Nations Framework Convention on Climate Change
WTW	Well-to-wheel
ZETs	Zero Emission Trucks

Glossary

Carrier	Any person, organization or government undertaking the transport of goods by road transport.
Common Carrier	Common Carrier denotes a person, other than the government, engaged in the business of transporting property under multimodal transport document or of transporting for hire property from place to place, by land or inland navigation, for all persons indiscrimately.
Consignee	Any person, organization or government which is entitled to take delivery of a consignment.
Consignor	Any person, organization or government who prepares a consignment for transport.
Distance-based emission factor (DEF)	DEF measures the amount of greenhouse gas emitted for every kilometer of payload movement.
Freight Forwarder	A person or organization who offers the service of arranging the transport of cargo.
Gross ton kilometer (GTKM)	It is a unit of measurement of the movement of one ton (including payload and curb weight of the vehicle) carried over one kilometer.
Gross Vehicular Weight (GVW)	GVW is the maximum load a vehicle can carry including the weight of the vehicle itself (curb weight).
Heavy-duty Vehicles	Vehicles with gross vehicular weight (GVW) greater than 12 tons.
Medium-duty Vehicles	Vehicles with gross vehicular weight in the range of 7.5 tons to 12 tons.
Net ton kilometer (NTKM)	It is a unit of measurement of the movement of one ton payload carried over a distance of one kilometer.
Payload	Payload is defined as the load which a vehicle can carry legally.
Shipper	Any person or a company responsible for organizing and transporting goods from one point to another.
Specific Emission Factor (SEF)	Specific Emission Factor (SEF) indicates the amount of GHG emission from moving 1 ton of payload by 1 kilometer.
Specific Energy Consumption (SEC)	SEC indicates the amount of energy involved with production process of any commodity or service.
Specific Fuel Consumption (SFC)	Amount of diesel and electricity consumed per volume (tons) of goods transported.
Tank-to-wheel (TTW)	TTW emission of a vehicle refers to a part in the entire energy chain that extends from the point where energy is absorbed (refuelling the tank) to its discharge point (movement of the vehicle, wheel).
Ton Kilometer (TKM)	It is a unit of measurement of the movement of 1 ton of payload over 1 kilometer.
Transport Companies	Truck companies are responsible for collecting, forwarding and distributing goods.
Truck Operators	Truck operators are responsible for the shipment from consignor to consignee, either by trucks owned by them or by hiring truck owners.
Well-to-wheel (WTW)	WTW emission of a vehicle assesses the emissions of GHG through the entire life-cycle of fuel used in a vehicle, from its extraction point (well) to the absorbption point (fuel tank) and finally to discharge point (movement of the vehicle).

01

INTRODUCTION: ROAD FREIGHT SECTOR

1.1 Background

Rapid rise in population and urbanization has resulted in an increased demand for transportation of goods and movement of passengers. As a result, the demand for energy from the transport sector has increased significantly over the years. Globally, the transport sector accounts for almost one-fourth of the world's total energy consumption and derives more than 90% of its final energy from oil (IEA, 2022).

With India crossing the 1.4 billion population mark in 2022, with an economy growing at an annual average rate of 6.8%[1] in the last 20 years, the transport sector has become the fastest growing end-use sector of energy. Currently, road freight accounts for over 70% of India's total freight (MoRTH, 2022). In India, road freight movement has increased by 5.8 times—0.47 trillion ton-kilometers (TTKM) in 1999–2000 to 2.69 TTKM in 2018-19 (MoRTH, 2021)—and it is projected to increase to 9.6 TTKM by the year 2050 (NITI Aayog, 2022).

A major factor contributing to increasing freight movement through road is the enhanced focus on road connectivity in India, particularly, development of world class national highways, and overhaul of transport infrastructure. India has witnessed a considerable expansion of roads and highways (an increase by 2.7 times) from 1990–91 to 2021–22 (MoRTH, 2022). The National Transport Development Policy Committee (NTDPC, 2014) projected that majority of freight traffic will continue to move via road in years to come.

[1] Estimated based on data sourced from National Accounts Statistics

Increasing road freight movement has resulted in increasing diesel consumption in India. In 2021 as per TERI estimate, there were approximately 5.5 million on-road heavy-duty vehicles (HDVs) in India (Qamar and Jamal, 2021), which entirely comprised of diesel engines. Currently, Indian transport sector accounts for approximately 50% of the total oil demand (IEA, 2021). Figure 1 highlights the end-use share of diesel consumption in India. HDVs and light-duty vehicles (LDVs) together consume approximately 55% of the total diesel sold through retail fuel stations and direct sales (PPAC, 2022). If we convert the percentage into absolute volume with respect to the total diesel consumption in India (76.6 million tonnes (MT))[2], HDVs and LDVs accounts for around 42.5 MT.

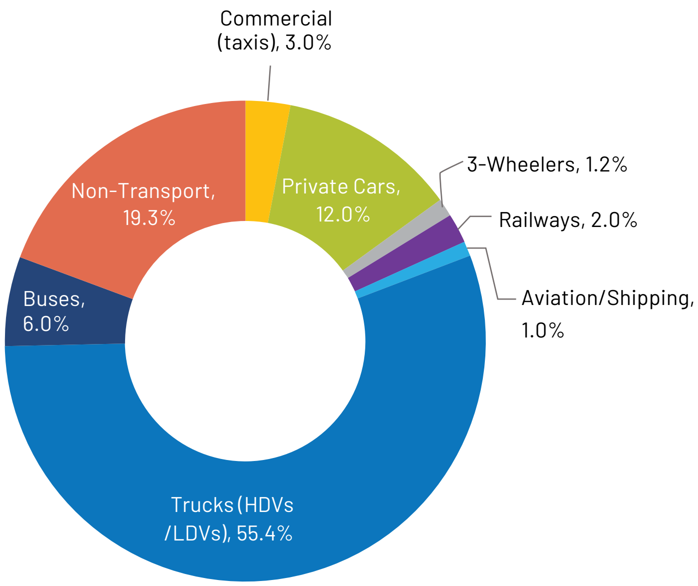


Figure 1: All India end-use diesel consumption (retail and direct)
*Note: Non-transport constitutes agriculture, power generation (gensets), industry, mobile towers, others.
Source: Petroleum Planning and Analysis Cell (PPAC)

Indian heavy-duty trucks consume more fuel per TKM as compared with other countries (NITI Aayog, 2022). More than 45% of the emissions from road transport in India is generated by the trucks (IEA, 2021). On account of projected increase in freight traffic, energy demand and GHG emissions from road freight transport are poised to rise further. Apparently, India's oil dependency is expected to increase from 84% in March 2019 to 93% by 2031, largely on account of the growth of HDVs (UNEP, 2015). Going forward, improvement in fuel efficiency and vehicle technology plays an important role in reducing the dependency on fossil fuels and mitigating overall emissions. NTDPC (2014) highlighted the need for devising policies related to energy efficiency in the road transport sector.

[2] Data sourced from Petroleum Planning and Analysis Cell (PPAC) for the year 2021-22

1.2 Objective of the study

As established in the background, fuel efficiency improvement is one of the important levers in the HDV sector, especially in a scenario where alternative low-carbon/zero emission technology is unavailable or inaccessible to vast majority. Examples could be drawn from other sectors within India where similar initiatives such as the Perform, Achieve and Trade (PAT) scheme, have already been taken, to conserve energy through efficiency improvement.

The key objectives of the study are as follows:

1. To establish requirements for a baseline study
2. To develop a methodology for identification of shippers and carriers, data collection, authentication, and management with respect to the study
3. Undertake data collection to establish a baseline
4. Authenticate the data collection, after ensuring quality checks; validate the findings for ensuring that they are fit for purpose
5. Provide inputs on policy design for a clean freight program

The aim of the report is to assess the non-urban HDV (goods) market in India and establish the importance of estimating baseline emissions for the long-distance road freight transport operators.[3] The report also discusses the Indian trucking sector with special reference to the global clean freight programs, followed by the challenges and opportunities associated with the sector. It further discusses the PAT scheme and key takeaways for the sector. Next, the report discusses the baseline data collection requirements for clean freight programs, followed by development of methodology for Indian road freight transport. Discussions on pilot survey data collection procedure and results are followed by policy recommendations.

1.3 Overview of the Indian trucking sector

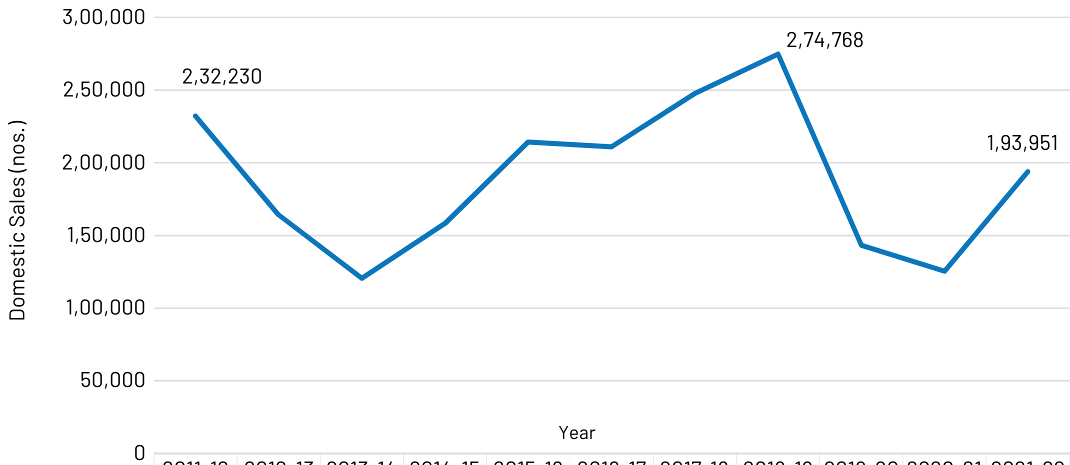
1.3.1 Heavy-duty vehicles (Goods) market

This section looks into the market trend, or the supply side of HDVs as these are largely deployed in the non-urban operations. In addition to this, projections for not only sale of HDVs and CO_2 emissions have been covered, but also analysis of the overall stock of HDVs currently on road as well as projected numbers for 2030 are included in the following sections.

[3] This report focusses only on goods HDVs. Therefore, passenger HDVs have not been considered in the analysis

Domestic sales

Figure 2 highlights the trend of HDV sales in India, based on automobile sales data (2011–12 to 2021–22). Domestic sales of HDVs have declined by 20% in the last decade (2011–12 to 2021–22). As compared to 2019–20, domestic sales of HDVs have increased by 35% in 2021-22. This shows a recovery after two years of slump in the industry following economic slowdown in 2019–20, followed by the COVID-19 pandemic in 2020-21.



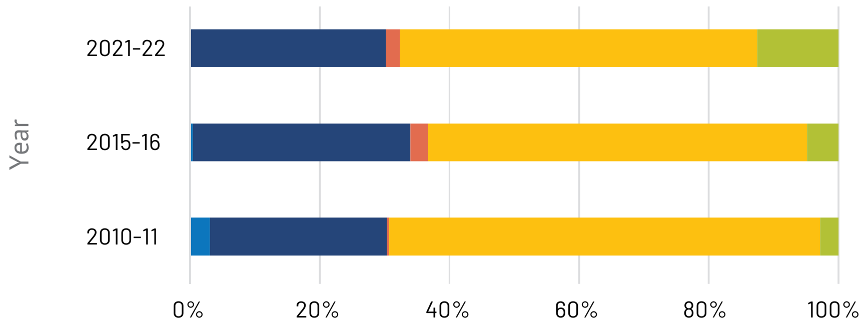
	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
HDVs	2,32,230	1,64,295	1,20,475	1,58,398	2,14,258	2,11,032	2,47,608	2,74,768	1,43,227	1,25,404	1,93,951

Figure 2: Year wise sale of HDVs in India

Source: Society of Indian Automobile Manufacturers (SIAM)

Major OEMs

Figure 3 depicts the market share of major original equipment manufacturers (OEMs) in HDV sales. Only 3 major OEMs account for more than 97% of the total share in HDV sales, these are: Tata Motors (55%), Ashok Leyland (30%), and VECVs-Volvo and Eicher (12%). Mahindra and Mahindra Ltd. accounts for 2% of the total share. It is evident that industry consolidation is more pronounced in India than other markets. Within HDVs, the share of rigid trucks is much higher in India than in any other country (IEA, 2017). These OEMs will play a major role in improving the overall efficiency of the trucking sector, thereby accelerating the decarbonisation of HDV sector.



	2010-11	2015-16	2021-22
AMW Motors	3.1%	0.4%	0.0%
Ashok Leyland Ltd	27.2%	33.6%	30.2%
Mahindra & Mahindra Ltd	0.4%	2.7%	2.2%
Tata Motors Ltd	66.4%	58.5%	55.1%
VECVs -Volvo and VECVs-Eicher	2.8%	4.8%	12.5%

Figure 3: Market share of OEMs in HDV sales
Source: SIAM

HDV sales projection

Based on annual sales and production data (for the year 2001–02 to 2021–22), domestic sales for goods HDVs have been forecasted till 2030–31. The end period values, highest achieved sales (corresponding to the year 2018–19) and the sales during 2020–21 are marked in the graph. These annual projections include two recent periods of slowdown in automobile sector:

(i) 2019–20 (biggest collapse in Indian automobile sector in last two decades),

(ii) 2020–21 (COVID-19 pandemic, first major lockdown).

Moreover, 2020–21 and 2021–22 also mark the disruption in global supply chain and chip shortage, which continues till date.

Figure 4 shows the projection of annual domestic sales of HDVs, which is expected to reach 2,53,094 by the year 2030–31. Based on TERI projection, Figure 5 highlights the estimated stock of HDVs and corresponding freight demand (in billion ton-kilometers, BTKM) by the year 2030–31. It is estimated that the stock of HDVs will reach 9 million contributing to about 3.3 TTKMs, by the year 2030–31. Sharp increase in the stock of HDVs and BTKM numbers will have an impact on CO_2 emissions in the business-as-usual (BAU) scenario.

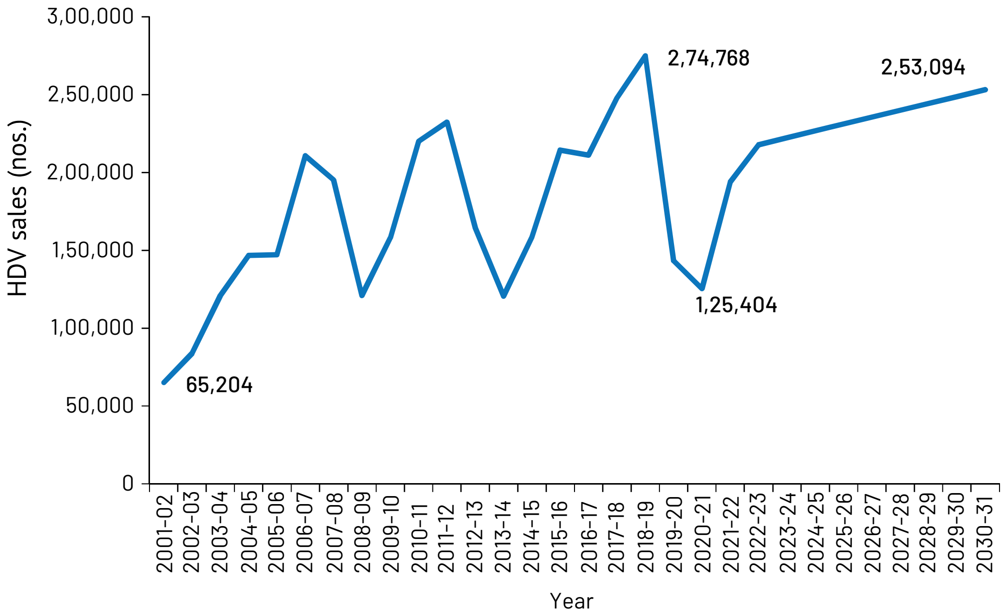


Figure 4: HDV sales projection

**Note: The estimates for 2022-23 to 2030-31 are based on linear projections. The fluctuations in actual sales will mimic the fluctuations in economic activity in the country.*

Source: SIAM Statistical Profiles and Factsheets (2001-02 to 2021-22), TERI projection (2022-23 onwards)

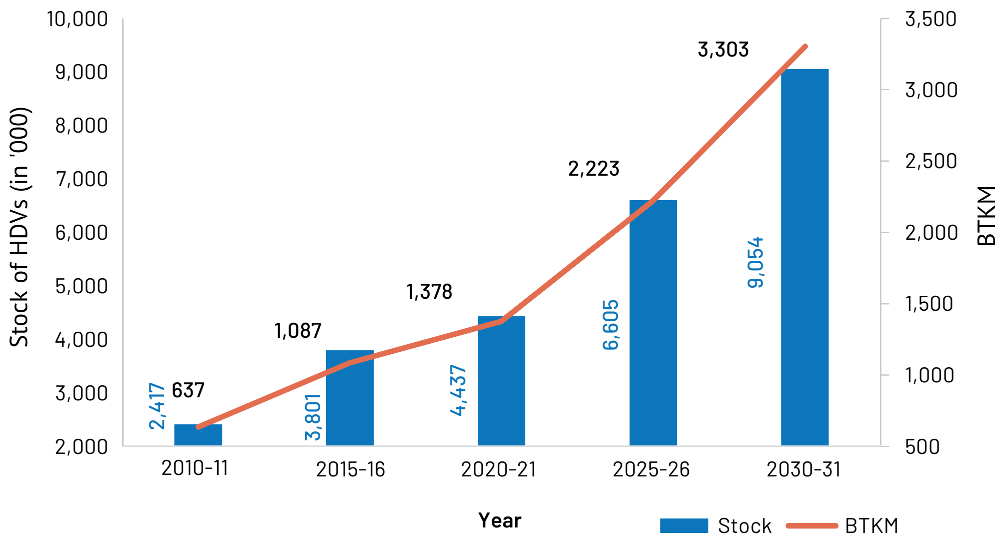


Figure 5: Projected stock of HDVs

Source: TERI Analysis based on data sourced from MoRTH

CO_2 emissions from HDVs

CO_2 emissions from HDVs (2010–11 to 2030–31) have been highlighted in Figure 6. It is evident that CO_2 emissions are projected to more than double from 70.9 million tons of CO_2 ($MTCO_2$) in 2020–21 to 149.7 $MTCO_2$ in 2030–31.

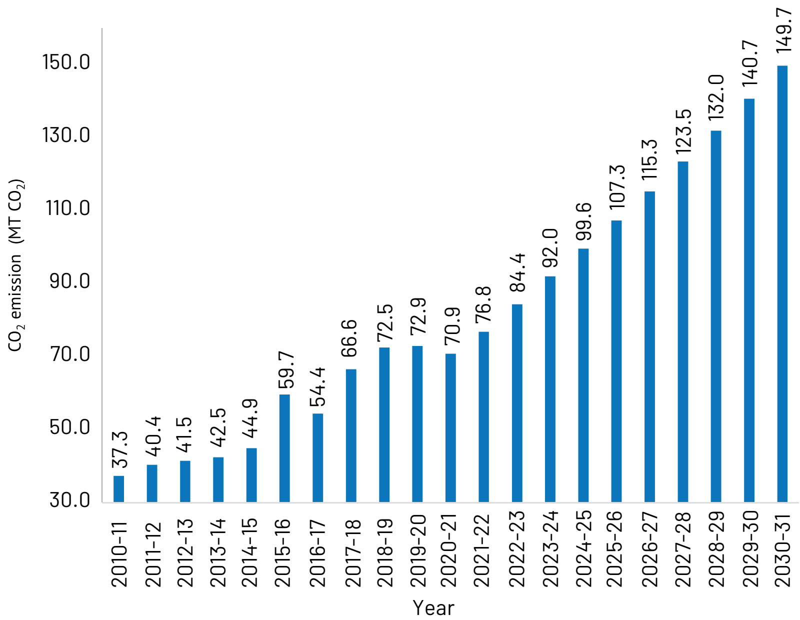


Figure 6: CO_2 emissions from HDVs

**Note: Projections represent business-as-usual scenario without any policy intervention*

Source: TERI

Existing market by emission norms

As per Vahan Database, there are 5.5 million HDVs on Indian roads[4], majorly dominated by diesel (98%), with petrol and compressed natural gas (CNG) having a miniscule share (1%). Figure 7 shows the break-up of HDVs across various emission norms (Bharat Stage standards/EURO). For approximately 40% of the total registrations, data for emissions norms is not available in the Vahan database. It is evident that a major proportion of the HDV fleet is BS-III, or older. Only 10% of the fleet is BS VI compliant.

If 'Not Available' category is dropped, then share of BS VI increases to 16%. However, 58% of the fleet is older than BS III. In both the cases, most significant ways to reduce emissions is to upgrade the existing fleet to newer vehicles—compliant with latest emission norms.

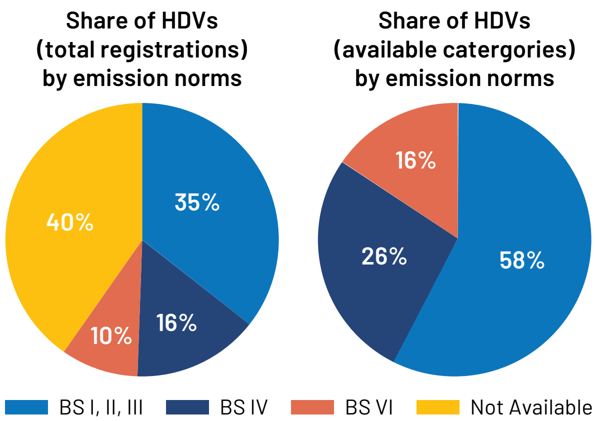


Figure 7: Classification of HDVs by emission norms

** Note: It is likely that the data under 'Not Available' category pertains to vehicles with older emission norms.*

Source: Vahan Dashboard

[4] Cumulative registrations till 30th March 2023.

1.3.2. Indian trucking sector

The Ministry of Road Transport and Highways (MoRTH) is the nodal agency dedicated to the overall road transport sector, which includes construction and maintenance of national highways and other key roads, and operations of the motor vehicles. However, there is no specific regulatory authority for the development and management of the trucking sector. There are various trucking associations in India, such as All India Transporters Welfare Association (AITWA), All India Motor Transport Congress (AIMTC), etc., that are involved with social welfare of truckers, and provisioning of- knowledge about best practices and standards; and roadside facilities (including legal assistance) among the member truck operators/organizations.

The Indian trucking sector consists of various stakeholders such as freight forwarders, truck operators, brokers, financial agencies (banking and non-banking lenders), OEMs, and users. Figure 8 highlights the key stakeholders involved in the trucking business, from both demand and supply sides. A user generates demand as per the need.

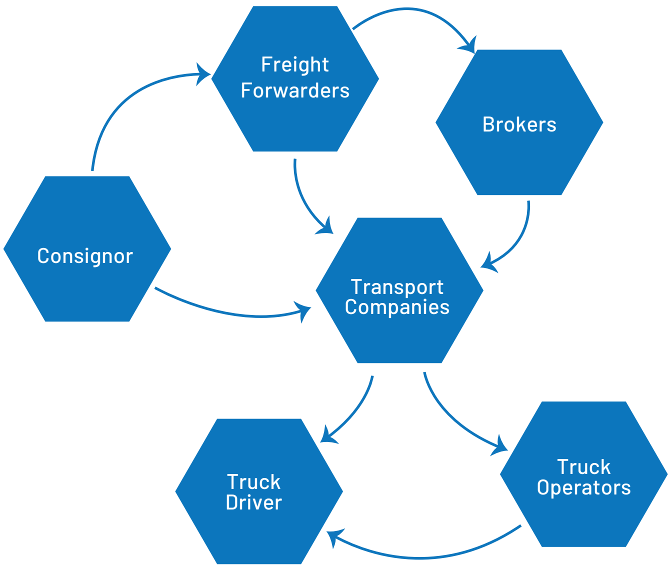


Figure 8: Stakeholders involved in the trucking business

Source: TERI

Transport companies are responsible for collecting, forwarding, and distributing goods. These companies raise business and coordinate with truck owners through intermediaries for availability of trucks. The intermediaries are termed as brokers who provide business to the truck owners. Therefore, a truck owner and operator has to depend on brokers for getting business. OEMs are involved in the manufacturing of either the entire truck or the chassis, the latter allowing a truck owner to get the customized body built as per the market needs. The dimensions of the truck body are governed by the Motor Vehicles Act, 1988 (amendment of 2019) to ensure safety and quality.

The truck driver is one of the main stakeholders involved in the trucking sector as his/her driving habits impact fuel efficiency. Trucks in India are mostly driven by a set of family members, or hired drivers (Raghuram G, 2015). The role of a truck driver in India is very challenging due to long working hours, geographic and weather variation, extreme road conditions, and poor roadside civic amenities.

In terms of trucking operation, a truck owner is associated with multiple stakeholders involving OEMs, financial institutions, insurance companies, after-market customization workshops, and various trucking associations. Figure 9 indicates the stakeholders involved in trucking operations.

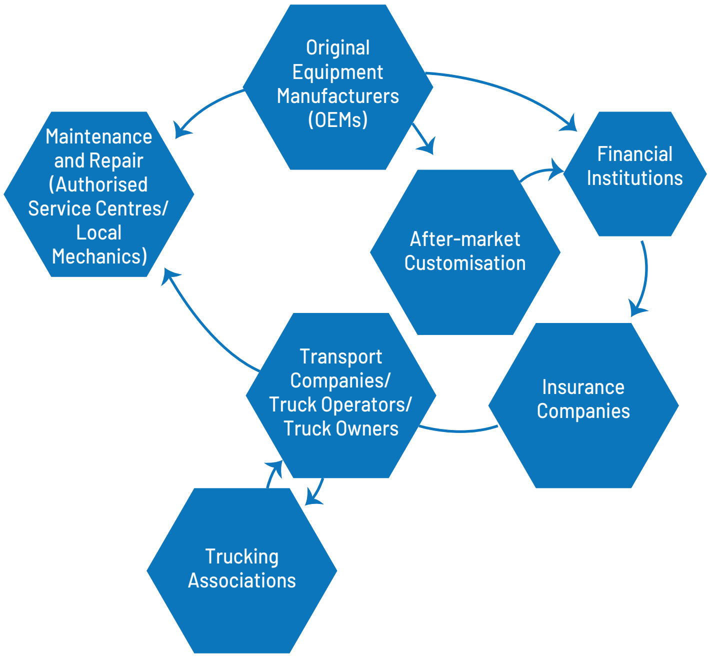


Figure 9: Stakeholders involved in trucking operations

Source: TERI

Fleet organizations in the literature (CIRT,1998) are generally classified into three major categories based on the fleet size:

1. **Small Fleet Owners:** Own 1 to 5 trucks
2. **Medium Fleet Owners:** Own 6 to 20 trucks
3. **Large Fleet Owners:** Own more than 20 trucks

Over the last few decades, the ownership profile of trucks in India has changed. Figure 10 indicates the change in ownership profile from 1980s to 2022. It is evident that the share of small fleet owners has reduced from 95% in 1980 to 65% in 2022, indicating consolidation of the market. Though the share of large fleet owners has mostly remained the same, restructuring of the market has largely been due to the growth of medium fleet owners over time.

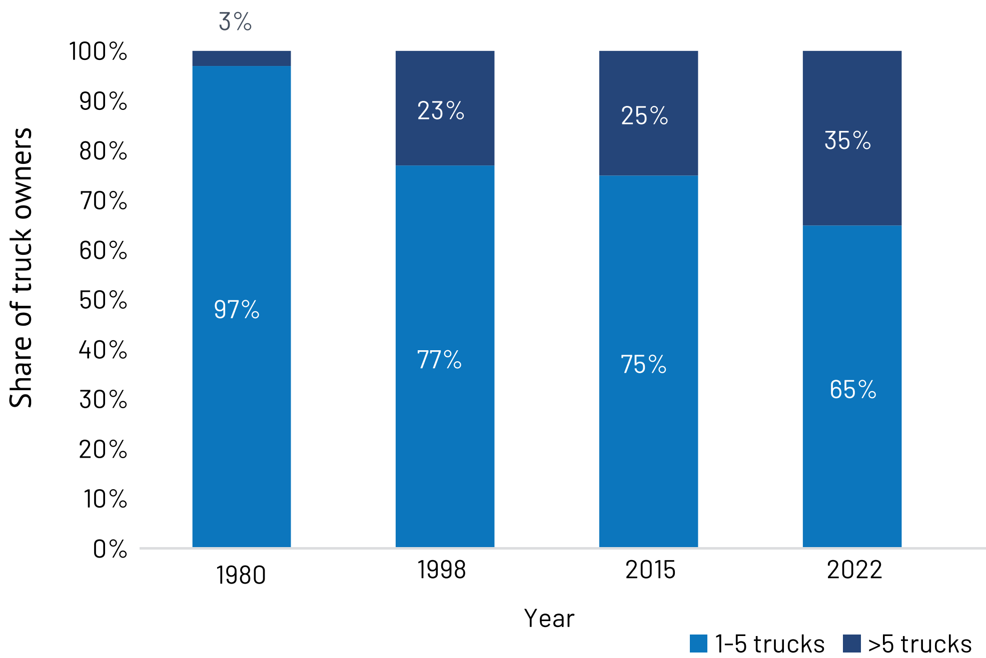


Figure 10: Ownership profile of trucks in India

**Note: Data available for the corresponding years only*

Source: NTDC, 1980; CIRT, 1998; Raghuram, 2015; TERI, 2022

There are three different business models in Indian trucking business: owned, leased, and third-party logistics (3PL).

Financing for the purchase of new trucks is available through non-banking financial institutions (NBFCs), for e.g., TCI Finance Ltd, Tata Capital, Shriram Transport Finance Ltd, etc. Figure 11 shows the existing business models in Indian trucking sector. The role of brokers is eliminated in case of **continuous business** (commodities like automobile, cement, industrial goods). However, in case of **intermittent business** (general goods, etc.), brokers are involved in price fixation in the local market.

After a demand is raised for freight shipment, transporters co-ordinate with truck owners through brokers. These brokers operate on commission-basis and generally set the price for a specific load. Small fleet owners charge a lump-sum amount based on the load, whereas large fleet owners charge rates on a per-ton basis. For business, small fleet owners either depend on brokers, or on large fleet owners on a demand basis. Except for the huge capital cost, there is no regulatory entry barrier for this sector; making it highly competitive.

Large fleet operators maintain long-term contracts with big companies, which protect them from the risks of uncertainty in fuel prices and other market risks. Industrial and consumer goods are majorly transported by large fleet operators. Big companies revise the rates for their transporters on a monthly basis to tackle any change in fuel or toll price.

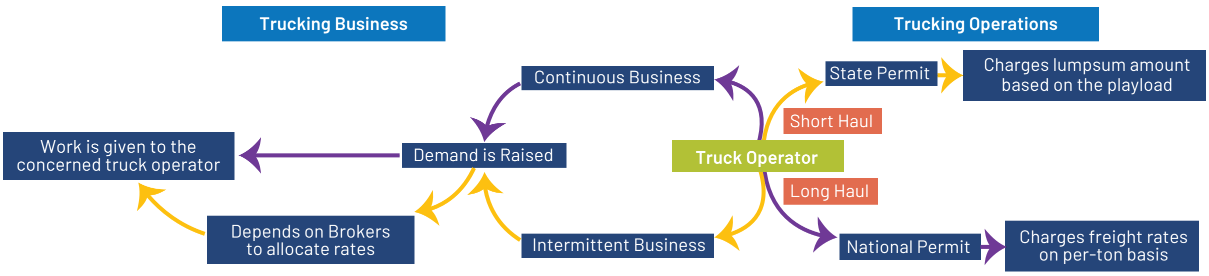


Figure 11: Existing business models in India

Source: TERI

1.3.3 Key studies on Indian Trucking sector

Table 1 highlights the relevant literature related to Indian trucking sector.

Table 1: Relevant studies for Indian trucking industry

S. No.	Title	Authors & Year of Study	Key-takeaways
1	Indian Trucking	Asian Institute of Transport Development (AITD), 2000	This study highlighted the issue of serious data gaps in Indian trucking sector in terms of ownership pattern, age profile, nature of operations and fleet utilization. It defines the role of different stakeholders involved in the trucking sector. In the year 2000, Indian trucking sector was a conglomeration of large number of small-scale operators rather than being an organized sector. The opportunities for employment were in the areas of haulage, manufacturing and maintenance of vehicles. Authors recommended that efforts should be made towards fleet formation and exploring new functions rather than haulage only. The regulations need to be reoriented. The trucking sector lacks technology.
2	Competition Issues in the Road Goods Transport Industry in India with Special Reference to The Mumbai Metropolitan Region	S. Sriraman, 2006	This study focused on Road Goods Transport Industry (RGTI) in India. Extensive interviews with truck operators, brokers, booking agents, users were conducted in the Mumbai Metropolitan Region, Goa and Satara. It was found that market segmentation has led to more powers in the hands of intermediaries. Trucking operations were classified into three parts: National operations, route based operations (inter-regional and intra-regional), local operation. Factors such as capacity utilization, number of trips, fuel prices and other operating costs affects the profitability of a truck operator. Indian trucking market is unorganized due to lower capital requirement, ease of obtaining trucking driving licenses and permits, low mental skills as compared to physical abilities and easy availability of freight. The issue of overloading was also studied and it was found that there is a tendency on the part of truck operators and consignors to overload the vehicles without regard to the law. This study recommended that the state governments should be encouraged to carry out competition audit of existing regulations especially those providing for the present system of checkpoints administered by the states and involve a number of agencies (which resulted in restrictions on smooth flow of commodities, the fiscal regime, etc.) to determine the need for their continuation.

S. No.	Title	Authors & Year of Study	Key-takeaways
3	The Impacts of India's Diesel Price Reforms on the Trucking Industry	Integrated Research and Action for Development, 2013	This study was undertaken to understand the vulnerability of the trucking sector to diesel prices and the coping mechanisms that could be used to reduce this vulnerability. Freight rates were compared for various countries. The operational efficiency of trucking sector is affected by road conditions, vehicle damage, unnecessary delays at check posts/ state borders. There are no entry barriers to the trucking sector. Motor Vehicle Act does not include minimum requirements for education, training or finance to enter the trucking business. Issues such as overloading reduces efficiency in the long run and leads to higher diesel consumption. About 75% of Indian trucks were two-axle with a capacity of nine tons, with average operational life of 20 years. The Indian trucking sector is extremely competitive, with low profit margins. The study recommended supporting measures to reduce vulnerability of Indian trucking market such as fixing minimum freight rates and reducing waiting times at tollgates.
4	Operational Efficiency of Freight Transportation by Road in India	Transport Corporation of India (TCI), IIM Calcutta, 2014-15	This study recommended that the government should simplify and standardize rules and regulations across different modes of transportation to facilitate multi-modal transportation. It was also highlighted that the government needs to ensure that truckers replace their old, fuel inefficient vehicles with fuel efficient vehicles. For achieving this, Government may ensure this either forcefully by law or through financial incentives such as subsidies, soft loans, tax benefits, etc. A survey was carried out on 28 major routes, to estimate the operational costs of a 9-15 ton truck. Co-relating it with an earlier survey resulted that the average journey time and vehicle speed has improved across major routes. It was observed that 22 out of 30 trips actually incur 'losses' when overhead costs were included. The fuel efficiency in terms of mileage of vehicles remained almost unchanged. Government should create an apex regulatory body, such as Multi-modal transport regulatory authority of India, to coordinate among the various ministries

S. No.	Title	Authors & Year of Study	Key-takeaways
5	Stakeholder Perception on Heavy Duty Vehicle (HDV) Fuel Efficiency	The Energy and Resources Institute (TERI), 2015	This study incorporated green trucks toolkit developed by Asian Development Bank. It highlighted the importance of efficient driving habits in improving fuel efficiency of HDVs. Interviews and surveys were conducted in 2015. It revealed that for small fleet organisations, most important point of consideration is the purchase price of the vehicles. Due to capital constraints, a very limited number of truck models are popular among small fleet owners, based on low acquisition costs, low maintenance, better fuel efficiency. Small fleet owners do not prefer workshops that are authorised by the OEMs, as they are more expensive as compared to local, non-OEM service station. Large fleet owners are more likely to follow the maintenance schedules as suggested by the OEMs. This study recommended that India can begin a tire labelling system to regulate the quality of tires in the market. A suitable vehicle simulation tool should be developed. Most of the truck fleet owners in India lack awareness, therefore, they cannot carry out the cost-benefit analysis of various technologies available in the market. A green freight program in India will assist fleet owners, shippers, and other stakeholders to make well-informed decisions about technologies and operational strategies for saving fuel.
6	An Overview of the Trucking Sector in India: Significance and Structure	G Raghuram, 2015	This study was conducted to understand the overview of trucking sector in India. Based on IISD, 2013 data, the sector was dominated by small fleet owners (owning 1-5 trucks) with 75% share, followed by medium fleet owners (6 to 20 trucks) with 15% share and large fleet operators with 10% share. It describes the stakeholders involved in the trucking sector along-with their key-roles and responsibilities. The dynamic competition in this sector is cost based rather than service based. Author devised a 'five S' framework to improve the overall efficiency of trucking sector: speed, sustainability, safety, security, and stresslessness.

S. No.	Title	Authors & Year of Study	Key-takeaways
7	Transforming Trucking in India	NITI Aayog, RMI, 2022	This study projected the trucks plying on Indian roads to quadruple, from 4 million in 2022 to 17 million trucks by 2050. It also highlighted the cost competitiveness of zero emission trucks (ZETs) as compared to internal combustion engine trucks. ZETs adoption can lower associated fuel costs by 46% over the vehicles lifetime, leading to a 17% savings in logistics costs, which in turn can benefit consumers by reducing the cost of end goods and commodities. ZET adoption can help India achieve its net zero goal by 2070. Therefore, by leveraging policies, financing, and domestic R&D investments, India can become a ZET hub. To drive ZET market growth, following factors will be important: 1. Policies that help drive first mover ZET adoption 2. Development of Charging infrastructure 3. Scaled manufacturing investment and greater ZET supply 4. Mobilisation of ZET financing to scale growth Adoption of ZETs will produce substantial economic, energy security, and emissions benefits for India. There is a need to expand EV policies (demand and supply-side both) to accelerate truck electrification.

Source: TERI

1.3.4. Challenges and Opportunities

It has been observed that the average speed of trucks in India is 30-40 kmph, approximately half as compared to global standard of 60-80 kmph (NSDC, 2013). Further, on an average, an Indian truck covers 300-325 kms per day, half as compared to the global standard of 600-800 kms (NSDC, 2013). The Indian trucking sector faces diverse challenges, which directly or indirectly impact the overall efficiency and emissions. Some of these are listed below:

01

Absence of a regulator: There is no regulatory body governing the trucking sector. This allows any individual entity/organization to enter the trucking business with/without any prior experience, provided that they meet the costs associated with the ownership and maintenance of trucks. This leads to a competitive market; thus, reducing the profitability of the operators. Though, it is easy to enter the market, exit is relatively hard due to high cost of investment in the assets (trucks).

02

Lack of information/Poor record keeping: Small fleet operators do not maintain a proper record on the performance and maintenance of their fleet. Therefore, it becomes very difficult to initiate data collection from them for any efficiency assessment.

03

Idling of vehicles: Delays at check-posts by Regional Transport Offices (RTOs), toll plazas, etc., increases the idling time; thus, increasing the fuel consumption and emissions. Further, idling leads to mechanical degradation of engine parts, resulting in higher costs of overall operations.

04

Uncertainty in fuel price: Fuel costs are approximately 65%[5] of the total cost of transportation. The dynamism in the fuel price affects the profit margin of fleet operators vis-à-vis truck rentals. During February 2021, diesel prices were hiked sixteen times (cumulatively INR 4.1/liter), which led to an increase of 8-10%[6] (as compared to January 2021) in the truck rentals. However, changes in freight rates are not commensurate with the dynamism in fuel prices, resulting in low/reduced margins for truck operators, thereby leading to lower adoption of fuel efficiency improvement solutions.

05

Low engine-to-weight ratio: In India, low engine-to-weight ratios of HDVs lead to lower speeds of trucks (Sharpe, 2015). Studies suggest that the Indian truck fleet has historically been small in size and under-powered as compared to the freight that it moves (Sharpe, 2015). Apart from this, overloading increases with the density of payload, which adversely impacts the performance of the vehicles and brings down the fuel efficiency.

Given the backdrop of the challenges faced by the trucking sector in India, there are several opportunities that need to be highlighted. These opportunities include reduction in logistics costs, automation, driver training programs, etc. India's transport sector consists of a significant number of HDVs mostly using diesel as fuel, showcasing the potential for energy and fuel savings from adoption of alternative fuel vehicles. Also, there are various opportunities to increase the fuel efficiency of HDVs such as eco-driving, reduction in idling (either manually or through technological interventions), improved maintenance practices, usage of low resistance tires, etc. Measures such as freight aggregation, multi-modal logistics park near urban and industrial centers could be encouraged to shift greater shares of freight onto bigger and efficient trucks, leading to reduction in emissions from trucks operating on highways.

[5] Based on the consultation with AITWA
[6] Data sourced from Indian Foundation of Transport Research and Training (IFTRT)

Major opportunities for the sector are listed below:

01

Driver training: A skilled driver with an efficient driving habit saves more fuel as compared to an unskilled driver—in comparison to other interventions such as preventive maintenance, or fuel-saving technologies. According to the Petroleum Conservation Research Association (PCRA), a good driving style may save fuel consumption up to 20%. Large shippers can conduct driver training programs for their associated carriers in order to increase the overall fuel efficiency of the fleet. In India, driver training programs should be encouraged (specially for small fleet owners). These could be in-accordance with similar driver training program conducted by PCRA for buses. Fleet organizations, MoRTH, and state transport departments can collaborate for conducting such programs.

02

Shifting to larger trucks and aggregation: Moving freight on trucks with higher capacities and aggregation of freight will result in making the operations more efficient. Sharing of assets will help in reducing the 'turn around' time of the vehicles. Different organizations can collaborate to use these assets, thereby, increasing the utilization of trucks. The major challenges of finding return load could be minimized by this collaborative effort, where organizations can post their loads/trucks. There are online portals such as CargoExchange, Vahak, WheelsEye, etc., which are working towards increasing the penetration of shared assets in Indian market, reducing empty running and carbon emissions.

03

Use of Internet of Things (IoT) and Artificial Intelligence (AI) devices: Utilizing IoT/AI devices assists in real time location tracking, route optimization, driver safety monitoring, etc. AI-based Advanced Driver Assistance Systems (ADAS) helps in collision avoidance and driver monitoring. Therefore, on-board telematics system could be utilized for better efficiency and data management, allowing truck companies to manage their fleet efficiently.

04

Implementation of fuel efficiency norms: Implementation of stringent fuel efficiency norms has the potential to significantly improve the fuel efficiency level, resulting in lower energy consumption and lower CO_2 emissions.

05

Scrapping end-of life HDVs: The HDV market is dominated by BS-III or older fleet (see Figure 7). Therefore, old HDVs need to be scrapped/ phased out in a planned manner. Currently, a few countries such as Japan, Korea, China, and the European Union (EU) have dedicated legislation for managing end of life vehicles (ELVs). MoRTH vide Central Motor Vehicles (24th Amendment) Rules, 2021 has fixed up to 15% concession in the motor vehicle tax for a transport vehicle against the submission of 'Certificate of Deposit', effective from April 2022. The government may consider provision of incentives for scrapping old HDVs and purchasing new fleet (including vehicles using alternative fuels).

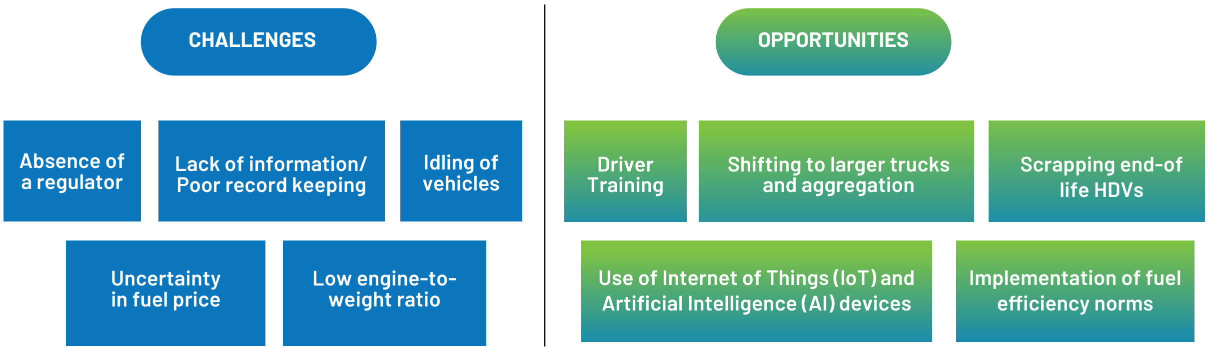


Figure 12: Challenges and opportunities in the trucking sector

Source: TERI

1.4 Current Policy Environment: Clean Freight

This section reviews international clean freight programs as well as India-specific policies applicable to the road freight sector. Globally, many countries have developed clean/green freight programs—where logistics companies and fleet organizations are encouraged to pursue more environment friendly operations, which in turn increases the overall efficiency of the truck operation. In India, a clean freight program is yet to be implemented. However, recently introduced policies, such as the National Logistics Policy 2022, and fuel economy standards in April 2023, aim to increase the overall efficiency of the logistics sector.

1.4.1. Global best practices: Clean freight programs

The clean freight programs collect data, such as fleet characteristics, ownership details, volume of cargo handled, distance travelled, fuel consumption, idling time, etc. These programs are either led by industry or by the government.

Based on the nature of clean freight programs, these could be categorized into three major types:

01

Partnership programs: Freight carriers and implementing agencies sign an agreement to achieve specific targets for reducing overall emissions. One such program is the SmartWay Transport Partnership implemented in the USA and Canada.

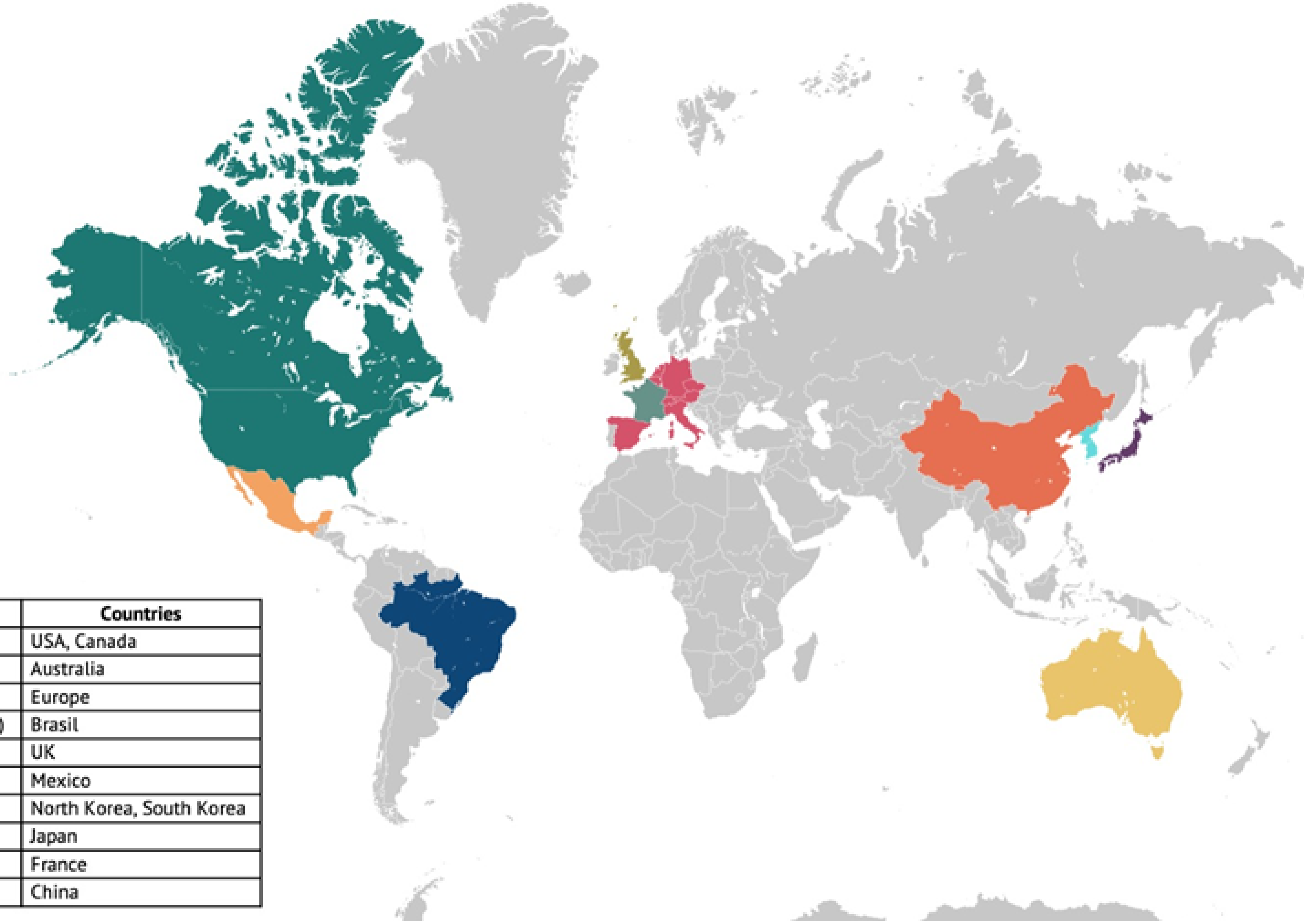
02

Industry-led voluntary programs: Freight carriers submit their sustainability targets to the program management and design action plans to achieve those targets. When the action plan is completed, accreditation is done by the program. Industry-led voluntary programs have been implemented in various countries and regions, such as Brazil (Programa de Logística Verde Brasil, or PLVB), Europe (Lean and Green).

03

Government-led voluntary programs: Under these programs, the government institutions/ministries associated with the program set targets for freight carriers. Government-led voluntary programs have been implemented in various countries such as China (China Green Freight Initiatives), and the UK (EcoStars Fleet Recognition).

Global clean freight programs have been mapped in Figure 13. Out of these, six programs from developed and developing countries are compared on the basis of different parameters as indicated in Table 2.



Legend	Clean Freight Programs	Countries
	SmartWay Transport Partnership	USA, Canada
	EcoStation	Australia
	Lean and Green	Europe
	Programa de Logistica Verde Brasil (PLVB)	Brasil
	EcoStars Fleet Recognition	UK
	Transporte Limpio	Mexico
	Green and Smart Transport Partnership	North Korea, South Korea
	Green Logistics Partnership	Japan
	Objectif CO_2, FRET 21	France
	China Green Freight Initiative	China

Figure 13: International clean freight programs

Source: TERI (map not to scale)

Table 2: Comparative assessment of international clean freight programs

Program	SmartWay	EcoStars Fleet Recognition	China Green Freight Initiatives	Objectif CO_2	Lean and Green	PLVB
Countries/ Regions	USA, Canada	UK	China	France	Europe	Brazil
Inception year	2004	2009	2012	2008	2007	2016
Voluntary/ Mandatory	Voluntary	Voluntary	Voluntary	Voluntary	Voluntary	Voluntary
Government-led/Industry-led	Government-led (Partnership)	Government-led	Government-led	Government-led	Industry-led	Industry-led
Agencies involved	• US EPA • NR Canada	• Transport Research Laboratory (TRL)	• Central Road Transport Association (CRTA) • Ministry of Transport • Research Institute of Highways (RIOH) • Clean Air Asia (CAA)	• Ministry of Ecological Transition • ADME (French agency for ecological transition) • Other transport organizations	• Connekt GS1 • Flanders institute for logistics • Cluster for logistics Luxemburg, • Freight Leaders Council, Italy	• PLVB academy • Logistics service providers • Carriers
Target sectors	All freight transport	Road freight	Road freight	Road freight	All freight transport	All freight transport
Member organisations involved	• Shippers • Freight carriers • Logistic companies	• Commercial fleet operators	• Freight carriers • Logistic companies	• Freight carriers	• Shippers • Carriers • Logistics service providers • Ports	• Shippers • Carriers • Logistics service providers
More than 100 members (Yes: >100 members, No: <100 members)	Yes	Yes	No	Yes	Yes	No
Phased implementation (Yes/No)	Yes	Yes	Yes	Yes	Yes	Yes
Measurement, Reporting & Verification	Logistic companies report their data to EPA through SmartWay truck tool[7] (accessible to members only), EPA reviews it	TRL collects qualitative and quantitative data related to fleet operations from members	Logistic companies are encouraged to meet the requirements for green trucking	Voluntary charter to reduce CO_2 emissions	It allows members to include any measures in their Action Plan to reach their reduction targets, covering vehicles/vessels, fleet movement, modal shift fuels	Member organisations measure, report, and verify their data
Ratings of member companies	Star ratings	Star ratings	Green leaf ratings	Star ratings	Star ratings	Star ratings
Methodology used	▪ Fleet Logistics Energy and Environment Tracking (FLEET) model	▪ Programs emission toolkit	▪ China freight enterprise standard ▪ China freight vehicle standard	▪ Web based tool (in-line with French Grenelle law)[8]	▪ GLEC Framework[9] ▪ EN 16258[10]	▪ Greenhouse Gas Protocol ▪ ISO 14064-1[11] ▪ EN 16258
Membership fee	No membership fee	No membership fee	No membership fee	Annual membership fee	Annual membership fee	Annual membership fee

Source: TERI Analysis

[7] https://www.epa.gov/smartway/smartway-truck-carrier-partner-resources
[8] Grenelle law mandates companies to include information on their environmental and social performance in their annual reports
[9] https://www.smartfreightcentre.org/en/how-to-implement-items/what-is-glec-framework/58/
[10] https://www.en-standard.eu/din-en-16258-methodology-for-calculation-and-declaration-of-energy-consumption-and-ghg-emissions-of-transport-services-freight-and-passengers/
[11] https://www.iso.org/standard/66453.html

Key-takeaways for India

Worldwide, clean freight programs are voluntary in nature (without any direct financial support); therefore, the role of freight carriers is crucial in the implementation of such programs. Successful programs, however, also have regulatory aspects in their approaches. These programs share standard data collection and performance benchmarking tools for measuring and reporting emissions with the active participation of the private sector. The member organizations commit to benchmarking, monitoring and reporting information, and taking specific verifiable actions. These programs provide consistent branding, strong initiatives for outreach, marketing to core stakeholder groups, and recognition events for leveraging financial support. In the Indian context, a centralized program administered by a central agency will be more beneficial.

Different clean freight programs use different methodologies. The SmartWay Transport program uses region-specific methods; while the European standard methodology (EN 16258) calculates energy consumption and GHG emissions (in CO_2e)[12] related to freight and passenger transport services. This methodology can be used for all modes of transport and includes empty trips and reporting is done on both Tank-to-wheel (TTW) and Well-to-wheel (WTW) basis. EN 16258 is presently in use by Lean and Green (Europe) as well as PLVB (Brazil).

While regulatory approaches are mostly used for new vehicles, voluntary approaches are used for addressing existing vehicles. Globally, clean freight programs have been implemented in a phased manner, with a tentative eligibility criteria of fleet size for becoming a member organization. For a similar program in India, a phased implementation starting with large fleet operators can be designed. These operators generally have greater access to capital and can be more responsive to any voluntary approach.

1.4.1.1 Data collection process

It becomes imperative to investigate the data collection processes involved with international clean freight programs; these are showcased below.

Partnership programs

Freight carriers and implementing agency sign a partnership agreement with terms and conditions. In the partnership programs, member organizations receive their program tools, add detailed data, and calculate the performance metrics for its associated fleets. The review of carrier tool is done by management companies. Similarly, the data fed by the organizations is reviewed and approved by the program management. Carrier performance information is grouped into pre-determined categories within the database for comparison. The database generates a file containing the carrier performance information. Tools calculate the companies' emissions footprint and the percentage of their carriers that are in the program. Depending on program goals, predefined performance levels may be set to qualify for a superior designation. Figure 14 shows the steps involved in data collection for partnership programs.

[12] CO_2 equivalent (CO_2e)"… is a unit for comparing the radiative forcing of a GHG to carbon dioxide. It is calculated using the mass of a given GHG multiplied by its global warming potential." (EN 16258)

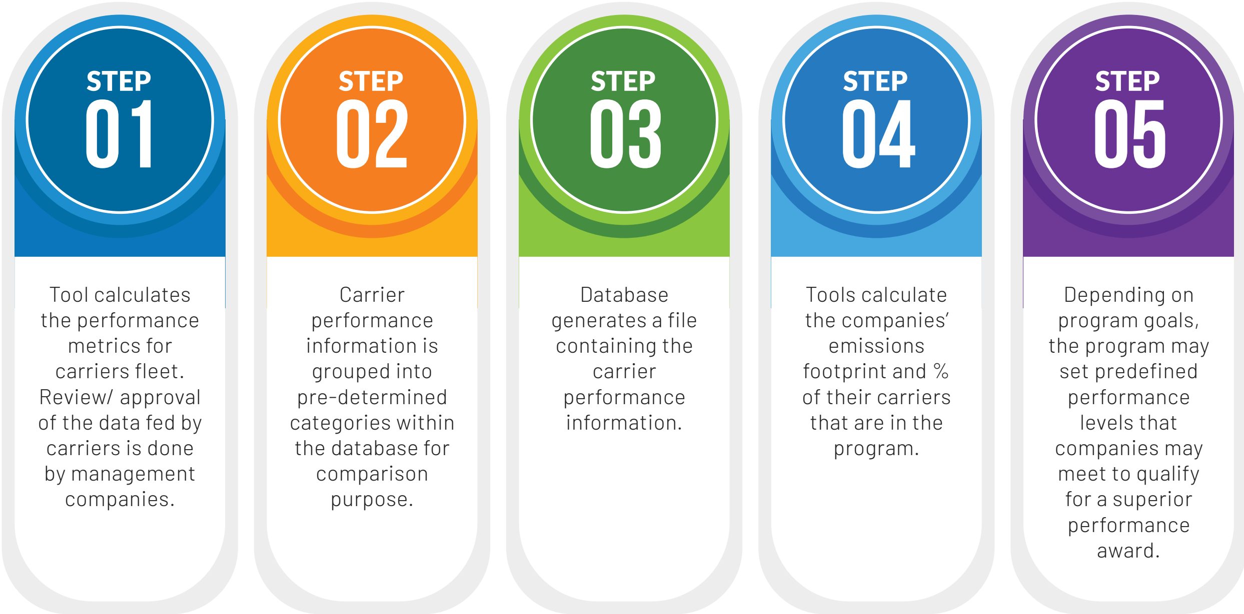


Figure 14: Data collection process for partnership programs

Source: TERI

Voluntary programs

Freight carriers voluntarily join the program, and their baseline efficiency is calculated by the assessment tools and validated by the program. Freight carriers then develop their action plan within program requirements. The action plan is evaluated and approved by the program. The energy saving performance is measured after the action plan's period ends.

The companies that meet the targets have the option to submit revised action plan to further increase improvements. The companies that fail to reach the targets are mandated to submit a modified action plan and participate again.

Figure 15: Data collection process for voluntary programs

Source: TERI

Figure 15 shows the data collection process involved in voluntary programs. These programs could be led by the industry (such as PLVB in Brazil, Lean and Green in Europe), or led by the government (such as China Green Freight Initiative, etc.) where different ministries are involved as implementing agencies.

1.4.2 Indian policy environment

Prior to the implementation of the Goods and Services Tax (GST) in 2017, India was burdened with high logistics cost, which accounted for 14% of the total value of goods in comparison to 6–8% for other major countries (MoRTH, u.d.). On 1st July 2017, the GST regime came into effect in India and physical check posts and barriers were removed. According to MoRTH, elimination of these check posts on road transport resulted in reducing the travel time of inter-state long-haul trucks and other cargo vehicles by one-fifth (MoRTH, u.d.). Time saved on account of this shift helped in reducing the time burden for the truck drivers. From December 2019, the Government of India made RFID based 'FASTag' compulsory for all vehicles at toll plazas across the country, to further streamline the movement of vehicles.

Overall, there are at least 16 different regulations governing the movement of freight by road in India (ADB, 2021); Table 3 highlights the same.

Table 3: Road freight movement and government regulations

Type of Act	Act/Regulation	Key takeaways
Taxation	Central Goods and Service Tax Act, 2017 The Integrated Goods and Services Tax Act, 2017	- Provision of e-Way bill to reduce tax evasion - Monitoring, collection of taxes at interstate barriers obviated
Road transportation/ Vehicle safety	Carriage by Road Act, 2007	- No person can engage in the business of a common carrier, unless granted a certificate of registration - Every consignor shall execute a goods forwarding note, which shall include a declaration about the value of the consignment and goods of dangerous or hazardous nature
	Central Motors Vehicle Act, 1988	- Ensuring road transportation and motor vehicle safety - Licensing of drivers/conductors, registration of motor vehicles, permit registration, traffic regulation, insurance, liabilities and offenses in case of violation of provisions.
	State Specific Motor Vehicle Rules	- Regulate road transportation and vehicle safety
Product specific	Essential Commodities Act, 1955	- Regulating license, permits, storage and transport of essential commodities
	Hazardous Goods Act; Product Specific Acts	- Regulating manufacturing, sale, and transportation of hazardous goods
Welfare of truck drivers	Motor Transport Workers Act, 1961	- Highlights that a truck driver can work for maximum 8 hours in a day without taking a break - It also highlights that a truck driver cannot work for more than 60 hours in a week

Source: TERI

Apart from the above-mentioned regulations, MoRTH has also mandated fitment of GPS devices (complying with the Automotive Indian Standard, AIS 140) for all commercial vehicles that apply for a national permit (amendment: Rule 90, CMV 1989). The Central Motor Vehicle (Eleventh Amendment) Rules, 2022 mandates fitment of vehicle tracking system devices, complying with AIS 140, for N2 and N3 vehicles carrying dangerous goods manufactured on or after 1st September 2022 (in case of new models) and 1st January 2023 (in case of existing models).

In 2022, the Bureau of Energy Efficiency (BEE) notified the fuel efficiency norm (phase 1) for HDVs based on constant speed fuel consumption (CSFC) by different classes of GVW and axle configuration at two speeds viz., 60 kmph and 40 kmph. Phase 1 of the HDV norm was supposed to be implemented from 2018; followed by the rollout of Phase 2 in 2021. However, Phase 1 notification was postponed to 2021 and further to April 01, 2022. These norms are to be implemented by MoRTH starting April 01, 2023. Even though there are schemes and regulatory mechanisms to push for efficiency, limited effort has been made to regulate the emissions from the trucking sector—as seen in the international clean freight programs.

The logistics industry is very complex as multiple agencies are involved in it. The National Logistics Policy, 2022 has been launched by the government to develop technologically enabled, integrated, cost-efficient, resilient, sustainable, and trusted logistics ecosystem in the country for accelerated and inclusive growth. Further, it aims to reduce logistics cost by improving efficiency of the transport sector. One of the key objectives of this policy is to promote and ensure optimal utilization of logistics infrastructure/assets/facilities through synergetic usage.

02

ENERGY EFFICIENCY MEASURES IN INDIA: PERFORM, ACHIEVE AND TRADE (PAT) SCHEME

The strategies for measuring and reducing energy consumption under the PAT scheme are important while measuring and regulating fuel efficiency in the road freight sector. PAT scheme is a regulatory mechanism created by BEE in 2012 with the aim to increase energy efficiency in energy intensive sectors, such as textile, cement, iron & steel, fertilizers, etc. across India.

This scheme is notified on an iterative process and implemented in a phased manner. Figure 16 shows the timeline of PAT cycles. To reduce energy consumption with each subsequent cycle, it is designed to tighten energy saving targets for companies that had previously participated in the PAT scheme, known as designated consumers or DCs. There is a flexibility in PAT scheme that makes it feasible for incorporation in the road freight sector, particularly shippers, in future cycles.

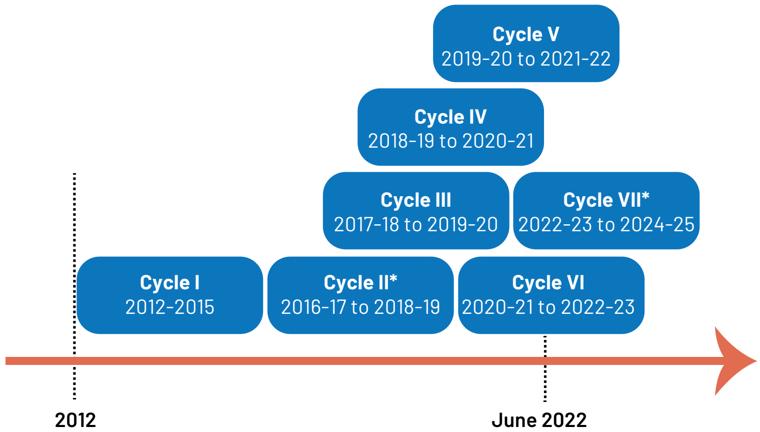
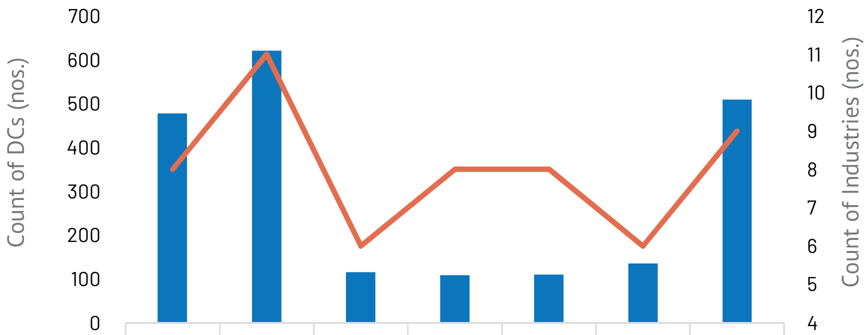


Figure 16: Timeline of PAT cycles

*Note: * indicates inclusion of Indian Railways as DC in PAT cycle*

Source: PAT scheme

Participation in the PAT scheme is mandatory for companies selected by BEE. From the transport sector, Indian Railways was selected as a DC under the PAT scheme. Indian Railways was selected under PAT Cycle II (2016-17 to 2018-19). Owing to the delay in the assessment of Cycle II and due to COVID-19 pandemic, Indian Railways has again been notified in Cycle VII (2022-23 to 2024-25). Figure 17 shows the number of DCs and industries selected under PAT cycles.



	I	II	III	IV	V	VI	VII
Count of DCs	478	621	116	109	110	135	509
Count of Industries	8	11	6	8	8	6	9

PAT Cycle
Count of DCs
Count of Industries

Figure 17: Number of industries and DCs under PAT cycles

Source: PIB & PCRA

2.1 Indian Railways and PAT Scheme

Under both the cycles II and VII, Indian Railways as a sector has been further broken into three subsectors (Figure 18). The traction sub-sector is most relevant for this study, as it includes operation of engines/locomotives for the movement of goods along the Indian Railways network. As the DCs, 16 Zonal Railways were selected.

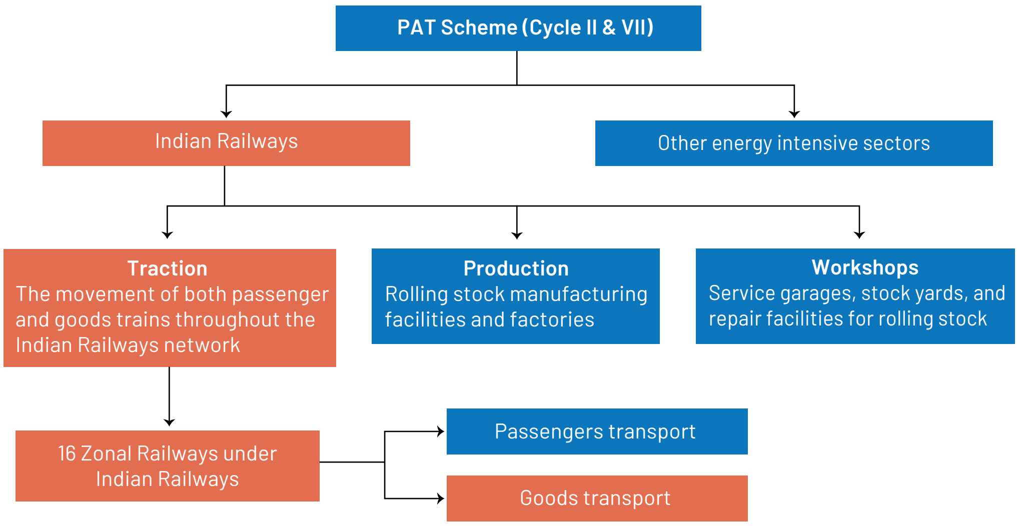


Figure 18: Indian Railways under PAT scheme

Source: BEE

After the completion of Cycle II, the traction subsector of railways saved 1,20,196 liters (INR 805 crore) of diesel, 866 million kWh (INR 498 crore) of electricity, and 1 million tons of CO_2 compared to the baseline year. The targeted energy savings of 771,094 million tons of oil equivalent (MTOE) was exceeded by 154%. In the traction sector, energy saving measures during the cycle included: 3 times increase in the electrified route km, locomotive operator trainings to increase fuel efficiency, and the use of more energy efficient technologies in the rolling stock. Table 4 lists the targets and baseline achievements for the different DCs of the Indian Railways.

Table 4: Baseline and target SEC from Cycle VII for each zonal railway selected as a DC

Zonal Railway (DC)	Baseline (in 1000 GTKM)	Diesel Consumption (Liters)	Baseline SEC (Liters/1000 GTKM)	Target SEC (Liters/ 1000 GTKM)	Targeted Net SEC Reduction (Liters/ 1000 GTKM)	Targeted Percent SEC Reduction
Central	2,42,85,488	5,19,70,944	2.14	2.12	0.02	0.93%
Eastern	1,97,37,682	3,23,69,798	1.64	1.62	0.02	1.22%
East Central	1,72,60,054	3,31,39,304	1.92	1.89	0.03	1.56%
East Coast	72,13,166	1,17,57,461	1.63	1.61	0.02	1.23%
Northern	6,34,29,696	11,54,42,047	1.82	1.79	0.03	1.65%
North Central	1,06,93,038	2,07,44,494	1.94	1.91	0.03	1.55%
North Eastern	1,97,89,102	3,89,84,531	1.97	1.94	0.03	1.52%
North East	3,26,15,040	4,76,17,958	1.46	1.44	0.02	1.37%
North Western	3,95,47,246	7,51,39,767	1.9	1.87	0.03	1.58%
Southern	1,01,80,793	2,03,61,586	2	1.98	0.02	1.00%
South Central	4,32,30,214	6,44,13,019	1.49	1.47	0.02	1.34%
South Eastern	2,14,12,686	4,02,55,850	1.88	1.86	0.02	1.06%
South East	2,20,68,600	4,21,51,026	1.91	1.88	0.03	1.57%
South Western	2,28,36,591	6,25,72,259	2.74	2.7	0.04	1.46%
Western	4,31,88,953	8,89,69,243	2.06	2.03	0.03	1.46%
West Central	7,23,94,210	13,03,09,578	1.8	1.77	0.03	1.67%

**Note: GTKM-Gross ton-kilometer is a unit of measurement of the movement of 1 ton (including payload, and curb weight of the vehicle) carried over 1 km.*
Source: Indian Railways

However, some of the largest pre-pandemic decreases in specific energy consumption (SEC) were observed between the ultimate and penultimate years of the cycle for all traction types. This highlights that the PAT scheme has influenced energy saving investments beyond the business-as-usual scenario.

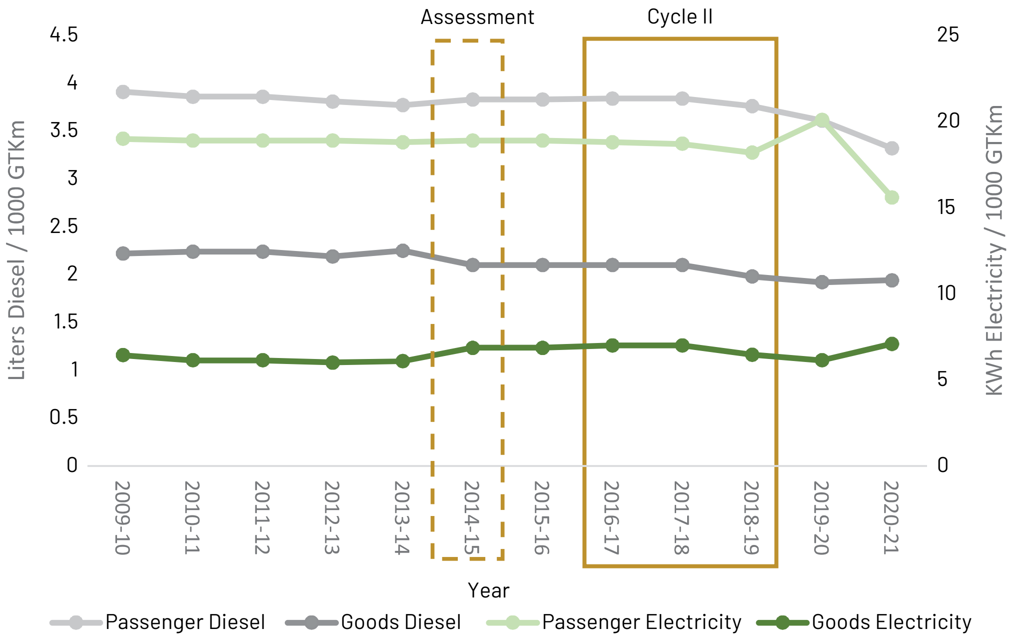


Figure 19: SEC time series for traction segment-Indian Railways

Source: Indian Railways

Figure 19 shows SEC time series for the traction segment for freight movements powered by both electricity and diesel. The assessment year and period of Cycle II have been indicated by boxes. The data includes all 18 zonal railways under Indian railways, of which two zonal railways tare not DCs in the PAT scheme. Since these two additional zonal railways are comparatively small consumers of energy, this data could be utilized to build a broad understanding of energy consumption trends from the traction segment of Indian Railways.

2.2 Regulation of Energy Efficiency

The PAT scheme uses two major components to regulate energy efficiency:

Energy consumption targeting and assessment: First component measures energy consumption baseline and sets reduction targets. Different baselines and targets are set for each DC, which must be achieved by the end of the cycle. These baselines are set according to the DC's annual energy consumption two years prior to the start of the cycle. Using the baseline as a reference, targets are set by in-depth consultation between BEE, sector-specific committees formed for PAT scheme assessments, and the DCs themselves. In case of external events, a normalization process is followed to adjust the measured baseline for impacted DCs. This process is dependent on a change in capacity utilization, defined as the company's actual production output and production capacity. This process is triggered whenever at least one of a fixed set of external factors impact a DC's capacity utilization. It begins with extrapolation of the production vs energy consumption curve, to determine the SEC at different capacity utilization levels. This data is used to estimate energy consumption under a normal capacity utilization scenario.

Market-based trading mechanism: In the second component of the PAT scheme, energy consumption of DCs is compared against its target at the end of the cycle. The energy consumption is measured and reported by the DC, with verification from an accredited third-party auditor. DCs that exceed the targeted energy savings are awarded tradable credits called **'Energy Saving Certificates (ESCerts)'** in proportion to the amount of excess energy saving. DCs can save these credits for use in future cycles, or they may sell them to other DCs on the PAT scheme marketplace. DCs that fail to achieve their energy saving target must purchase ESCerts from this marketplace, or face penalties for non-compliance.

2.3 Relevance to the Indian Trucking Sector

It is imperative to first determine the number of DCs to be included from the road freight sector based on resource availability and targeted total energy savings. It could be done in a phased manner, starting with the largest energy consumers within this sector.

The PAT scheme uses SEC to assess energy efficiency for all sectors. For the traction subsector of the Indian Railways, volume of passenger and goods transported are considered for diesel and electricity consumption. Therefore, SEC for the subsector is defined as the amount of diesel and electricity consumed per volume of passengers and goods transported, which is equivalent to specific fuel consumption.

Since operators of urban and non-urban freight trucks are often different, SEC should be calculated separately for these types. For both urban and non-urban road freight, the only product will be the volume of goods transported (payload) [see Transportation Research Board and National Research Council, 2010]. For non-urban road freight, the dominant fuel type is diesel, while additional considerations for electric, CNG, and petrol fuel types could be made for urban freight.

Context	Specific energy consumption		
General	Amount of Production	÷	Amount of Energy Consumed
Railways (Traction)	Volume of Passengers and Goods Transported	÷	Amount of Fuel Consumed
Road freight (TERI's mapping)	Amount of Goods Tranported	÷	Amount of Fuel Consumed

Figure 20: Specific energy consumption in trucking sector
Source: TERI

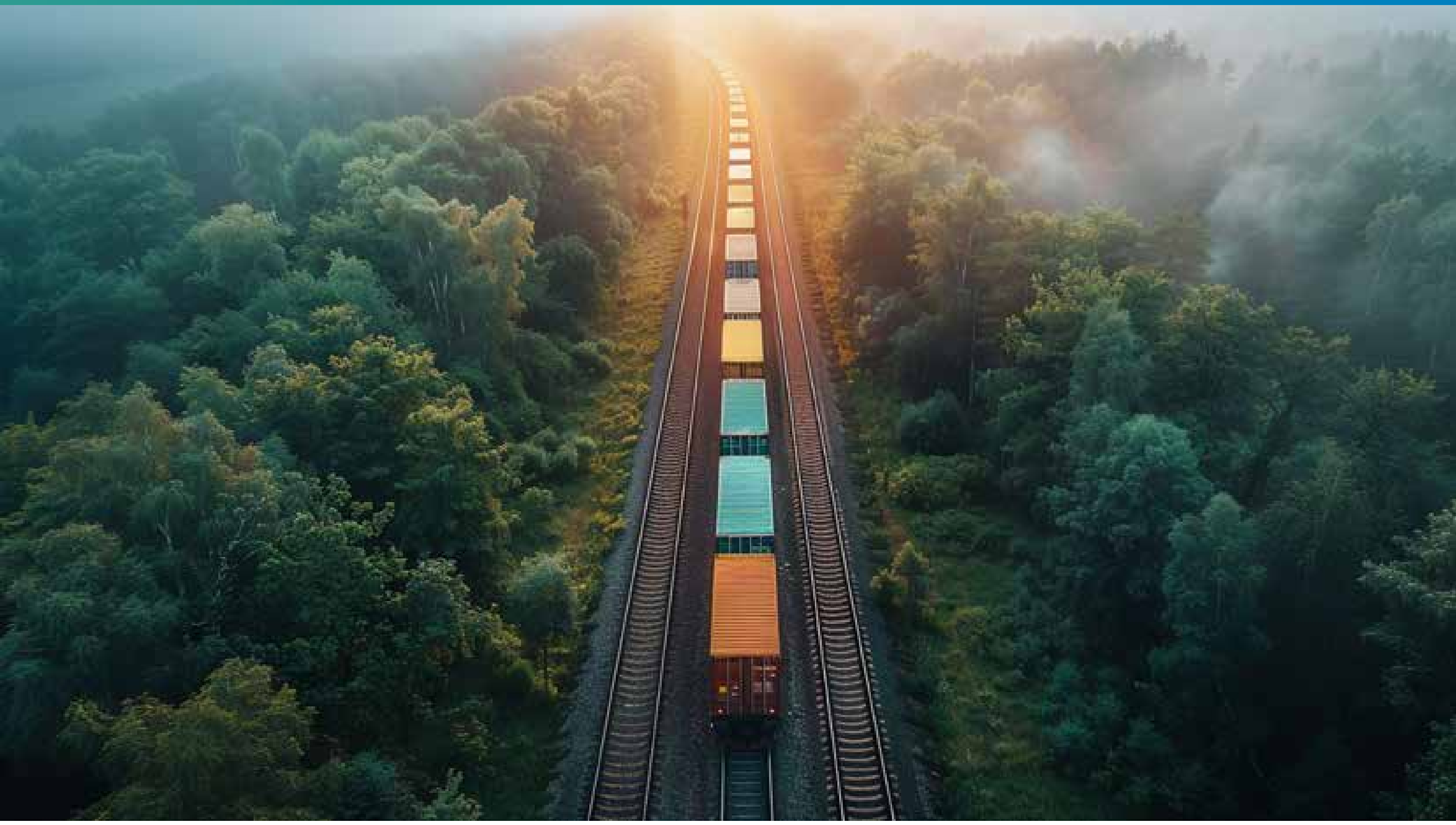


Figure 20 shows TERI's mapping of specific energy consumption (SEC) for road freight under the PAT scheme. The energy consumption of different road freight operators may be relatively flat; therefore, utilizing DC selection methodology from PAT scheme may result in either too few or too many DCs, depending on the energy consumption threshold. Applying PAT scheme's methodology to the road freight sector will involve performing the entire process (from baselining to ESCert transfer) for a large number of DCs due to the sector's fragmentation. Limited data availability for road freight sector makes it difficult to identify the highest energy consumers in the road freight industry. Since the target-setting and energy audit processes are resource intensive, it may be difficult to perform these processes for all road freight DCs.

03

BASELINE IN INDIAN TRUCKING SECTOR

A baseline estimates/calculates the emission from the concerned transport segment (or the entire transport sector, depending upon the interest of the researcher) in a specific time period. The data requirement for baselining has been described in this section, along with the parameters considered during the overall process.

3.1 Data Requirements for Baselining

For freight transport, a baseline characterizes the sector by fleet strength (and composition), fuel consumption, vehicle characteristics, freight movement patterns (freight tonnage, trip distance, route etc.), costs of operation, and emission, at a given point of time. To establish the importance of India's freight policies—for GHG emission mitigation—a baseline serves as a starting point for projecting emission improvements with introduction of alternative policy scenarios. Table 5 highlights the parameters considered for baselining.

Table 5: Data requirement for estimating baseline

S. No.	Parameters	Units
	General fleet characteristics	
1	Fleet size	no.
2	Classification of fleet by vehicle make	no.
3	Classification of fleet by vehicle capacities (GVW)	no.
4	Classification of fleet by fuel efficiency norms	no.
5	Classification of fleet by fuel type	no.
6	Ownership-Owned and leased	no.
7	Distance travelled per month	km
8	Commodities handled	-
9	Average days in service per year	days
10	Engine size	liter
	Fuel consumption	
1	Average idling hours per year	hour
2	Average mileage	km/liter
3	Fuel consumption	liter or kg

Source: TERI

3.2 Checks to Ensure Quality of Data

To ensure quality of data collected from fleet organizations, a detailed list of possible parameters to be considered for baselining was prepared. Further, after integrating the parameters with the Indian context, final survey sheet was floated amongst the fleet organizations. The detailed information regarding process and method of data collection have been highlighted in the Section 4 of this report. In addition to this, two datasets were acquired which constituted pan-India data on truckers. Integrating and verifying data from both datasets helped in ensuring the quality of the data (identity of the operators) while selecting the potential fleet organizations to be surveyed.

3.3 Monitoring, Reporting, and Verification of Data

The detailed processes of monitoring, reporting, and verification of data in case of different clean freight programs have been listed below:

01

United Kingdom: Under EcoStars Fleet recognition program, both qualitative (fleet specifications, eco-driving training, preventive maintenance systems, etc.) and quantitative data (fuel consumption, etc.) are collected from the freight carriers by the Transport Research Laboratory. Utilizing the program toolkit, impacts on air quality are then measured.

02

Europe: For reporting data under Lean and Green Program, freight carriers have the option to either use the programs' emission calculation handbook—consistent with EN 16258 and GHG protocol—or use their own methodologies. The reporting of this data is done once in every 6 months. Once the carrier achieves the target, it is verified by independent partners (TNO, Netherlands or TUV NORD, Germany) or by an auditor appointed by the company.

03

United States: Under the SmartWay Program, freight carriers report their data to US EPA through program assessment tool. The methodology is devised by US EPA for different modes. The reporting of the data is done annually and it includes parameters, such as fuel type, vehicle weight class distribution, engine age, road type, average speed, and idle hours. Reviews are conducted by EPA to cross-check and validate reported data; ensuring quality and accuracy. The agreement between EPA and freight carriers allows for audits if requested; however, these are not mandatory.

3.4 Operational Requirement of Data Collection, Authentication, and Management

Internationally, data collection and authentication are done by freight carriers, or third-party auditor in some cases. The companies are encouraged to meet their targets as per the action plan. The data collection processes for international clean freight programs have been mentioned in Section 1.4.1.1. of the report.

In India, many organizations have committed to reduce their carbon emissions as a part of their environmental, social, and governance (ESG) activities. Similarly, international organizations with their franchises in India are following green trucking norms as their parent company is following a framework for the same. For example: Global logistics emission council (GLEC) framework, developed by the Smart Freight Centre, is a voluntary partnership framework for emission reduction in freight. Many organizations such as DHL, HP enterprise, PepsiCo, Nestle, Cargill, Microsoft, Lenovo, Scania, P&G, Unilever, and the likes have partnered under this framework.

With its experience in implementing the PAT scheme, as part of a future clean freight program for India, BEE could act as the accreditation agency. The shippers should be involved in the process of target setting. While, carriers would be responsible for the implementation. Carriers can then report their data and energy savings to the shippers. An accredited energy auditor under BEE can act as an auditor for verification and certification of the data submitted by fleet organizations. Further, BEE can check-verify the data for ESCerts trading. Figure 21 highlights the process for implementation of a clean freight program in India.

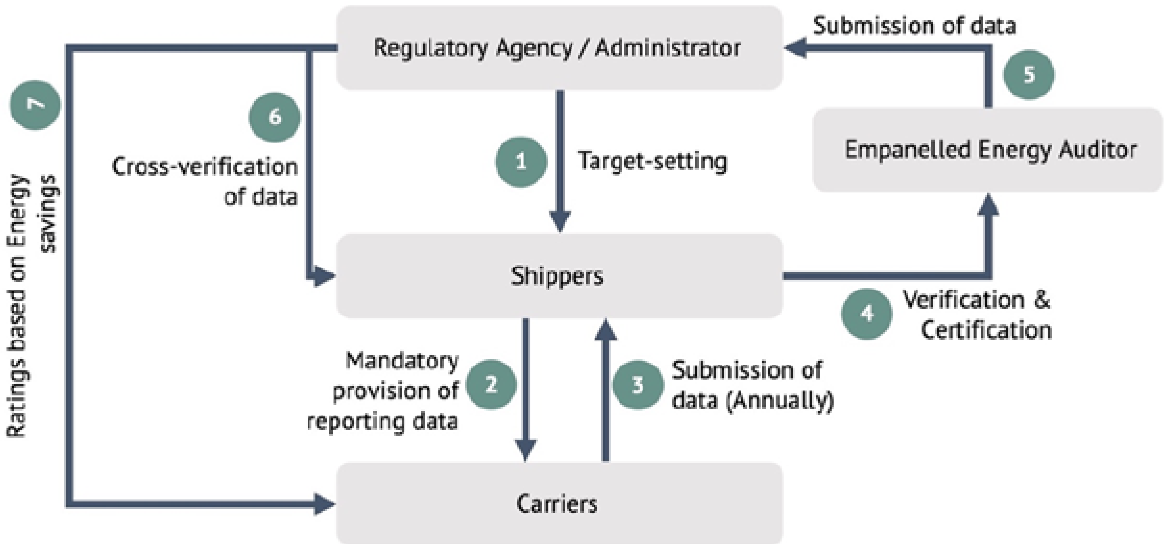


Figure 21: Implementation process of a clean freight program in India
Source: TERI

04

METHODOLOGY OF ESTIMATING BASELINE EMISSIONS

To establish a baseline, it is important to identify the unit in which the baseline emission needs to be measured. For developing a clean-freight policy in India, the baseline emission can be measured as kgs of CO_2 per TKM, or kgs of CO_2 per km.[13] The first one can be considered as a Specific Emission Factor (SEF); whereas the latter can be considered as a Distance-based Emission Factor (DEF).

Generally there are two types of baselines that could be developed for freight movement: (i) a technical baseline—uses base year's emission data and assumptions about technologies and improvements for BAU projections in future, and (ii) a historical baseline—establishes emission trend from historical data and extends it for future years (see OECD, 2001).[14] Due to decentralized operation of freight movement (by road) and high percentage of small-scale ownership of vehicles among freight transporters, establishing a historical baseline is not feasible in India. So, this section provides a methodology to establish a technical baseline at the fleet level for any truck operator, on the basis of survey data on vehicle ownership and freight operation.

The detailed methodologies proposed in this section are based on the United Nations Framework Convention on Climate Change (UNFCCC) (CDM tool 17) guidelines.[15] Note that these methodologies depend on quality of available data and detailed information of freight operation of the transporters. Freight transport sector and its operations can be classified in the following:

- Commodity groups
- Operational classifications (state and national permits)
- Fuel types (diesel and CNG/LNG)[16]

The first classification may help in devising future policies to curb emission; starting with selective enforcement on specific freights (similar to selecting industries/sectors under the PAT scheme) depending upon their social desirability characteristics.

Method 1

$$SEF_i^1 = \frac{\sum_k \sum_d \sum_n (FC_{i,k,d,n} \times EF_n)}{\sum_k \sum_d \sum_n (CW_{i,k,d,n} \times D_{i,k,d,n})} = \sum_k \sum_d \sum_n \frac{(FC_{i,k,d,n} \times EF_n)}{(CW_{i,k,d,n} \times D_{i,k,d,n})}$$

where,

SEF_i^1=specific emission factor (method 1) for transporter i (in kg of CO_2 /TKM); $FC_{i,k,d,n}$ = monthly fuel consumed by transporter i to transport cargo type k over distance category d by trucks using fuel type n (in liter or kg); EF_n = emission factor of fuel type n (in kg of CO_2/liter /kg)[17]; $CW_{i,k,d,n}$ = monthly weight of cargo type k carried by transporter *i* over distance category d by trucks using fuel type n (in ton); $D_{i,k,d,n}$ = monthly distance (including empty trips) travelled by the trucks of transporter i, carrying cargo k, over distance category d, using fuel n (in km); $i \in T$; $n \in$ [Diesel,CNG]; $k \in C$; $d \in L$. Also, T, C and L are the sets of transporters, cargo categories, and domain of operation categories, respectively.

15 Well-to-wheel emission factors measured as kgs of CO_2 equivalent/TKM.

16 One must take note that neither of the baselines can accommodate the spillover or interaction effects of prediction scenarios (see pp. 12-14, OECD, 2001).

17 Accessed from https://cdm.unfccc.int/Reference/tools/index.html

18 Presently there are no alternative fuel vehicles in India, but electric or fuel-cell trucks can be incorporated in the methodology without loss of generality.

Also, distance-based emission factor can be calculated by dividing the emission of each transporter by the total distance traversed by its fleet. It is described by the following equation:

$$DEF_i^1 = \sum_k \sum_d \sum_n \frac{(FC_{i,k,d,n} \times EF_n)}{D_{i,k,d,n}}$$

where,

DEF_i^1 = distance-based emission factor for transporter i (in kg of CO_2 / km).

Depending upon the availability of data (and cognitive burden) required for the proposed disaggregated methodology, some of these disaggregations can be collapsed for more aggregated measures. This is given by the second methodology when, for instance, data disaggregated by domain of operation are not available.

Method 2

$$SEF_i^2 = \sum_k \sum_n \frac{(FC_{i,k,n} \times EF_n)}{(CW_{i,k,n} \times D_{i,k,n})}$$

where,

SEF_i^2 = specific emission factor (method 2) for transporter i (in kg of CO_2 / TKM); $FC_{i,k,n}$ = monthly fuel consumed by transporter i to ship commodity k by trucks using fuel type n (in liter or kg); $CW_{i,k,n}$ = monthly weight of commodity k carried by transporter i by trucks using fuel type n (in ton); $D_{i,k,n}$ = monthly distance (including empty trips) travelled by the trucks of transporter i shipping commodity k and using fuel type n (in km); $i \in T$; $k \in C$; $n \in$[Diesel, CNG] ; T and C are the set of transporters and commodities.

Similarly, the equation for distance-based emission factor for transporter i is:

$$DEF_i^2 = \sum_k \sum_n \frac{(FC_{i,k,n} \times EF_n)}{D_{i,k,n}}$$

Ideally, either of the two methods mentioned above should be employed to establish baseline emission from the non-urban freight transport by HDVs. However, these two methods require detailed data collection from the transporters (fleet operators), and such disaggregated information (based on commodity classes) in a developing country like India may be difficult to maintain by the operators. Hence, we also propose a least-cost methodology (in terms of both data requirement and cognitive burden on the respondents) mentioned below.

Method 3

$$SEF_i^3 = \sum_n \frac{(FC_{i,n} \times EF_n)}{(CW_{i,n} \times D_{i,n})}$$

where,

SEF_i^3 = specific emission factor (method 3) for transporter i (in kg of CO_2 / TKM); $FC_{i,n}$ = monthly fuel consumed by transporter i for trucks using fuel type n (in liter or kg); $CW_{i,n}$ = monthly weight of commodities carried by transporter i by trucks using fuel type n (in ton); $D_{i,n}$ = monthly distance (including empty trips) travelled by the trucks of transporter i using fuel type n (in km); i $\in T$; $n \in$[Diesel,CNG] ; T is the set of transporters.

Similarly, the equation for distance-based emission factor for transporter i is:

$$DEF_i^3 = \sum_n \frac{(FC_{i,n} \times EF_n)}{D_{i,n}}$$

It is to be noted that, ideally, method 1 should be adopted for a more granular approach to baseline emission estimation. However, it depends on the quality of the available data. For the Indian market, perhaps a more aggregated approach as discussed in the second or third method can be applied.

In consonance with the standard practice of emission calculation, all the three methods capture SEF in terms of TKM of payload carried (Ragon and Rodriguez, 2021). In this specification, the SEF indicates the amount of GHG emission from moving 1 ton of payload by 1 kilometer, and accounts for any variation in terms of payload. The SEFs calculated from any of these methods correspond to an average month of operation. However, annual baseline SEFs can also be calculated for the truck operators by scaling up the monthly averages. It is also to be noted that these methods are generic and can be applied to any type of goods vehicles and for both urban and non-urban freight operations, with suitable modifications.

05

BASELINE DATA COLLECTION AND ANALYSIS

A census of the trucking sector is not feasible for a vast, fragmented market like India. Hence, a sample-based approach to baseline estimation is undertaken. Under the sample survey, data were collected through a pilot survey of 46 truck operators owning ~800 trucks. A dataset containing information of the truckers was acquired to identify the major truck operators in India. Further, to verify the data, an additional dataset was acquired and both datasets were used for cross-verification and combined. Six major cities were identified for conducting the pilot survey. For identifying potential target truck operators, a proportionate random sampling technique was used. The details of the steps involved in data collection and analysis are given in Figure 22.

1. Pan-India dataset on truck operators was acquired
2. Six metro cities (Ahmedabad, Chennai, Delhi NCR, Hyderabad, Kolkata, and Mumbai) were selected for pilot survey
3. A proportionate random sample was constructed using % of truck operators in each city as the corresponding weight
4. The data for these cities were compared with another dataset on major truck operators in India
5. Truck operators existing in both the datasets were retained for identification of survey respondents
6. Random numbers were assigned to the cleaned dataset
7. Dataset was sorted in ascending order of random numbers
8. Pilot survey was conducted by contacting the truck operators based on ascending order of random numbers for each city
9. Responses were recorded in the survey questionnaire (Annexure I)
10. Data was analyzed for 46 truck operators (~800 trucks)
11. Truck operators were ranked on the basis of estimated Specific Emission Factors (SEF)

Figure 22: Methodology of data collection
Source: TERI

5.1 Identification of Truck Operators

A dataset on truck operators was acquired for the purpose of conducting a pilot survey. The acquired dataset contained information on 32,746 truck operators in India, owning 1.33 million trucks. Figure 23 shows the truck ownership distribution (including leased, hired trucks) of the 1.33 million trucks in the dataset. In the dataset, 49% of the operators own at least 20 trucks and cumulatively they own 90% of the 1.33 million trucks. Large operators (owning at least 100 trucks) represent only 5% of the total truck operators, but own 43% of the trucks.

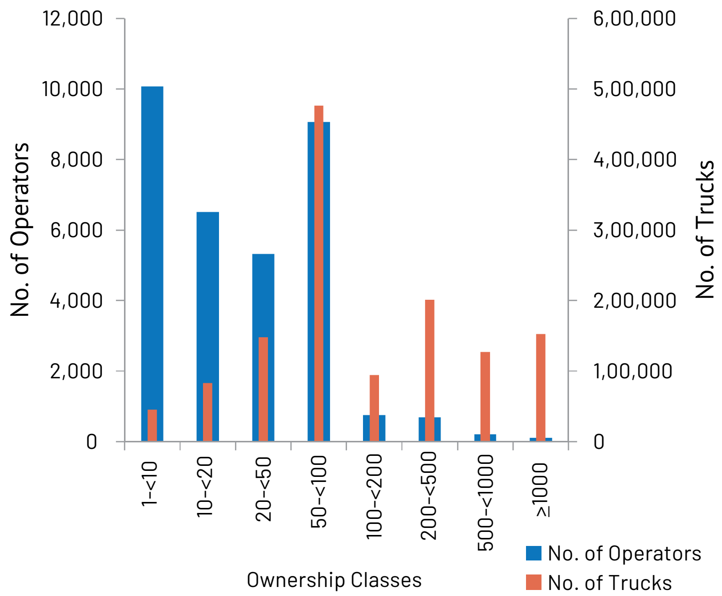


Figure 23: Truck ownership distribution
Source: TERI analysis based on dataset acquired from ACG

Figure 24 shows the spatial distribution of truck operators (based on their registered offices) from the dataset. Clearly, there are few clusters of truck operators such as: Delhi NCR, Chennai, Mumbai, Hyderabad, Kolkata, and Bengaluru.

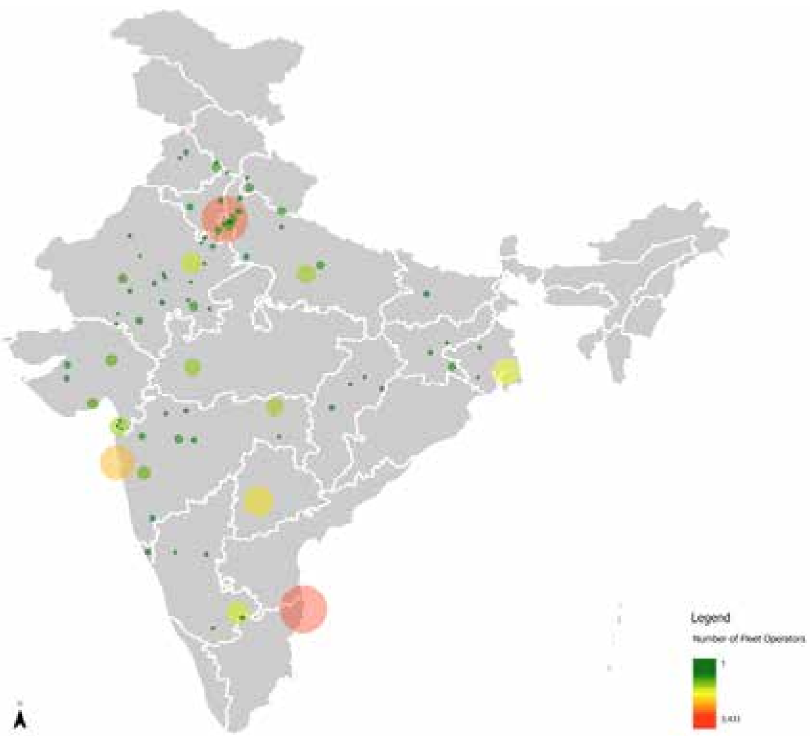


Figure 24: Spatial distribution of fleet operators
Source: Representation by TERI based on data acquired from ACG

Six metro cities (Ahmedabad, Chennai, Delhi NCR, Hyderabad, Kolkata, and Mumbai) were identified for pilot data collection to test the methodologies. These cities collectively represent 40% of the trucks and 42% of the truck operators in ACGs dataset. A proportionate random sample was constructed using the percentage of truck operators in each city as the corresponding weight. A pilot survey was conducted on 46 truck operators; the corresponding regional distribution and weights have been provided in Table 6. Following sample selection, the data on truck operators for these six cities were compared with another dataset (on contact details of major truck operators in India) and only the truck operators existing in both the datasets were retained for identification of survey respondents. Next, random numbers were assigned to the cleaned dataset. The dataset was then sorted based in ascending order of the corresponding random numbers. More than half of the identified transporters were reported to operate at least 50 trucks in their fleet, as per the ACG database. Finally, the pilot survey was conducted by contacting the truck operators based on the sorted list of truck operators (using random numbers) for each city.

Table 6: Regional distribution of number of truck operators for pilot survey

Cities	Actual sample	Weights (%)
Delhi	13	28%
Ahmedabad	2	4%
Kolkata	5	11%
Hyderabad	7	15%
Chennai	11	24%
Mumbai	8	17%
Sample for pilot	**46**	**100%**

Source: TERI

5.2 Pilot Survey

A questionnaire (see Annexure I) was prepared for the pilot survey that included fleet level questions on: GVW classification of vehicles, types of commodities handled, payload tonnage, distance travelled, speed, fuel consumption, maintenance cost distribution, servicing requirements, revenue and profit margin details, etc. A response matrix to aid detailed emission factor calculation with the three methodologies is presented in Table 12 (see Annexure II). The pilot survey was conucted during October-November 2022.

5.3 Sample Characteristics

The characteristics of the sample including vehicle classifications, operational characteristics, and operational challenges have been highlighted in this section.

5.3.1 Vehicle classification(s)

It is to be noted that the ownership pattern is different in the responses, compared to the planned representation (more than half being) of large operators, each with at least 50 trucks.[18] Table 7 provides the details of OEM and GVW categorization of the trucks. The sampled fleet was almost entirely made up of trucks from Ashok Leyland and Tata group. 38% of the trucks were relatively older (at least 8 years old). A very small fraction of the sampled trucks complied with BS VI emission norms. Also, only 3 trucks were CNG trucks and these were less than 12-ton GVW classification. There were two operators in Chennai, with all their trucks operating within Tamil Nadu. There were two operators in Delhi and Kolkata, who were operating trucks with both state and all India permits.

Table 7: Classification of the truck operators

Vehicle classifications		No. of vehicles	% share
OEM classifications	Ashok Leyland	467	58
	Tata	320	40
	Eicher	2	0
	Others	10	1
GVW classifications	<12 tons	3	0
	12 - 16 tons	64	8
	>16-25 tons	398	50
	>25-40 tons	332	42
	>40 tons	2	0
Emission norm classification	BS III or lower	52	7
	BS IV	741	93
	BS VI	6	1

[18] This is due to some non-working contact numbers, changed addresses, business closures after COVID-19 lockdowns, and shrinking fleet size for many large operators.

Vehicle classifications		No. of vehicles	% share
Age of vehicle (years)	0 - 03	79	10
	>03 - 07	417	52
	>07 - 11	281	35
	>11 - 15	22	3
	> 15	0	0
Permit distribution (region of operation)	Within state	15	2
	All India	784	98

Source: TERI

5.3.2 Operational characteristics

Most of the surveyed truck operators reported of carrying varied range of commodities, and only a few reported carrying specific commodities. Table 8 classifies the truck operators in terms of the type of commodities carried.[19] Out of the 46 surveyed operators, only 14 were engaged with exclusively transporting any one category of commodity. Additionally, 26 truck operators transported all types of commodities.

[19] These operators explicitly mentioned the types of commodities they transport.

Table 8: Classification of operators by types of commodities transported

Commodity groups	Number of operators
Agricultural, forestry, fishing, animals (live, raw)	6
Processed food items/beverages/milk/FMCG	10
Industrial intermediate items, construction materials, mining and quarrying (minerals, stones, etc.)	7
Manufactured items	2

**Note: FMCG–Fast moving consumer goods; there were 26 truck operators who transport all types of items and did not specify any particular commodity type. Hence, these have been excluded from the table.*

Based on the pilot survey, the following observations could be drawn (see Figure 25).

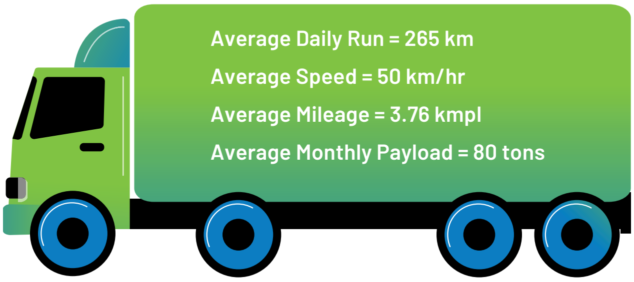


Figure 25: Operational characteristics of the sample

Source: TERI

5.3.3 Operational challenges

Based on the interaction with the respondents, it is found that there are several challenges faced by the truck operators in their business. Most of these are related to the cost of operation. Figure 26 provides the frequency distribution of sampled truck operators by different institutional and operational issues plaguing their operation. Most of the operators cited high fuel cost and toll charges, along with on-road corruption from different government and semi-government agencies to be the most common challenges to their smooth functioning.

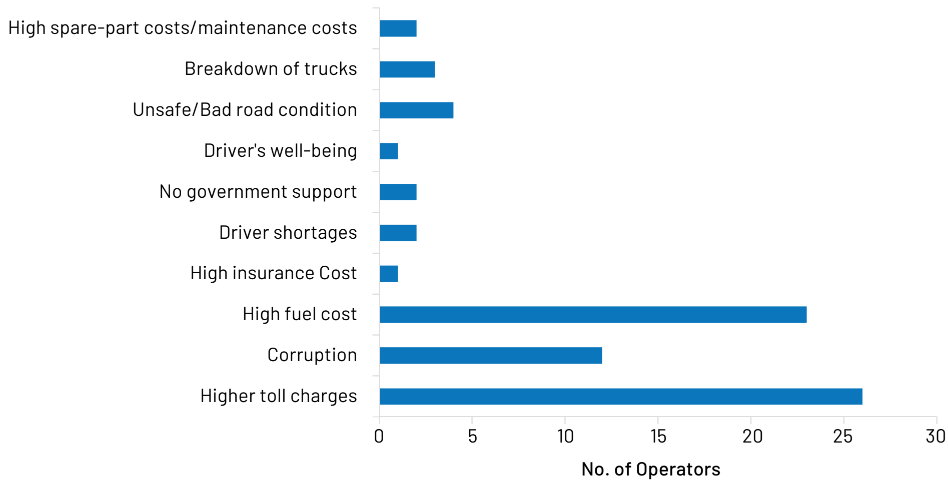


Figure 26: Operational challenges

Source: TERI

5.4 Specific Emission Factors

Collected from the pilot survey, the operational characteristics of the truck operators are used for assessing their baseline emissions at the fleet level. The fuel specific emission factors used in the calculation (2.6444 kgs of CO_2/liter of diesel, 2.692 kgs of CO_2/kg of CNG) are based on the well-to-wheel or WTW CO_2 emission factors [see India GHG Program, 2015]. Table 9 reports the SEF (in grams of CO_2/TKM) for the 45 anonymized truck operators (Truck Co.), along with corresponding DEF (in grams of CO_2/km). A similar table (Table 13 in Annexure II) provides the SEF and DEF measured in grams of CO_2 equivalent (fuel specific emission factor of 3.24 kgs of CO_2e/liter of diesel, 3.07 kgs of CO_2e/kg of CNG) per TKM and km respectively.[20]

Table 9: Ranking of surveyed freight operators by SEF (grams of CO_2/TKM)

Rank	Truck Co.	SEF	DEF	Rank	Truck Co.	SEF	DEF	Rank	Truck Co.	SEF	DEF
1	Hyd2	0.1632	881.5	**16**	Del4	0.5037	755.5	**31**	Che6	1.0750	528.9
2	Del10	0.1836	881.5	**17**	Che7	0.5037	528.9	**32**	Mum6	1.2020	661.1
3	Kol5	0.2204	661.1	**18**	Hyd5	0.5185	661.1	**33**	Del3	1.2108	460.1
4	Del7	0.2361	661.1	**19**	Hyd3	0.5289	528.9	**34**	Del13	1.2243	881.5
5	Kol4	0.2449	661.1	**20**	Che1	0.5724	881.5	**35**	Hyd7	1.3773	661.1
6	Kol3	0.2504	661.1	**21**	Che9	0.6781	881.5	**36**	Ahm1	1.5671	587.6
7	Mum5	0.2617	659.4	**22**	Mum1	0.6886	661.1	**37**	Mum3	1.8364	881.5
8	Che4	0.2644	661.1	**23**	Mum4	0.7346	881.5	**38**	Mum8	1.9184	671.4
9	Che3	0.2755	661.1	**24**	Del1	0.7420	881.5	**39**	Hyd6	2.2037	661.1
10	Kol2	0.2938	661.1	**25**	Kol1	0.7835	705.2	**40**	Mum2	2.7546	881.5
11	Che8	0.3015	881.5	**26**	Che5	0.8476	661.1	**41**	Che10	3.3055	661.1
12	Che11	0.3047	661.1	**27**	Del5	0.8815	661.1	**42**	Hyd4	4.1319	661.1
13	Del11	0.3526	661.1	**28**	Del9	0.8815	661.1	**43**	Mum7	4.1319	661.1
14	Ahm2	0.3526	528.9	**29**	Del6	0.9794	881.5	**44**	Hyd1	5.8764	881.5
15	Che2	0.4407	661.1	**30**	Del12	1.0330	661.1	**45**	Del8	8.2638	1322.2

**Note: Ahm-Ahmedabad, Che-Chennai, Del-Delhi, Hyd-Hyderabad, Kol-Kolkata, Mum-Mumbai. One data-point from Delhi has been dropped for inconsistency. Truck Co.- Anonymized ids of the truck companies. One operator from Delhi (Del2) has been dropped from the analysis.*

Source: TERI estimate

[20] Fuel specific emission factors in kgs of CO_2 equivalent units are from EN 16258

Due to the unavailability of disaggregated data, method 3 was used to calculate the SEF for each of the truck operators. Average SEF for the entire sample of 45 operators was estimated to be 1.27, whereas the median was 0.73, both measured in grams of CO_2/TKM. There were 11 transporters in the sample with greater than the average SEF. Further, the range of variation—difference between the highest and the lowest values—was 8.10. The DEF varied between 460.1 and 1322.2 gms of CO_2/km, with an average of 720 and median of 661.1 gms of CO_2/km. There were 31 transporters with less than the average DEF.

5.5 Insights: Determinants of Specific Emission Factors

Data collected for baseline emission estimation (through SEF or DEF) can be used for econometric analysis, to determine the factors that have significant impact on a transporter's emission. SEF can be affected by average speed, mileage, payload carried, age of vehicle/vehicle technology, axle configuration, road condition, frequency of maintenance, driving habits, terrain characteristics of the regions of operation, weather conditions, etc.

SEF for a truck operator can be modeled in the following functional form:

$$
\begin{aligned}
SEF_i = \beta_1\,(speed)_i + \beta_2(mileage)_i + \beta_3(payload)_i \\
+ \beta_4(percentage\ of\ BS\,4{,}6\ vehicles)_i \\
+ \beta_5(frequency\ of\ maintenance)_i + \varepsilon_i
\end{aligned}
$$

where, SEF_i = specific emission factor of truck operator β_j are the coefficients associated with the factors; ε_i = error term.

From such an econometric analysis, one can infer about the contribution of each of the factors in reducing SEF.

5.6 Verification and Authentication

A pilot survey was undertaken in six cities of India to test the methodology developed in Section 4. The data collection method initially used two sets of datasets available on truckers in India. These two were used to verify identity of the truck operators and for the purpose of the survey only the truck operators listed in both databases were considered. Further, there were multiple questions in the questionnaire capturing similar information. These were introduced for internal consistency of the answers. For example, two separate questions asked information on total number of vehicles by GVW classes as well as by the types of OEMs; total fleet size derived from the two should match. Moreover, the respondents were asked about the total monthly fuel consumption per truck, along with two questions on: (i) average mileage; and (ii) average distance travelled per truck in a month. Fuel consumption can also be derived by the latter two (average distance divided by mileage), and act as cross-verification of the responses. However, for accurate measurement and verification of operational characteristics, odometer readings and information on driving habits (speed, braking, and acceleration) and vehicle usage (idling, fuel consumption) based on fleet telematics should be used in future.

The estimated SEF and DEF are then cross-verified with the existing literature. For example, the average DEF in the pilot was 720 gms of CO_2 /km, which is close to the 737.5 grams of CO_2 /km reported by India GHG Program (2015) for HDVs. The DEFs are also in line with the DEFs observed for HDVs in the EU (see Ragon and Rodriguez, 2021). However, the SEF estimates are very different from the existing estimates of other regions (see Ragon and Rodriguez, 2021; ACEA, 2020). So, a change in the methodology of SEF estimation is proposed in next section.

5.7. Proposed Changes in the Methodology

The methodology adopted in the pilot was drawn from the UNFCCC guideline on baseline emission estimation. The formula overestimates the TKM for a truck operator (as it estimates TKM as a product of total payload and total distance). It is proposed that the methods should use average cargo weight per trip per truck, instead of total cargo weight in the calculation (see also EN 16258). With such an adjustment, the proposed method of estimating baseline emission for a truck operator is as follows:

$$SEF_i^1 = \sum_k \sum_d \sum_n \frac{(FC_{i,k,d,n} \times EF_n)}{(W_{i,k,d,n} \times D_{i,k,d,n})}$$

where,

SEF_i^1 = specific emission factor for transporter i (in kg of CO_2 /TKM); $FC_{i,k,d,n}$ = monthly fuel consumed by transporter i to transport cargo type k over distance category d by trucks using fuel type n (in liter or kg); EF_n = emission factor of fuel type n (in kg of CO_2/liter or / kg); $W_{i,k,d,n}$ = average weight of cargo type k carried by transporter i per trip over distance category d by trucks using fuel type n (in ton); $D_{i,k,d,n}$ = monthly distance (including empty trips) travelled by the trucks of transporter i, carrying cargo k, over distance category d, using fuel n (in km); $i \in T$; $n \in$ [Diesel,CNG]; $k \in C$; $d \in L$. Also, T, C, and L are respectively the sets of transporters, cargo categories, and distance categories.

The above formula is an adjustment of the method 1. Similar adjustments are required for the other two methods as well.

Using the adjustment, the SEF for three transporters (from Delhi, Hyderabad, and Kolkata) were estimated as 38.89, 34.79, and 30.05 gms of CO_2/TKM, respectively. These are improvements over the SEFs reported in Table 9 and in line with the figures reported by Ragon and Rodriguez (2021) for the EU. It was not pursued further as the information on average payload per truck per trip was showing a huge variation for the truck operators. The revised SEF for each truck operator can also be estimated by dividing the DEF by average payload carried per trip per truck.

SEF calculation for baseline requires a detailed disaggregated data for each of the trucks being operated by the transporter. Table 14 provides (see Annexure II) the updated response matrix for SEF calculation based on the proposed modifications.

06

KEY FINDINGS

Table 10 shows the findings of the survey along-with the recommended measures to address the issues pertaining to data availability, verification, and authentication.

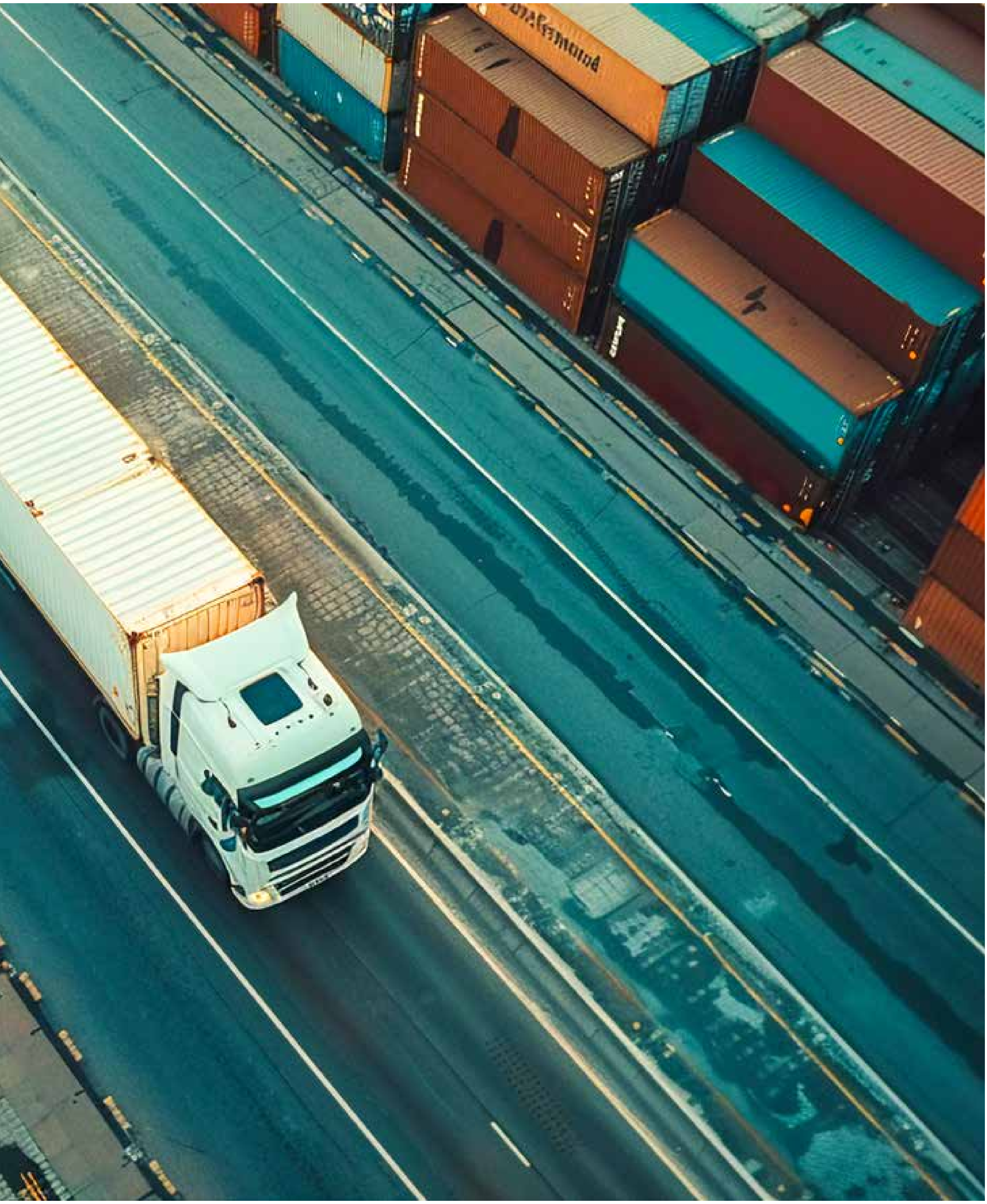
Table 10: Key findings of the study

Parameters	Outcomes/Findings	Recommendations
Data Availability	Small and Medium fleet owners do not digitize operational characteristics and most of the data collected through the pilot were on a recall basis. This limit the use of disaggregated analysis of SEF calculation for the operators. Many truck operators do not directly calculate total fuel consumption by each truck or fleet. If measured accurately, this has a potential for efficiency improvement. There is a lack of information on empty trip percentage, as most of the trucks return with some payload (arrangement through the local brokers at the destination).	**Odometer readings** and information from **on-board telematics** need to be integrated with data management. Per trip information on fuel consumption, time, payload, speed, mileage, acceleration, braking, and idling are essential for detailed baseline assessment. **Payload monitoring system** can accurately measure the payload per truck and help in estimating the load factor.
Data Verification	Multiple questions capturing the same factors were included in the questionnaire for internal consistency check for the responses. However, the responses were majorly based on memory recall. This lacks cross-verification with their actual business operations.	Involvement of a **government department** or a **regulator** can help in getting accurate information related to the fleet operations. The **e-Way bill system** of GST calculation can be used to cross-verify the number of times a vehicle was used for shipment, distance travelled, as well as types of commodities carried in a month.
Data Authentication	Lack of pan-India truck owner/operator data pose challenges for identification of target cohorts and verification of their identity. The databases that were acquired for the pilot survey provided a list of truck operators to start with. However, a major issue that emerged during the survey was that most of the listed operators (in the two databases) presently are not in business and a large section of them was unavailable for contact (non-functional telephone numbers, not interested in responding).	A **database on truck operators** needs to be maintained and annual updation is necessary to reflect on changing asset holding pattern, changes in operation, business closure or expansion. Different **truck associations,** such as AITWA, AIMTC, etc., can be partnered with for this.

Source: TERI

07

ACTION POINTS: CLEAN FREIGHT PROGRAM IN INDIA



For implementing a clean freight program in India (in-line with the PAT scheme), following considerations should be taken into account:

- The target-setting for the implementation should be done on shippers (as they can instruct their associated carriers to comply with pre-defined targets).
- Shippers can then mandate their carriers to report data related to fuel consumption, CO_2/CO_2e emissions annually.
- Shippers can share the data received from their respective carriers to an empaneled energy auditor for verification and certification.
- Regulatory agency can cross-verify this data with shippers, in case of any discrepancy.
- Based on cross-verification, regulatory agency can certify whether the shippers have achieved the respective target or not.
- The program could be implemented in a phased manner, starting with large shippers.
- For the initial stage, it would be ideal to first target DCs already under the PAT scheme. The movement of raw materials and end-products of following industries depends on road transport, majority of which is transported through HDVs. Therefore, shippers and their associated carriers operating under the following DCs may be targeted:
    a. Cement: 2/3rd of the movement of cement industry is via roads.
    b. Petrochemicals: 3/4th of petroleum products are moved by road and pipelines.
    c. Thermal Power Plants: The raw material used in thermal power plants (such as coal and coke) are transported via roads. Approximately 1/3rd of the movement of coal and coke is attributed to road freight.
    d. Iron & Steel: More than 1/3rd of the movement of iron ore is via road.
    e. Fertilizers: 1/5th of the movement of fertilizers rely on road transport.
- In addition to these, other sectors relying majorly on road transport can also be targeted, including automobile sector and FMCG industry. Similarly, containerized movements can also be covered under the program as more than 3/4th of the domestic container traffic relies on road transport.

The process of implementation for clean freight program has been shown in Figure 21. Table 11 highlights the role of various stakeholders involved in the implementation of a clean freight program in India.

Table 11: Framework for implementing a clean freight program

Stakeholders	Roles	Responsibilities
Bureau of Energy Efficiency (BEE)	Administrative/ Regulatory	BEE could act as the regulator for a clean freight program (in-line with existing PAT scheme).
	Target setting for shippers	In consultation with shippers, BEE would set specific targets for each shippers.
	Cross-Verification	BEE would cross-verify the data reported by shippers (in case of any discrepancy).
	Issuing star ratings for carriers	BEE would issue star ratings to the carriers associated with shippers, after ensuring data authenticity (based on the certificate issued by the auditor).
Empaneled Energy Auditor of BEE	Verification	Energy auditor would verify the data reported by shippers.
	Certification	Energy auditor would issue certificate of authenticity of data reported by shippers.
Shippers	Target Setting for shippers	Shippers would collaborate with BEE for setting specific targets.
	Data monitoring and verification	Shippers would monitor and verify the data reported by their carriers.
	Data reporting to the energy auditors	Shippers would submit the data to the energy auditor.
	Cross-verification	Shippers would aid BEE in cross-verification of documents (in case of any discrepancy).
Carriers	Data reporting to the shippers	Carriers associated with their respective shippers would report the data related to their overall operations (e.g. fuel consumption, GHG emissions, etc.) to the shippers.
	Star ratings	Carriers would receive the final star ratings issued by BEE.

Source: TERI

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Annexure I

Survey Sheet

Date of survey:

1. Name of the company: ____________________________________
2. Location: ______________________
3. Total number of vehicles (fleet size): __________
4. Permit details:
   - National permits: _______
   - State permits: _______
5. Regions of operation of your truck fleet: ___________________________
6. Classification of vehicles in your fleet:

Vehicle make	Tata	Ashok Leyland	Mahindra	Bharat Benz	Eicher	Volvo	Others (Specify)
Number of trucks							

7. Capacity of trucks:
   a. <12 ton GVW (nos.): _____
   b. 12-16 ton GVW (nos.): _____
   c. >16-25 ton GVW (nos.): _____
   d. >25-40 ton GVW (nos.): _____
   e. 40+ ton GVW (nos.): _____

8. Number of vehicles by:
   a. BS-III and old (nos.): _____
   b. BS-IV (nos.): _____
   c. BS-VI (nos.): _____

9. Type of commodities carried at the fleet level; please name the commodities: _________
   ____

10. Average end-life of a truck in your fleet (years)/ On an average, after how many years do you retire your vehicles from fleet? _________________

11. Ownership type:
    a. Owned (nos.): _____

       First owner (nos.) | Second owner (nos.) | Third owner (nos.)

    b. Leased (nos.): _____
    c. Hired (nos.) [if you have hired individual truck owners for your freight operation]: ________

12. Number of vehicles by age:
    a. 0–3 years (nos.):
    b. >3–7 years (nos.):
    c. >7–11 years (nos.):
    d. >11–15 years (nos.):
    e. >15 years (nos.):

13. Fuel Type:
    a. Diesel (nos.): _____
    b. CNG/LNG (nos.): ______

14. Total distance per month (kms):
    a. Overall fleet: _____
    b. Per vehicle (average) in your fleet: _____

15. Average volume handled per month (tons):
    a. Overall fleet: _____
    b. Per vehicle (average) in your fleet: _____

16. Average mileage (km/litre):
    a. Diesel vehicles (km/litre): _____
    b. CNG/LNG vehicles (km/kg): _____

17. What type of tires are used for trucks? (put a ✓)
    a. Radial ☐
    b. Non-radial ☐

18. Frequency of maintenance per year per vehicle: (put a ✓)

	1	2	3	>3
a. CNG/LNG:	☐	☐	☐	☐
b. Diesel:	☐	☐	☐	☐

19. Average annual maintenance cost per truck (✓): ___________

20. Place of service: (put a ✓)
    a. Authorized service centre ☐
    b. Local mechanic ☐
    c. Others (please specify): __________________________

21. Break-up of annual total cost of operations per vehicle (% share):
    a. Fuel cost: _____
    b. Tire cost: _____
    c. Insurance cost: _____
    d. Toll charges: _____
    e. Driver/conductor cost: _____
    f. Miscellaneous: _____

22. Do you incentivize your drivers to save fuel [economic incentives, training programs] (put a ✓)

    Yes ☐ No ☐

23. Have you ever invested in your vehicles with a motive to increase fuel efficiency? [ex – better tyres, engine oil, etc.] (put a ✓)

    Yes ☐ No ☐

24. How do you pay the driver/conductor of your trucks? (put a ✓)
   a. Fixed salary ☐
   b. Payment based on cargo (distance and tonnage) ☐
   c. Fixed salary + additional payment based on consignment ☐
   d. Other (please specify) _________________________

25. Do you calculate savings from increased fuel efficiency (✓)? YES ☐ No ☐
   If YES, then how?
   ____
   ____

26. What are the current regulations that impact your business? [ex-emission norms, over weight restrictions, etc.] ____
   ____

27. Percentage of empty trips (%): ____________
28. Average monthly trip distance (km/vehicle): ____________
29. Average idling hours per month (entire fleet): ____________
30. Average distance covered per hour (speed) (km): ____________
31. Average days of operation per month (entire fleet): ____________

Annexure II

Table 12: Sample response matrix (for each transporter) for baseline emission calculation

Commodities transported		Number of trucks (in ton GVW)				Percentage (%) of fleet by fuel type		Permit distribution of trucks (either % or numbers)		Average monthly payload of cargo handled per truck (weight in tons)		Average monthly fuel consumed per truck		Annual business		Average monthly distance travelled; including empty trips (in km)	
Groups	Please tick [√]	< 12	12-25	>25-40	40+	Diesel	CNG/ LNG	State permit	All India permit	Diesel	CNG/ LNG	Diesel (liter)	CNG/ LNG (kg)	Turnover (INR lakhs)	Profit margin (%)	State	All India
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Agricultural, forestry, fishing, animals (live, raw)																	
Processed food items/beverages/ milk																	
Water supply, fuel																	
Industrial intermediate items, construction materials, mining and quarrying (minerals, stones, etc.)																	
Manufactured items																	
Mail and packages																	
Medical items																	
ALL ITEMS (TOTAL)	×																

Source: TERI

Table 13: Ranking of surveyed truck operators by SEF (grams of CO_2 e/TKM)

Rank	Truck Co.	SEF	DEF	Rank	Truck Co.	SEF	DEF	Rank	Truck Co.	SEF	DEF
1	Hyd2	0.2000	1080.0	**16**	Del4	0.6171	925.7	**31**	Che6	1.3171	648.0
2	Del10	0.2250	1080.0	**17**	Che7	0.6171	648.0	**32**	Mum6	1.4727	810.0
3	Kol5	0.2700	810.0	**18**	Hyd5	0.6353	810.0	**33**	Del3	1.3808	524.7
4	Del7	0.2893	810.0	**19**	Hyd3	0.6480	648.0	**34**	Del13	1.5000	1080.0
5	Kol4	0.3000	810.0	**20**	Che1	0.7013	1080.0	**35**	Hyd7	1.6875	810.0
6	Kol3	0.3068	810.0	**21**	Che9	0.8308	1080.0	**36**	Ahm1	1.9200	720.0
7	Mum5	0.3206	808.0	**22**	Mum1	0.8438	810.0	**37**	Mum3	2.2500	1080.0
8	Che4	0.3240	810.0	**23**	Mum4	0.9000	1080.0	**38**	Mum8	2.3504	822.7
9	Che3	0.3375	810.0	**24**	Del1	0.9091	1080.0	**39**	Hyd6	2.7000	810.0
10	Kol2	0.3600	810.0	**25**	Kol1	0.9600	864.0	**40**	Mum2	3.3750	1080.0
11	Che8	0.3694	1080.0	**26**	Che5	1.0385	810.0	**41**	Che10	4.0500	810.0
12	Che11	0.3733	810.0	**27**	Del5	1.0800	810.0	**42**	Hyd4	5.0625	810.0
13	Del11	0.4320	810.0	**28**	Del9	1.0800	810.0	**43**	Mum7	5.0625	810.0
14	Ahm2	0.4320	648.0	**29**	Del6	1.2000	1080.0	**44**	Hyd1	7.2000	1080.0
15	Che2	0.5400	810.0	**30**	Del12	1.2656	810.0	**45**	Del8	10.1250	1620.0

Table 14: Revised response matrix for transporters

Commodities transported		Number of trucks (in ton GVW)				Percentage (%) of fleet by fuel type		Permit distribution of trucks [either % or numbers]		Average payload (weight in tons) handled per truck per trip		No of trips per truck per month	Average monthly fuel consumed per truck		Average monthly distance travelled; including empty trips (in km)	
Groups	Please tick [√]	< 12	12-25	>25-40	40+	Diesel	CNG/ LNG	State	All India	Diesel	CNG/ LNG		Diesel (liter)	CNG/ LNG (kg)	State	All India
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
Agricultural, forestry, fishing, animals (live, raw)																
Processed food items / beverages/milk																
Water supply, fuel																
Industrial intermediate items, construction materials, mining and quarrying (minerals, stones, etc.)																
Manufactured items																
Mail and packages																
Medical items																
ALL ITEMS (TOTAL)																

Source: TERI Analysis

Annexure III

List of Participants for Focused Group Discussion on "Non-Urban Road Transport in India"

Date: October 31, 2022 **|** **Time**: 14:00 – 16:00 IST

1. Ms Avni Mehta, GIZ
2. Ms Aishwarya Raman, Ola Mobility India Foundation
3. Mr Dinesh Gupta, Transport Research Wing, MoRTH
4. Mr Satya Kumar Yerubandi, CargoExchange
5. Mr Mehul Khandelwal, Smart Freight Centre [Virtual]
6. Ms Sunitha Anup, International Council on Clean Transportation (ICCT)
7. Ms Priti Shukla, Shakti Sustainable Energy Foundation [Virtual]
8. Ms Chetna Nagpal, Rocky Mountain Institute (RMI India) [Virtual]
9. Mr Pawan Aggarwal, Maruti Logistics Suzuki India
10. Ms Barsha Paul, pManifold [Virtual]
11. Ms Abhansha Somvanshi, pManifold [Virtual]
12. Mr Rohit Pathania, Ola Mobility India Foundation
13. Mr Kumar Nitant, The Climate Group [Virtual]
14. Ms Sayali, pManifold [Virtual]
15. Ms Sharvari Patki, World Resources Institute [Virtual]
16. Mr Sudeept Maiti, World Resources Institute [Virtual]
17. Mr Shri Prakash, The Energy and Resources Institute (TERI)
18. Mr Mukesh Nigam, The Energy and Resources Institute (TERI)
19. Mr I V Rao, The Energy and Resources Institute (TERI)

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