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FAST TRACKING FREIGHT IN INDIA

A ROADMAP FOR CLEAN AND COST-EFFECTIVE GOODS TRANSPORT

NITI AAYOG, RMI, AND RMI INDIA | JUNE 2021

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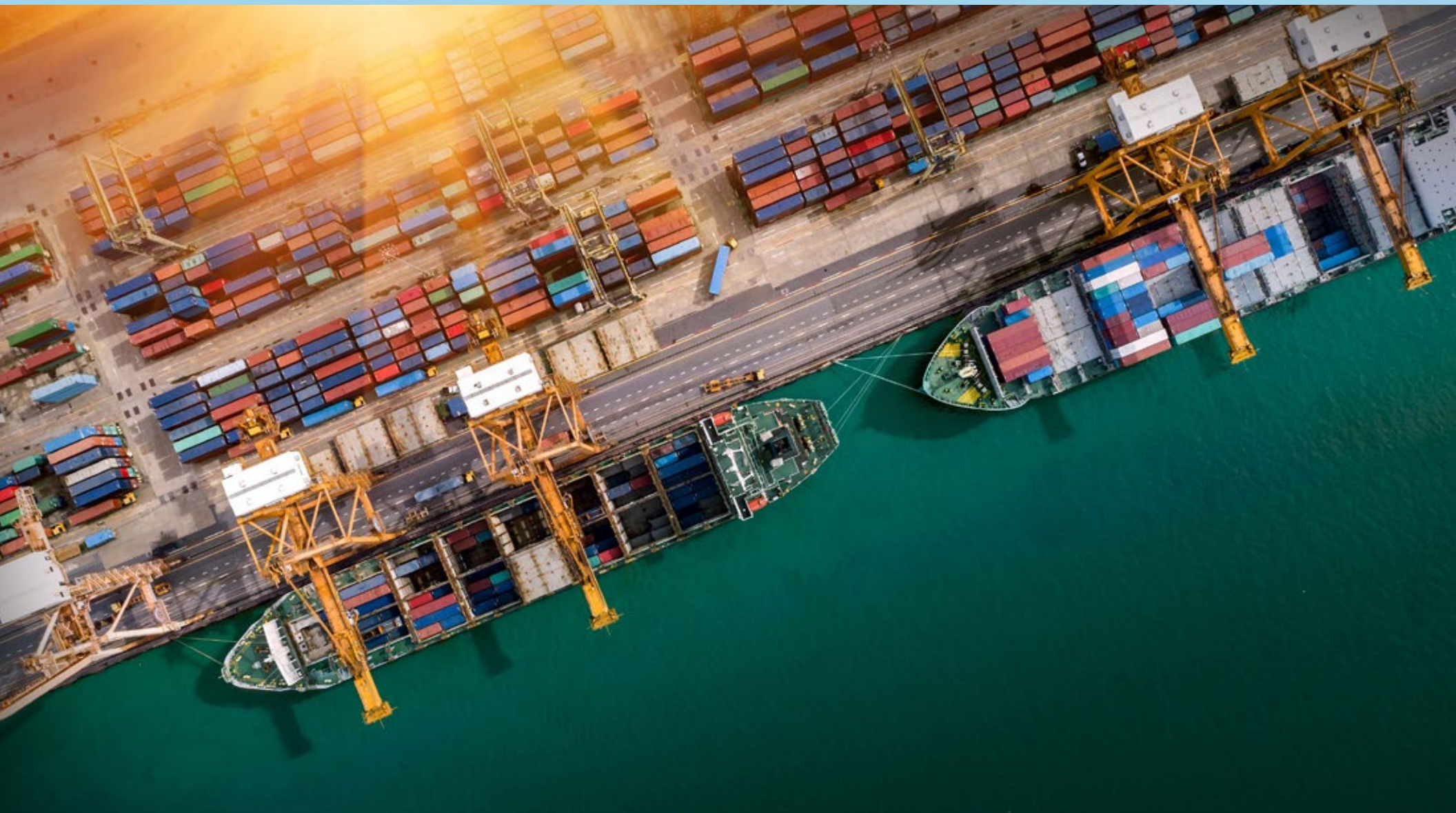


FREIGHT TRANSPORT IS CRITICAL TO INDIA'S GROWING ECONOMY

India has been the world's fastest-growing major economy for four of the past five years, due to rising demand for goods and services. The movement of goods across the country and beyond its borders has created economic opportunities for millions of India's citizens.

Today, the logistics sector represents five percent of India's Gross Domestic Product (GDP)[1] and employs 2.2 crore people.[2] India handles 4.6 billion tonnes of goods each year, amounting to a total annual cost of INR 9.5 lakh crore.[3] These goods represent a variety of domestic industries and products: 22 percent are agricultural goods, 39 percent are mining products, and 39 percent are manufacturing-related commodities.[4] Trucks and other vehicles handle most of the movement of these goods. Railways, coastal and inland waterways, pipelines, and airways account for the rest.

Recognising the critical role of the sector in the country's future, the Government of India (GOI) is pursuing a range of actions to improve its logistics performance. These include the development of dedicated rail-based freight corridors, improvements to the capacity and connectivity of coastal and inland water-based shipping. It is also looking at the buildout of road infrastructure projects such as Bharatmala and the Golden Quadrilateral, and the creation of supportive policies.

As national freight activity grows about five-fold by 2050, India's freight transport ecosystem has a critical role to play in supporting India's ambitious priorities. Some of these include international competitiveness, job growth, urban and rural livelihoods, and clean air and environment.

OBJECTIVES OF THE REPORT

This report aims to:

> Establish a coherent vision for a cost-effective, clean, and optimised freight transport system in India

> Quantify the economic, environmental, and public health benefits of that system

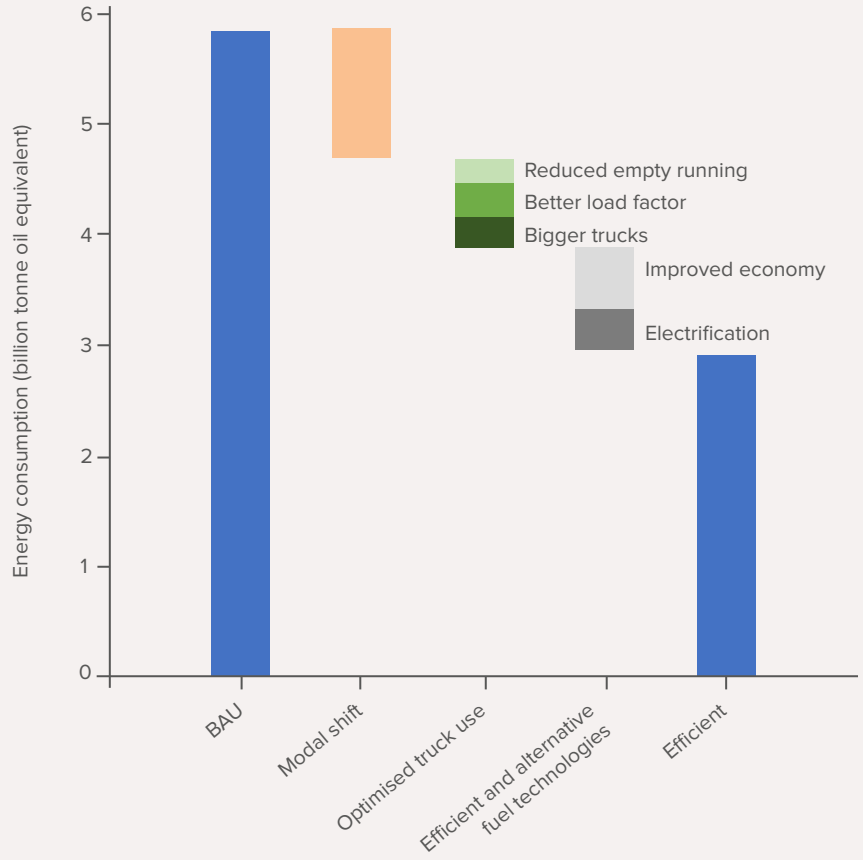
> Describe techno-economically feasible solutions that would collectively deliver those benefits

> Create a call for coordinated action on promising technology, policy, infrastructure, and finance solutions

SHIFTING TO COST-EFFECTIVE, CLEAN FREIGHT TRANSPORT CAN SAVE THREE BILLION TOE OF ENERGY

FIGURE ES-1

Cumulative energy consumption by freight sector between 2020-2050



India's cumulative energy consumption from freight transport between 2020 and 2050 under a business as usual (BAU) scenario will be around 5.8 billion tonnes of oil equivalent (TOE).[6] However, India can reduce this energy consumption by 50 percent under an efficient scenario through three opportunity areas:[7]

> **Increasing the share of rail transport**
> **Optimising truck use**
> **Promoting use of fuel-efficient vehicles and alternative fuels**

These opportunities will also lead to the following benefits:

Reduced logistics costs – India has set a target of reducing the logistics costs as a share of GDP from 14 percent currently to 10 percent by 2022,[8] which can save up to INR 10 lakh crore.[9]

Reduced carbon emissions and improved air quality – India can save 10 giga tonnes of CO_2, 500 kilo tonnes of particulate matter (PM) and 15 million tonnes of nitrogen oxide (NO_x) caused by freight transport by 2050.[10]

Less truck traffic on roads – Improved mode share and efficient logistics can reduce the vehicular-freight activity by 48 percent in 2050 over a BAU scenario.[11]

This new freight paradigm will also lead to higher economic growth, more employment opportunities, better public health, and enhanced logistics productivity, which will meet many of India's development goals.

ENHANCE RAIL MODE SHARE IN INDIA BY INCREASING RAIL NETWORK CAPACITY, PROMOTING INTERMODAL TRANSPORT

CONTEXT

Rail's share in freight transportation in India has been declining since 1951. In 2020, it stood at merely 18 percent as compared to road's share of 71 percent.[12] This is due to insufficient rail capacity, especially on certain high-density routes. Several factors suggest that rail could be a cost-effective and efficient alternative for a significant share of India's freight:

- **A commodity mix that has a high share of bulk goods –** suitable for rail's bulk-handling capabilities
- **Freight travel is often over longer distances –** suitable to rail's economies of scale relative to road transport
- **India has a low coast-to-landmass ratio** – between the two low-carbon freight modes, rail and coastal, India's geography makes rail more feasible in many areas of the country as compared to coastal

The role of rail is not limited to bulk freight. By combining rail and road transport for containerised goods, a practice known as intermodal, rail can compete for a market share of higher value, non-bulk goods.

SOLUTIONS

To increase the mode share of rail transport, India can prioritise the following solutions:

- Increase the rail network capacity
- Increase the share of intermodal transportation

The following actions can support the deployment of these solutions:

- Improve existing network infrastructure by increasing axle loads, increasing train length, and enabling trains to move faster
- Add new network capacity by developing specialised heavy-haul corridors and dedicated freight corridors
- Identify and upgrade corridors with high potential for intermodal transport
- Ensure better modal integration across rail, road, and water

Existing government policy to support the change: Dedicated Freight Corridors

The GOI has invested in the buildouts of dedicated freight corridors. While the eastern and western dedicated freight corridors are expected to be commissioned by June 2022, work on four other corridors will be undertaken in the future.[13] These corridors will increase rail network capacity and support improved rail mode share.

OPTIMISE TRUCK USE BY IMPROVING TRANSPORTATION AND WAREHOUSING PRACTICES

CONTEXT

Logistics costs in India are high, accounting for 14 percent of the GDP.[14] Transportation and inventory costs account for more than 90 percent of these costs.[15] These high costs are, in part, a result of low logistics efficiency due to a fragmented market, lack of standardised trucking assets, old vehicles[16] and obsolete warehousing technologies.[17] These factors have resulted in:

- Low truck utilisation
- High empty running of trucks
- Overloading of trucks

By optimising truck use, vehicular movement and travel time can be reduced, and logistics practices can be made less emission- and cost-intensive.

SOLUTIONS

To optimise truck use, India can prioritise the following solutions:

- Improve transportation practices
- Improve warehousing practices

The following actions support the deployment of these solutions:

- Improve load matching using digital platforms and get freight on the right type of truck, depending on the use case
- Maximise vehicle productivity through efficient packaging and loading
- Improve the siting of warehouses using the principles of optimised network design
- Improve the performance of warehouses by implementing advanced digitised tools

Existing government policy to support the change: Logistics Efficiency Enhancement Program (LEEP)

LEEP is designed to improve logistics efficiency using infrastructure solutions like building 35 multimodal logistics parks as well as introducing technological and digital solutions like goods tracking.[16]

FUEL-EFFICIENT, CLEAN AND ELECTRIC VEHICLES CAN REDUCE DIESEL CONSUMPTION OF FREIGHT MOVEMENT IN INDIA

CONTEXT

Internal combustion engine (ICE) vehicles, mostly powered by diesel, dominate India's road-based freight activity. Electric vehicle (EV) sales penetration of freight vehicles is less than 1 percent.[18] Moreover, trucks in India also have poor fuel economy. Three market characteristics contribute to these factors:

- Low availability and lack of information about fuel-saving technologies among fleet operators[19]
- Reluctance to invest in fuel-saving technologies and EVs due to lack of access to finance[20]
- High capital cost of EVs

Poor fuel economy leads to externalities such as high costs, higher CO_2, PM and NO_x emissions. For example, fuel costs account for 70 percent of a diesel-powered heavy-duty truck's total cost of ownership (TCO).[21] Medium and heavy-duty trucks comprise 41 percent of vehicular CO_2 emissions and 53 percent of PM emissions.[22] This is disproportionately high compared to their share in India's total vehicle population.

SOLUTIONS

To promote clean, fuel-efficient vehicle technologies such as EVs, India can prioritise the following solutions:

- Improve fuel economy and reduce ICE vehicles' emissions
- Use EVs and cleaner fuels

The following actions can support the deployment of these solutions:

- Enhance fuel consumption and emissions standards of ICE vehicles
- Promote collaboration across industry players to share experiences with technology solutions
- Implement supportive policies and pilot projects to deploy EVs and charging infrastructure
- Manufacture high-quality electric vehicles and create a robust charging infrastructure network

Existing government policy to support the change: Faster Adoption and Manufacturing of Electric Vehicles II (FAME II)

FAME India Scheme Phase II
(National Mission on Electric Mobility)

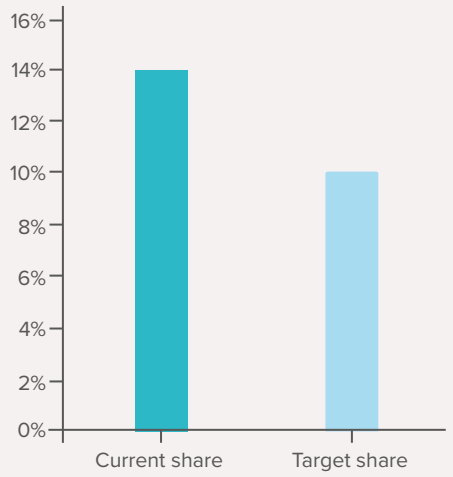
FAME II is a subsidy by GOI to accelerate manufacturing and the deployment of EVs. The scheme focuses on reducing TCO of EVs by providing upfront subsidies. Under the FAME II scheme, the government has allocated INR 8,596 crore for upfront subsidies for electric vehicles and INR 1,000 crore for charging infrastructure.[23]

THIS FREIGHT PARADIGM CAN UNLOCK ECONOMIC, ENVIRONMENTAL AND PUBLIC HEALTH BENEFITS

REDUCED LOGISTICS COSTS

FIGURE ES-2

Logistics costs as a share of GDP

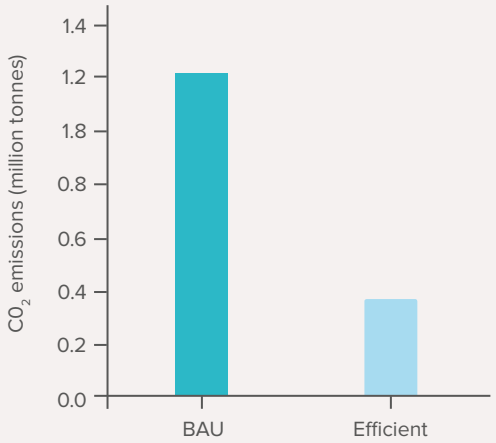


By moving freight to rail and optimising truck use, India can reach its goal to reduce logistics cost from 14 percent of GDP to 10 percent by 2022.[24] This can save up to INR 10 lakh crore in 2022.[25]

REDUCED CO_2 EMISSIONS

FIGURE ES-3

CO_2 emissions from freight sector in India in 2050



By switching from inefficient ICE vehicles to cleaner fuels and efficient vehicles, moving freight away from road to rail, and optimising vehicle use, CO_2 emissions can be reduced by 70 percent in 2050 over a Business-As-Usual scenario (BAU), which projects current trends into the future.[26]

IMPROVED SAFETY AND PUBLIC HEALTH

FIGURE ES-4

NO_x emissions from freight sector in India in 2050

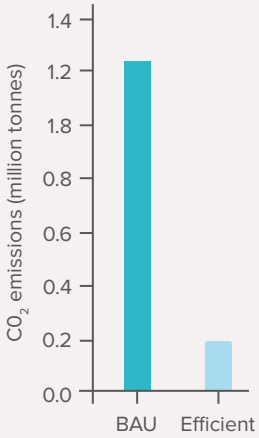
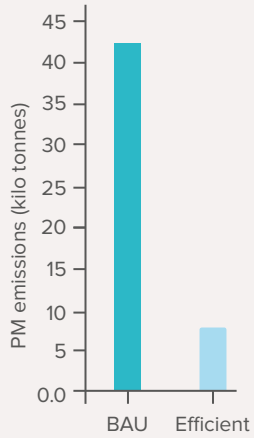


FIGURE ES-5

PM emissions from freight sector in India in 2050



BS VI standards will enable big reductions in NO_x and PM emissions. However, these emissions can be reduced by an additional 80 percent by 2050 by deploying cleaner freight vehicles and optimising mode share.[27]

A PHASED, MULTISTAKEHOLDER IMPLEMENTATION APPROACH CAN ENABLE INDIA TO CAPTURE THOSE OPPORTUNITIES

Improved rail mode share, increased logistics efficiency and clean vehicles are the building blocks for a transformative freight paradigm that is within India's reach. This freight paradigm will be cost-effective with reduced transport costs, clean with more efficient and electric vehicles, and optimised with improved mode share and operational efficiency. Implementing multistakeholder collaboration in a phased manner is critical to this transformation and can be implemented as below:

Ecosystem of actors to enable cost-effective, clean and optimised freight paradigm

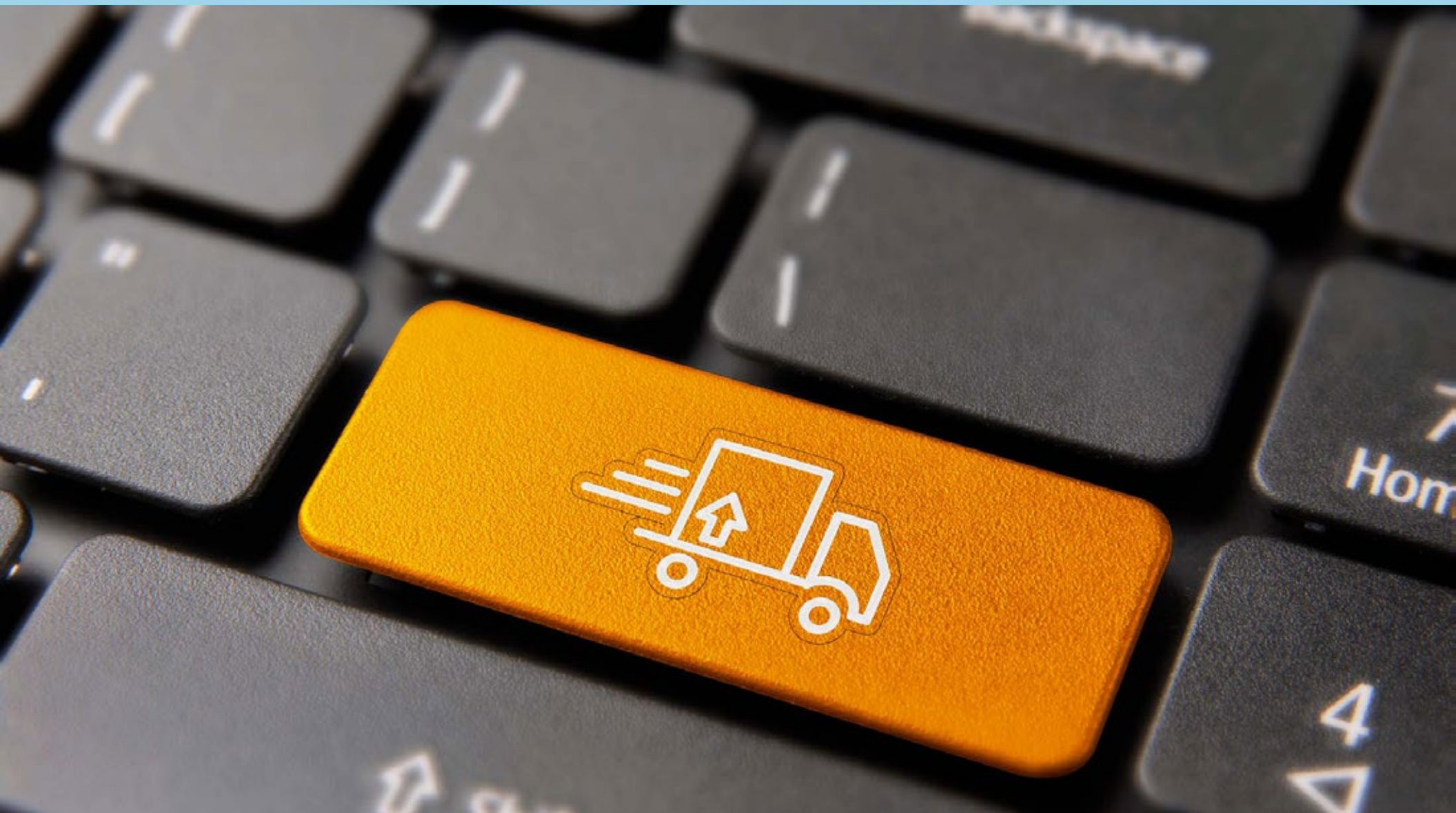
	PHASE 1 **NOTCHING THE ARROW**	PHASE 2 **DRAWING THE BOW**	PHASE 3 **LETTING THE ARROW FLY**
Government	• Make investments in rail infrastructure and multimodal logistics parks • Design policies to make cleaner fuels and EVs affordable • Ensure fuel economy standards are met	• Develop a specialised heavy-haul rail corridor • Optimise siting of intermodal parks • Design mandates to scrap the use of old ICE vehicles	• Build a national network of dedicated. freight track with intermodal and heavy haul capabilities • Introduce EV mandates for trucking
Industry	• Invest in manufacturing and adoption of bigger and better trucks • Digitise warehousing practices • Invest in the standardisation of logistics assets	• Introduce R&D and manufacturing programmes to improve EV design • Introduce sustainability initiatives within the corporate sector across the supply chain	• Manufacture best in class electric trucks. • Ensure warehouses have state-of-the-art assets and practices
Multistakeholder collaboration	• Host pilots to test alternative fuels, EVs and efficient logistics practices • Optimise siting of EV infrastructure	• Promote standardisation across different modes of transport • Build capacity amongst leaders and technical workers to develop an advanced rail network	• Run multistakeholder consortiums to continually evaluate and improve policymaking and business models on transportation and warehousing efficiency

This report aims to provide a perspective on the future of goods movement in India and covers following topics:

1. **Background and context:** India's rapidly evolving freight sector
2. **Vision and opportunity:** Levers for transformation
3. **Opportunity overview:** Context, solutions, case studies and next steps for identified opportunities
4. **Path forward:** A roadmap towards the transition

01 BACKGROUND AND CONTEXT

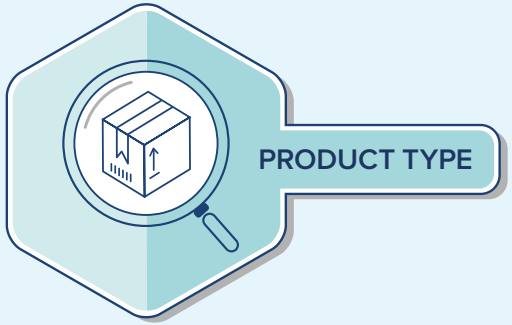
> INDIA'S RAPIDLY EVOLVING FREIGHT SECTOR



LOGISTICS REFERS TO THE PROCESS OF MOVING AND STORING GOODS AS THEY MAKE THEIR WAY TO THE CONSUMER

As products are made, they move along a supply chain until they reach the consumer. To move those goods, the logistics sector combines vehicles and warehouses, all of which are selected to efficiently move and process them. The types of vehicles and storage facilities selected are typically based on the type of goods being moved and the distance over which they are being moved. This process of supply chain managers efficiently deploying and using a set of vehicles and warehouses to move goods through the production process to their final use by consumers is critical to the wellbeing of communities and economies.

PRIMARY CHARACTERISTICS OF FREIGHT TRANSPORT

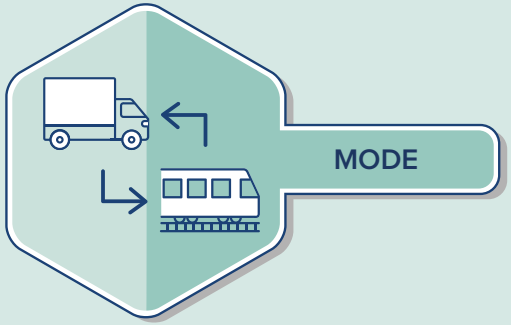


On a high level most freight transport falls into one of five categories:

- Dry bulk
- Wet bulk
- Refrigerated
- Containerised
- Break bulk

Based on the distance between the pickup and drop off locations of goods, freight movement can be categorised into three types:

- **Long haul:** movement of goods across countries or states
- **Regional haul:** movement of goods within a region, state, or metropolitan area
- **Urban haul:** movement of goods terminating in the city boundaries



Depending on both good type and the distance which it must travel, five modes of transport can be deployed:

- Road
- Rail
- Air
- Water
- Pipeline

PRODUCT SUPPLY CHAIN INVOLVES MULTIPLE MODES OF TRANSPORT

The manufacturing and distribution of any product typically involves multiple types of modes. For example, consider a product made in Malaysia, bought by a consumer in India. The raw material may be transported to the processing unit by rail. The finished goods may be shipped overseas on a container vessel, across the country by rail, brought to a distribution centre by a truck and LCV, and finally delivered to the store by a three-wheeled goods vehicle where it is sold to a consumer.

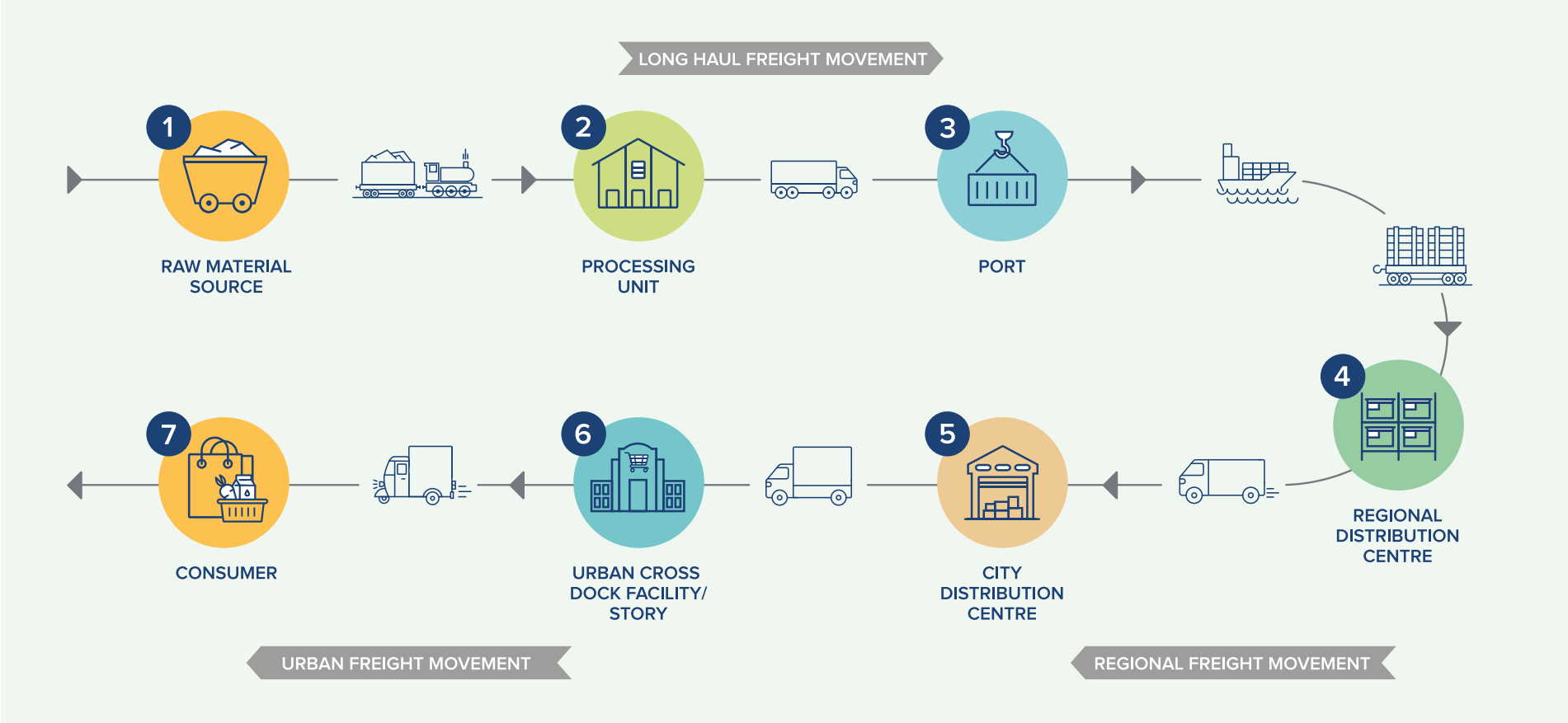
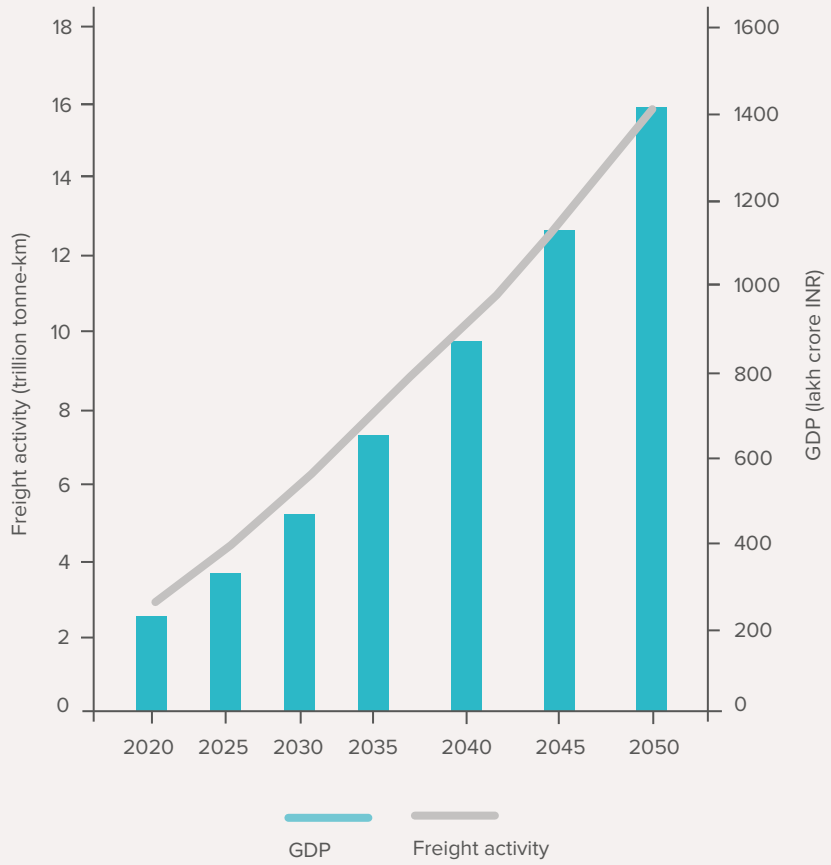


Exhibit 1-1 Supply chain of goods across various modes

INDIA'S LOGISTICS SECTOR IS AN INR 11 LAKH CRORE INDUSTRY THAT IS EXPECTED TO GROW AT 7%

FIGURE 1-1

Projected freight activity and GDP growth in India



India's logistics sector comprises over 10,000 types of products and has a market size of INR 11 lakh crore. It is expected to grow to a market of INR 15 lakh crore by 2022.[28] Currently, commercial activities in India generate about 4.6 billion tonnes of freight annually, which results in over three trillion tonne-km of transportation demand at a cost of INR 9.5 lakh crore.[29] This demand for freight transport has been rising as the population has grown and standards of living have improved, leading consumers and business to demand and consume more goods.

Between 2015 and 2020, India's GDP grew by 32 percent to 217 lakh crore[30] —making India the sixth largest economy in the world.[31] In the same decade, India's population also increased by 5 percent,[32] while freight demand increased by 28 percent.[33] With rising income levels, higher exports, a rapidly growing e-commerce sector, a growing retail sales market, and a projected GDP growth of seven to eight percent in the next five years, the demand for goods movement is also expected to increase at 7 percent Compound Annual Growth Rate (CAGR).[34] As the demand for goods continues to grow, goods movement is expected to increase to 15.6 trillion tonne-km in 2050.[35] This activity will spur growth across freight modes, but especially in road-freight transport. This will lead to over three trillion kilometres travelled on Indian roads by freight vehicles in 2050.[36]

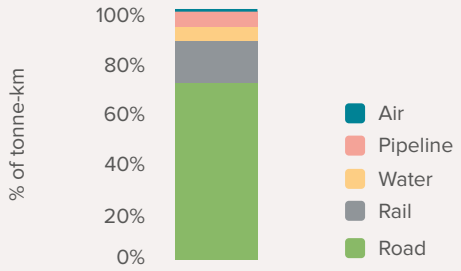
To meet this demand, India has been continuously improving its logistics system. India had improved its score on the Logistics Performance Index (LPI), a World Bank tool, commonly used to measure a country's logistics capabilities, from 3.07 to 3.42 between 2007 and 2016.[37] This progress came from improving infrastructure, introducing policies and programmes like Make in India, and incorporating technological and digital improvements in the logistics supply chain. However, work remains to be done. Despite being one of the world's biggest and fastest-growing logistics industries, India's LPI only ranks 44th in the world.[38] This ranking can be improved by tapping into the opportunity areas outlined in the report.

EXISTING INEFFICIENCIES IN THE SYSTEM ARE CREATING A DRAG ON LOGISTICS DEVELOPMENT

EXISTING INEFFICIENCY IN THE FREIGHT TRANSPORT SYSTEM

SKEWED MODAL SHARE

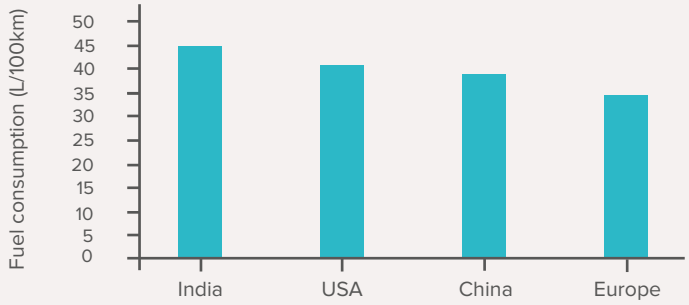
FIGURE 1-2 Modal split for freight movement in India in 2020



Around 71 percent of India's freight is transported through road, and only 17.5 percent is through rail.[39] Road transport is more energy and CO_2 intensive, costly, and accident-prone than other modes for moving freight like rail and water. India's current overuse of heavy trucks lead to high costs, air pollution and excess traffic deaths, especially from overloaded trucks. If these issues grow, they put the development of the logistics system at risk.

EXCESS CONSUMPTION OF DIESEL AND OTHER POLLUTING FUELS

FIGURE 1-3 Fuel consumption of HDVs[40]



Heavy-duty vehicles in India are not fuel-efficient as compared to peer geographies like USA, China and Europe. This has led to higher fuel consumption and higher fuel costs. Around 90 percent of road freight movement (in terms of vehicle kilometre travelled (VKT)) uses diesel as a fuel,[41] which is a significant source of pollution in India. This creates an opportunity to switch to cleaner fuels, like battery-electric or hydrogen-fuel-cell electric vehicles.

LOW OPERATIONAL EFFICIENCY

- 40–50% lower annual truck utilisation than the global standards
- 28–43% empty running
- Overloading of trucks

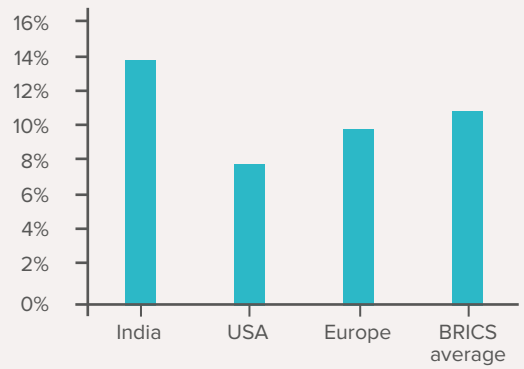
Truck productivity in India is low as compared to global standards. For example, trucks in India travel about 300 km per day compared to the global average of 500 to 800 km per day.[42] The truck sizes are smaller, they are often overloaded beyond their capacity,[43] and have empty running rates as high as 40 percent.[44] This results in more driving to move the same amount of goods, causing high costs and higher emissions.

THE NEGATIVE IMPLICATIONS OF THESE INEFFICIENCIES WILL COMPOUND WITH INCREASED FREIGHT ACTIVITY

HIGH LOGISTICS COSTS

FIGURE 1-4

Logistics costs as a share of GDP

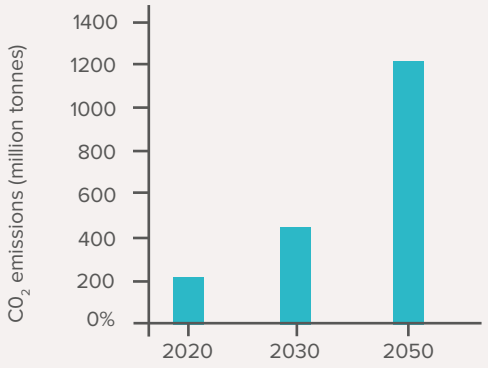


India's logistics cost as a share of GDP is 14 percent, which is high when compared to developed nations, where it ranges between eight and ten percent.[45] Compared to the United States, road transportation costs in India are 30 percent higher, while rail and coastal are 70 percent higher.[46,47] The high cost of logistics hampers the economic prosperity of the nation.

CO_2 EMISSIONS

FIGURE 1-5

CO_2 emissions from freight transportation



CO_2 emissions from freight transport are projected to increase by 451 percent – from 220 million tonnes in 2020 to 1,214 million tonnes in 2050.[48] Road freight is the biggest contributor to these emissions, responsible for 95 percent of the freight CO_2 emissions in 2020.[49] In 2050, road freight will still be the biggest contributor to CO_2 emissions, while air transport will be the second-biggest contributor, mainly due to increased express and overnight deliveries of products.[50]

SAFETY AND PUBLIC HEALTH

FIGURE 1-6

NO_x emissions from freight transport

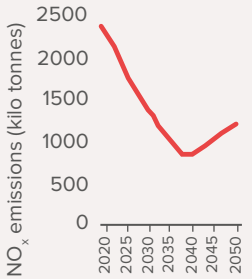
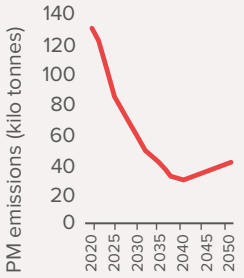


FIGURE 1-7

PM emissions from freight transport



Note: "The initial decrease in PM and NO_x reductions is anticipated with the implementation of BSVI norms"

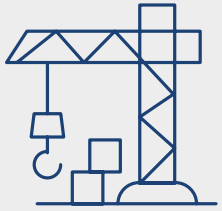
Freight vehicular activity has negative externalities associated with public health and safety for two reasons. First, ICE freight vehicles contribute significantly to particulate matter (PM), nitrogen oxides (NO_x), which negatively impact human health. The freight sector is responsible for 132 kilo tonnes of PM emissions and 2.4 million tonnes of NO_x emissions in 2020.[51] Secondly, freight transport is one of the leading causes of road accidents. Trucks account for 12.3% of road accidents and 15.8% of total road transport related deaths (24,000 deaths per year), majority of which are due to overloaded trucks.[52]

INDIA HAS A STRONG FOUNDATION, BOTH IN PUBLIC AND PRIVATE SECTORS, TO BUILD A WORLD-CLASS FREIGHT SYSTEM

India has a portfolio of policies and supportive market trends that can accelerate the transition to effective, cost-efficient, clean, and safe freight movement.

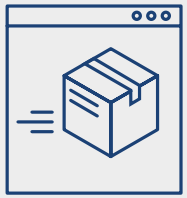
ENABLING MARKET CONDITIONS

INDIA'S GROWING IT CAPABILITIES



EXPERIENCED MANUFACTURING SECTOR

DYNAMIC MARKET ECONOMY



GROWING E-COMMERCE MARKET

BLOOMING ENTREPRENEURIAL CULTURE

CULTURE OF INNOVATION

SUPPORTIVE POLICY ENVIRONMENT

MAKE IN INDIA

Make in India is an initiative to promote domestic manufacturing of products and infrastructure by providing dedicated investments. The initiative aims to reduce India's reliance on other nations for manufacturing capabilities of goods and associated infrastructure.[53]

DIGITAL INDIA

Digital India is a flagship programme with a vision to transform India into a digitally empowered society and knowledge economy. The vision of the programme will support the digitisation of the supply chain that can improve logistics efficiency.[54]

LOGISTICS EFFICIENCY ENHANCEMENT PROGRAM (LEEP)

LEEP is designed to improve freight transportation efficiency by improving associated cost, transportation time, and logistical practices like goods transferring and tracking through infrastructure, technology, and process interventions.[55]

NATIONAL LOGISTICS POLICY (DRAFT)

The goal of the National Logistics Policy is to enhance the economic growth of India by making the logistics sector more efficient, seamless, and integrated. It also aims to drive down logistics costs as a share of GDP.[56]

FASTER ADOPTION AND MANUFACTURING OF ELECTRIC VEHICLES (FAME II)

FAME II is a subsidy scheme by the GOI to accelerate the manufacturing and uptake of electric vehicles. Policies like FAME II will promote the deployment of EVs and associated charging infrastructure for freight EVs.[57]

BHARAT STAGE (BS) EMISSION NORMS

Bharat Stage Emission Norms are emissions standards set by the GOI to reduce criteria pollutant emissions from motor vehicles and improve vehicle efficiency. BS VI has been effective since April 2020.[58]

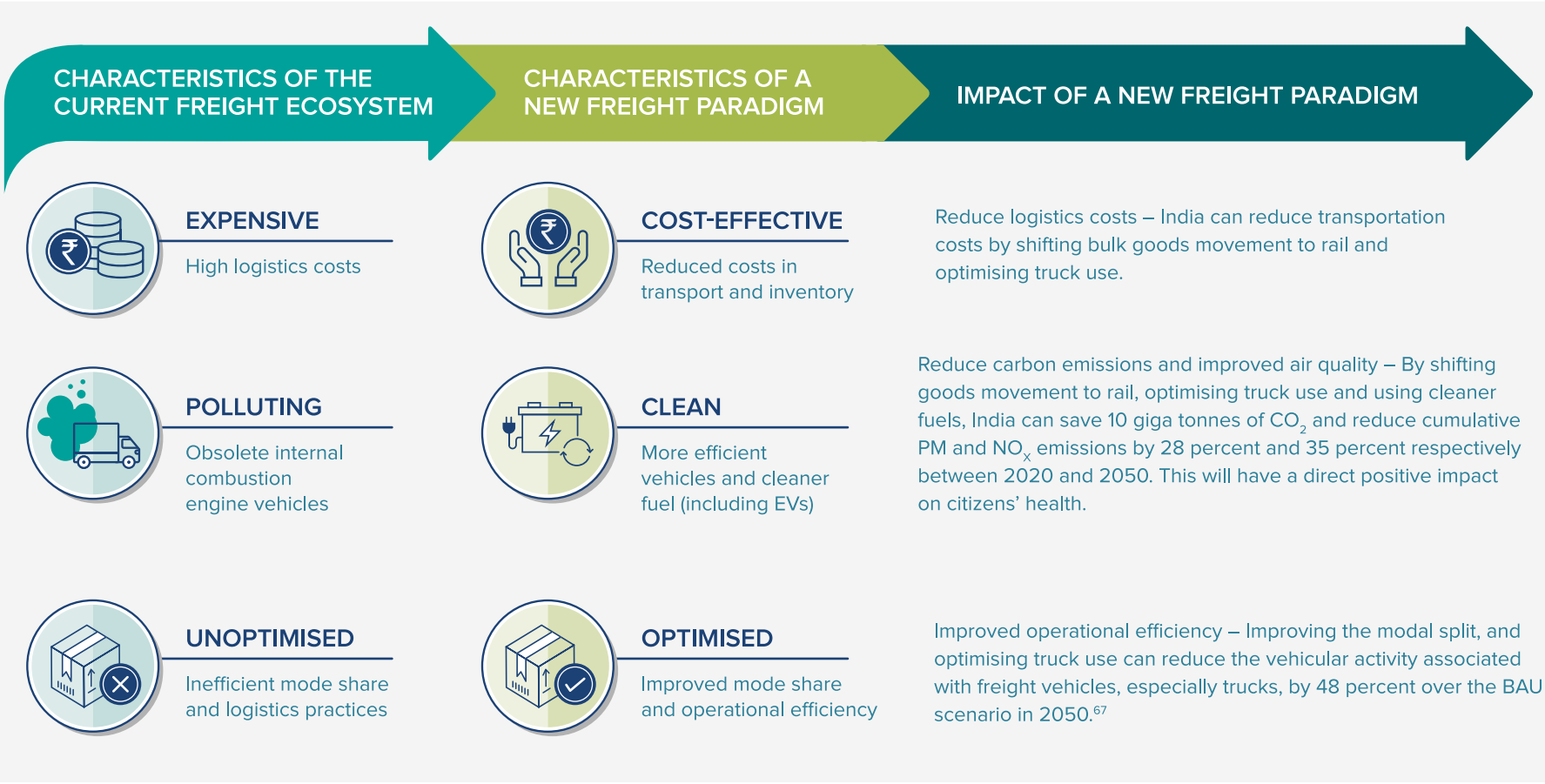
INDIA IS ALSO DEVELOPING INFRASTRUCTURE TO SUPPORT GROWING FREIGHT DEMAND

The Union Budget announced in 2021 allocated INR 2.3 lakh crore for transport infrastructure.[59]

1	**The dedicated freight corridors** are long distance, high-capacity freight rail routes that are being developed by the GOI for freight movement.[60]
2	**The Sagarmala** project focuses on developing waterways transport by improving existing ports and developing Coastal Economic Zones.[61]
3	**The Bharatmala and Golden Quadrilateral** projects focus on the development of road highway infrastructure in the country.[62]
4	**The Jal Marg Vikas Project (JMVP)** is developed for operations for operations of National Waterway 1 is under progress.[63]
5	**National infrastructure pipeline** includes over 7,400 infrastructure projects – INR 30 lakh crore for roads, INR 14 lakh crore for railways, INR 1.4 lakh crore for airports and INR one lakh crore for ports and inland waterways.[64]
6	**UDAN scheme** aims to establish 100 more airports to improve air connectivity.[65]
7	**Hydrogen Energy Mission** is aimed to ramp up the production for green hydrogen used for various end use sectors such as industries and transport.[66]

INDIA CAN SHIFT TO A CLEAN, OPTIMISED, AND COST-EFFECTIVE FREIGHT TRANSPORT SYSTEM

To sustain the growing demand for freight transport without driving existing externalities to extreme levels, Indian stakeholders need to take steps to shift to a new freight paradigm that is more cost-effective, clean, and efficient. This new freight transportation paradigm will also help India achieve its development goals, including improved air quality, improved GDP, better public health, enhanced logistics productivity, more employment opportunities, and is in-line with India's clean mobility ambitions.



02 VISION AND OPPORTUNITY

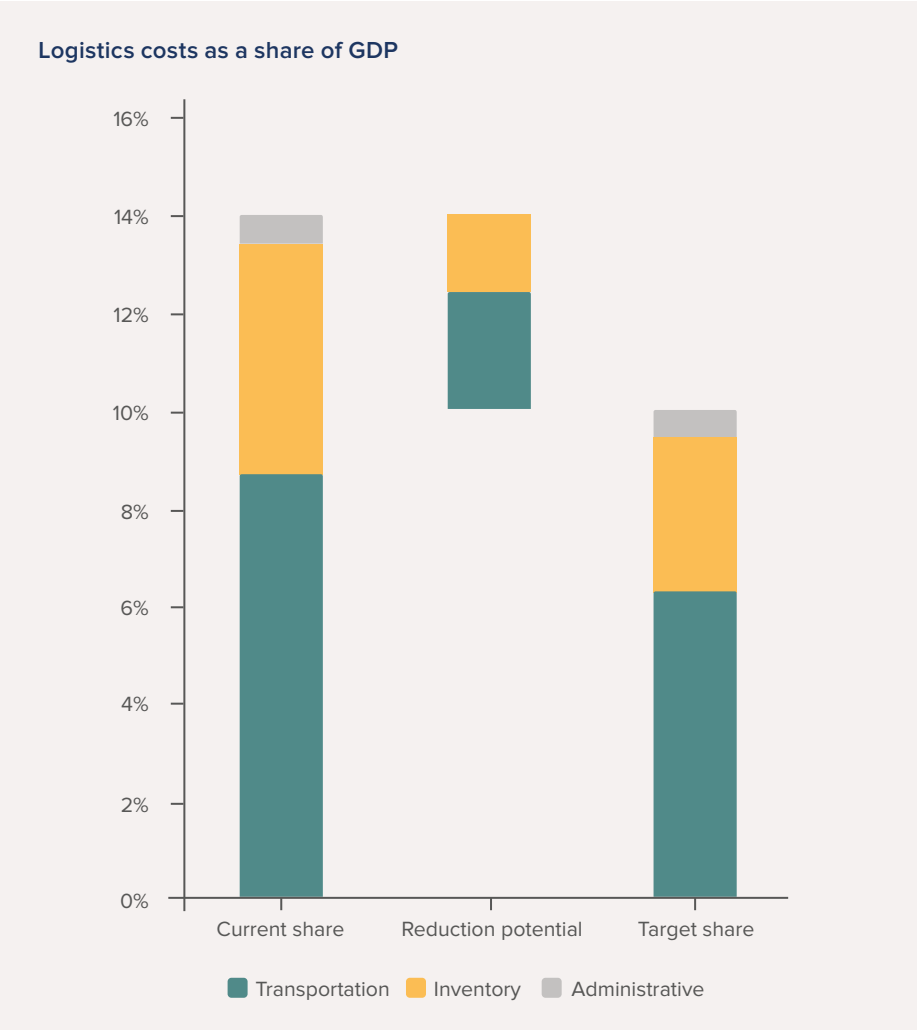
> LEVERS FOR TRANSFORMATION

THREE OPPORTUNITIES EXIST TO SHIFT TO AN EFFICIENT FREIGHT PARADIGM

	1 INCREASE THE MODE SHARE OF RAIL TRANSPORT	2 OPTIMISE TRUCK USE	3 PROMOTE EFFICIENT AND ALTERNATIVE FUEL TECHNOLOGY
WHAT DOES THIS MEAN?	• Shift the movement of goods from trucks to rail.	• Improve utilisation and reduce empty running of trucks.	• Improve vehicle efficiency and switching to alternative fuels.
WHY SHOULD INDIA DO IT?	• Rail costs less compared to trucks. • Rail emits less CO_2 than trucks on a per tonne-km basis and improves air quality by emitting lesser PM, SO_X, NO_X emissions. • With fewer trucks on the road, public health of citizens will improve.	• This can improve logistics efficiency and truck productivity and in turn, reduce costs and emissions.	• Cost effective technologies exist to make ICE vehicles more fuel-efficient. • EVs consume less energy, emit less CO_2 than ICEs, have no tailpipe emissions and have lower operational costs.
HOW CAN INDIA DO IT?	• India will need to invest heavily in rail capacity additions and infrastructure upgrades, and tap into the intermodal market.	• Truck use can be optimised by improving transportation and warehousing practices.	• ICE vehicles can be made more fuel-efficient by investing in efficiency technologies and tightening fuel consumption standards. • Policy interventions and innovative business solutions can accelerate the deployment of EVs.

INDIA CAN REDUCE ITS LOGISTICS COSTS BY INR 10 LAKH CRORE IN 2022 BY IMPROVING FREIGHT EFFICIENCY...

FIGURE 2-1



As shown in figure 2-1, India can reduce its logistics cost through three measures:

1. Transport costs can be reduced by improved modal share, trucking efficiency, and reducing fuel costs.
2. Inventory costs can be reduced by improving warehousing infrastructure, and by enhancing supply chain design and management.
3. Admin costs can be reduced with modern IT and management techniques.

By reducing these costs, India can save INR 10 lakh crore in 2022.[68]

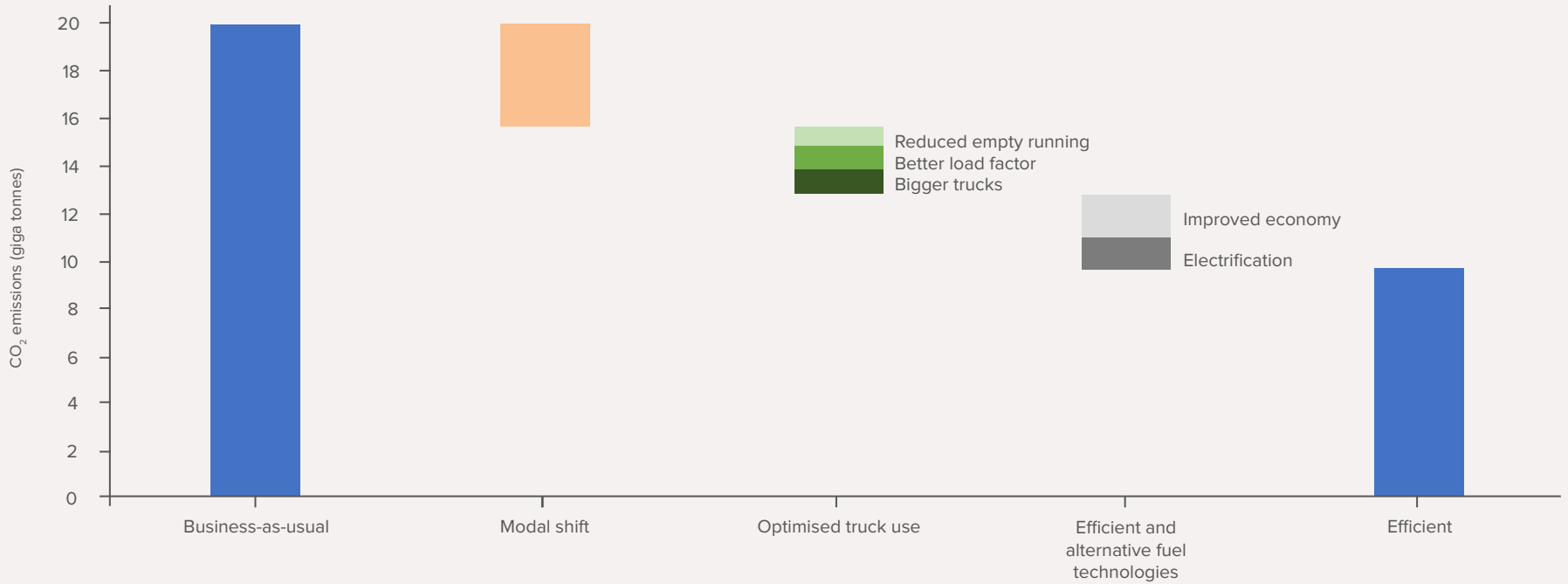
Sustainable and efficient freight development also promotes the economic and social development of the country:

- The development of freight infrastructure reduces costs for businesses and improves delivery productivity by reducing travel time and enabling improved supply-chain practices.
- Improved freight movement increases employment opportunities for less-developed regions or disadvantaged social groups through direct jobs such as freighters, managers, and shippers. More importantly, improved connectivity through the development of infrastructure can lead to the creation of manufacturing jobs as well as supporting service sector jobs such as insurance and finance. Overall, this can help reach the Ministry of Commerce and Industry's target to increase employment in the logistics sector by 2 crore by 2022.[69]
- The development of freight-specific infrastructure can provide robust connectivity between major agricultural, industrial, and cultural centres in India, creating economic benefits. For example, the faster transfer of farming goods between farms and cities for sales and exports can reduce spoilage by 25 percent.[70]

...WHILE DECREASING ITS FREIGHT-RELATED CO_2 EMISSIONS BY 52 PERCENT IN 2050

FIGURE 2-2

Cumulative CO_2 emissions from freight sector in India between 2020-2050



Presently, in India, CO_2 emissions due to the freight transport sector are 220 million tonnes, road freight accounting for 95 percent of it.[71] Shifting from road to rail can be the most effective lever to decarbonise the freight transport sector, reducing CO_2 emissions by 4.3 giga tonnes between 2020-2050. Following mode shifting, minimising truck usage to reduce empty running, and improve load factors can reduce emissions by 2.8 giga tonnes in the same 30-year timeframe. Improving vehicle technology by using efficient vehicles and EVs can reduce emissions by another 3.2 giga tonnes. Overall, this will lead to a reduction of 52 percent cumulatively (or 10 giga tonnes) by 2050 over a BAU scenario.[72]

THESE OPPORTUNITIES WILL HAVE A POSITIVE IMPACT ON PUBLIC HEALTH

FIGURE 2-3

Cumulative NO_x emissions from freight sector in India between 2020-2050

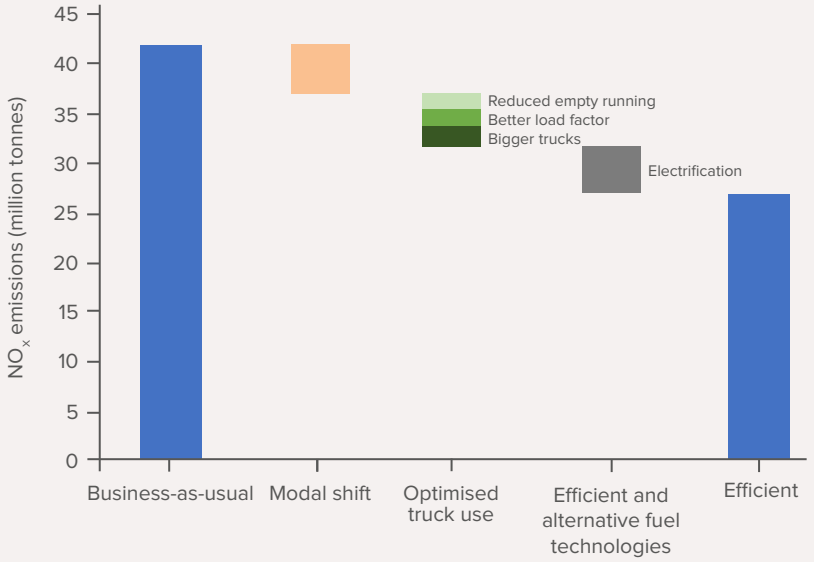
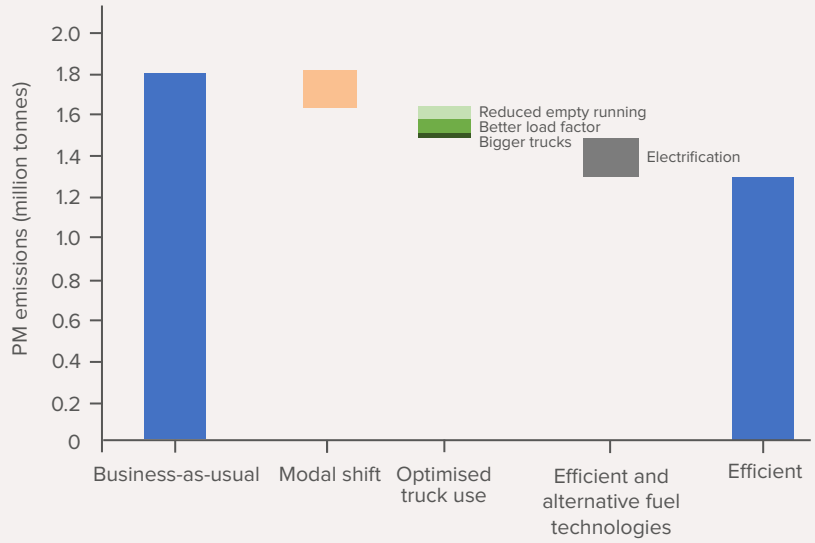


FIGURE 2-4

Cumulative PM emissions from freight sector in India between 2020-2050



ICE vehicles emit criteria pollutants such as NO_x and PM, which directly impact public health. PM particles affect the respiratory and cardiovascular organs leading to problems such as heart attacks, asthma, and other lung issues.[73] NO_x particles combine with other particles to form PM, aggravating its effect. NO_x also attacks the respiratory system.[74] In 2015, these criteria pollutants from the transport sector in India led to 74,000 premature deaths.[75]

Presently NO_x and PM emissions in India stand at 2.4 million tonnes and 132 kilo tonnes respectively. India recently introduced Bharat Stage VI standards that regulate emissions from vehicles. India can further reduce these criteria pollutant emissions by moving freight from road to rail, optimising truck use and switching to EVs. With these levers, India can reduce NO_x emissions by 35 percent and PM emissions by 28 percent between 2020 and 2050 over a BAU scenario.[76]

A SET OF SOLUTIONS EXISTS TO REALISE THE IDENTIFIED OPPORTUNITIES

With a strong foundation of supportive policies and market trends, India can leverage the opportunities mentioned in exhibit 2-1 by implementing a set of solutions. The following sections of the report will outline these solutions, highlight India's current status, and support the analysis with global case studies.

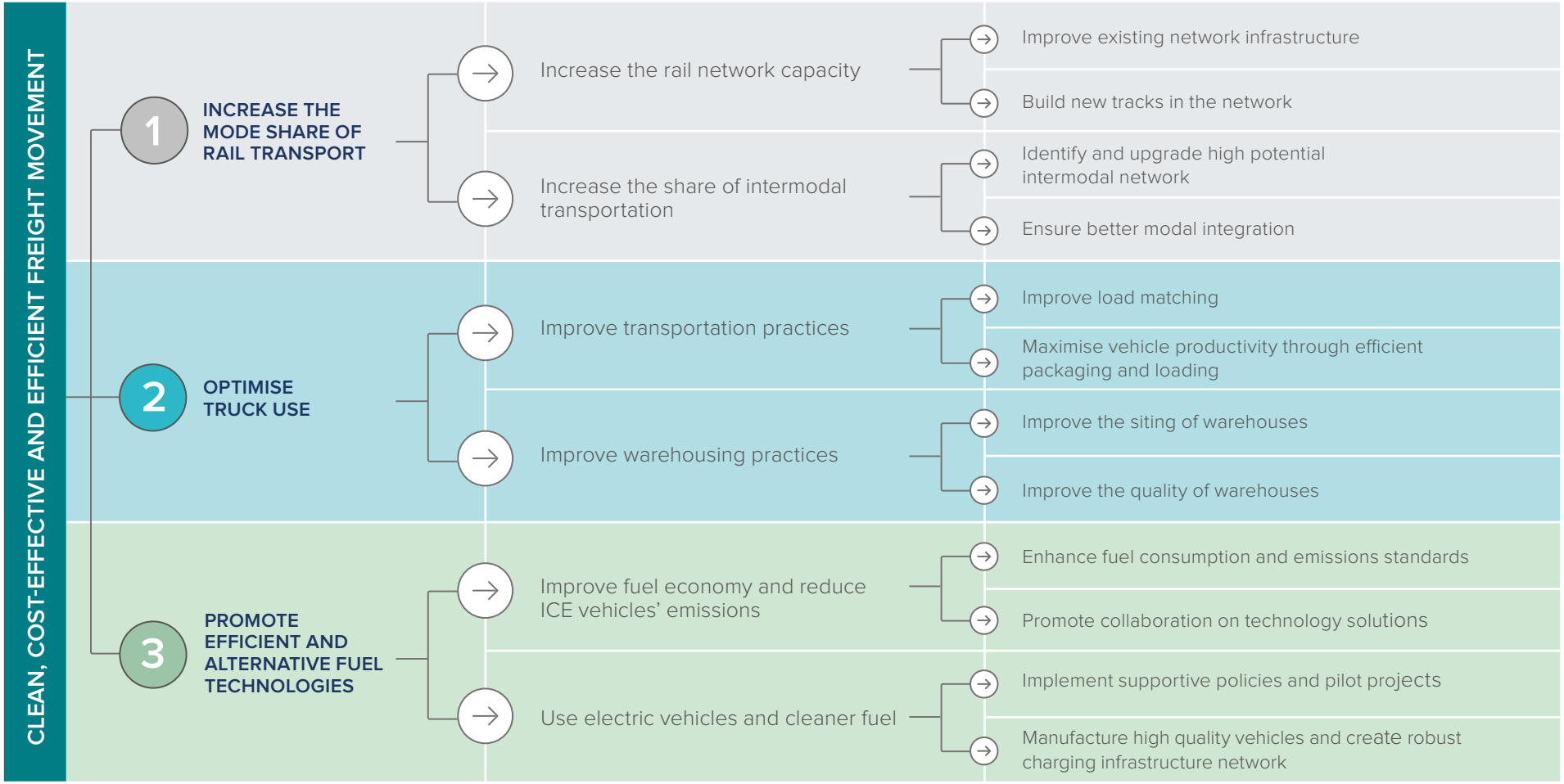


EXHIBIT 2-1 Set of solutions to achieve clean, cost-effective and efficient freight movement

03 OPPORTUNITY 1 OVERVIEW

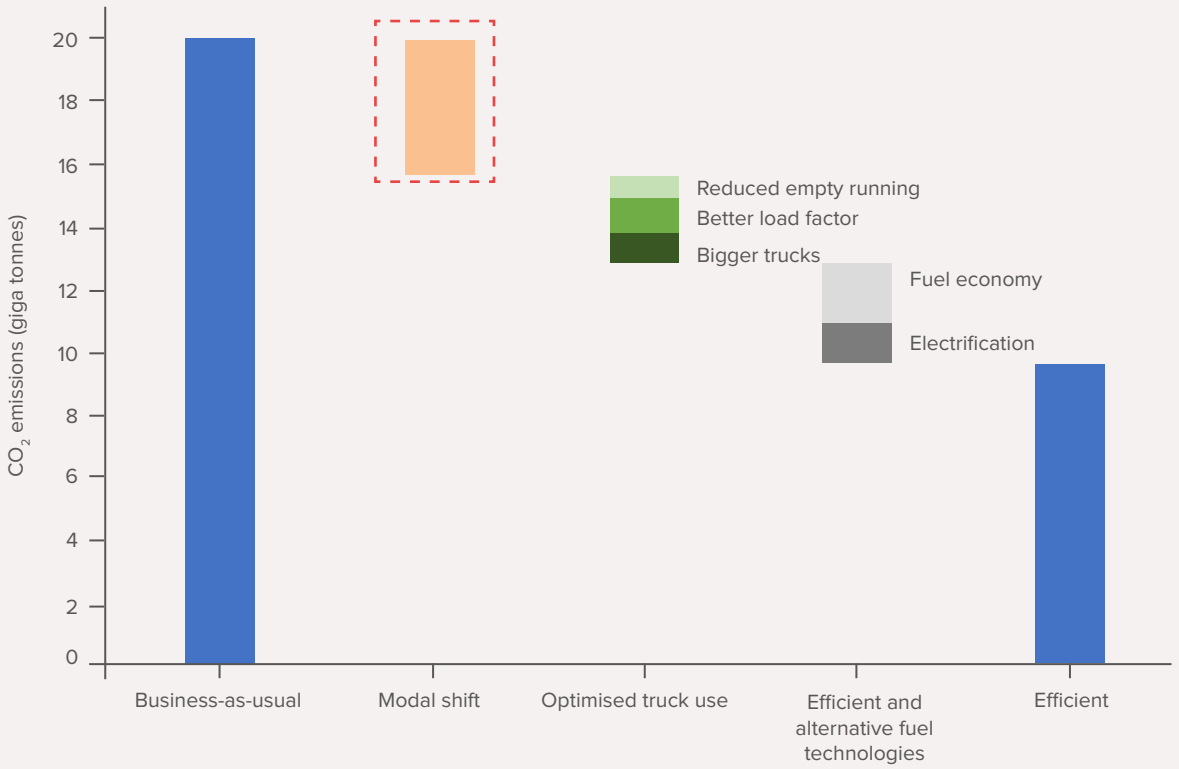
> INCREASE THE MODE SHARE OF RAIL TRANSPORT

SNAPSHOT: INCREASE THE MODE SHARE OF RAIL TRANSPORT

Cumulative savings by 2050: 4.3 giga tonnes of CO_2; INR 125 lakh crore; 171 kilo tonnes of PM; 4.8 million tonnes of NO_x.[77]

FIGURE 3-1

Cumulative CO_2 emissions from freight sector in India between 2020-2050



SOLUTIONS/LEVERS

Increase the rail network capacity

- Improve existing network infrastructure
- Develop new tracks in the network

Increase the share of intermodal transportation

- Identify and upgrade high potential intermodal network
- Ensure better modal integration

RECOMMENDATIONS

- Continue investments to upgrade existing rail infrastructure and build new corridors
- Continue investment in infrastructure for rail-port-road integration
- Promote digitisation to streamline container movement across modes
- Optimise siting and explore opportunities for the development of multimodal parks
- Involve corporations to promote the use of rail over road for long-haul goods transport
- Explore public-private partnership opportunities for financing rail projects

FIVE MODES OF TRANSPORT ARE BEST SUITED FOR DIFFERENT FREIGHT USE CASES

There are many modes, discussed below, by which freight is moved, each with its own strengths and weaknesses. A healthy mode share matches goods to the mode best suited for them. This minimises cost to the final consumer as well as negative externalities such as emissions and congestion. Sometimes, the most efficient mode for transport changes over the course of a goods journey. To accommodate that, supply chain managers can change modes over the course of a shipment – a practice known as multimodal or intermodal transportation.

MODE	RAIL	ROAD	WATERWAYS	AIR	PIPELINE
Cost (INR/tonne-km)	1.6[78]	3.6[79]	2[80]	18 (5 times the rate of road transport)[81]	2 (equivalent to water transport cost)[82]
CO_2 emissions (gm CO_2/tonne-km)	11.5[83]	101[84]	11[85]	610 – 650[86]	8[87]
Route flexibility	✓✓	✓✓✓✓✓	✓	✓✓	✓
Timeliness/ quickness of transport	✓✓	✓✓✓✓	✓	✓✓✓✓✓	✓
Volume flexibility	✓✓		✓	✓✓	✓
Flexibility with respect to the type of goods	✓✓	✓✓✓	✓	✓✓	✓
Suitable use cases	Suitable for the long-haul of large, regular flows of low-to-medium-value density goods between fixed origin/destination points	Suitable for non-bulk goods moving over shorter distances and on corridors with lower transport volumes	Suitable for the long-haul of large, regular flows with less fragmentation along the coastline or navigable inland waterways	Suitable for high value goods in need of urgent delivery	Suitable for liquids and gases and any stable chemicals such as water, oil, natural gas, and biofuels

The tick marks indicate scrore between one and five.

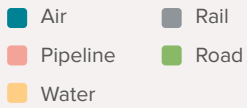
EXHIBIT 3-1 Characteristics of various modes of freight transport

OTHER COUNTRIES OFFER INSIGHTS ON EFFICIENT MODAL SPLITS FOR INDIA

The figure below compares the mode share of India with China, the United States, and EU 28 – regions with either, similar geographic characteristics or development stages compared to India.

FIGURE 3-2

Modal split of freight transport by tonne-km



Coastal and inland waterways shipping are cheaper and less emission-intensive and can also replace truck's mode share in India. However, a discussion on this topic warrants more in-depth analysis and is out of the scope of this report.

	CHINA[88]	USA[89]	EU 28[90]	INDIA[91]
DEVELOPMENT STAGE	Developing	Highly developed	Highly developed	Developing
GEOGRAPHIC CHARACTERISTICS	• Coast on the east boundary with many large economic centres, limited inland economic activity concentrated in a few cities.	• Coasts on east and west boundaries, rural inland with several significant cities. • Substantial goods movement between west and east.	• Long coastline surrounded by the Atlantic and Arctic Oceans and the Mediterranean Sea. • Extensive network of navigable waterways.	• Coastline narrowing on the southern half boundaries. • Substantial inland economic activity and goods movement.

INSIGHTS

The mix between rail and water varies by country, with one mode tending to dominate based on geography and policy: Rail makes up a high share of the USA modal split because of development of the United States Class 1 rail, which is almost entirely dedicated to freight and not capacity constrained.

Waterways are a dominant mode of transport for countries with high coast-to-landmass ratios or high concentration of cities near the coast: The EU, with a high ratio of coastline to landmass, has developed an effective water freight transport system through convenient access to the Atlantic Ocean and the Mediterranean Sea. On the other hand, the United States, with a smaller coastline relative to its land mass, has developed a rail dominant mode share. China with a large landmass but economic activity concentrated on the coast, has developed a mixed mode share that uses both rail and water.

Mode share depends on country's policy focus: India's logistics policies have focused on road transport. As a result, about 70 percent of freight transport is road-based in India.

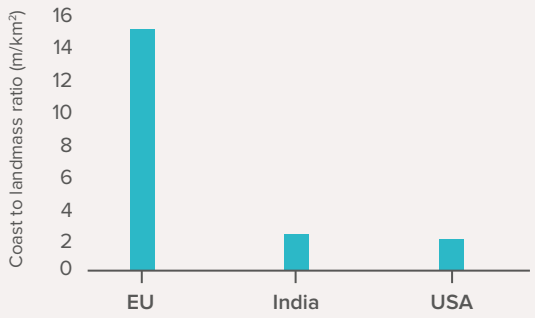
GEOGRAPHIC FEATURES MAKE INDIA WELL-SUITED TO RAIL

Low coast-to-landmass ratio, long distances between major cities, and high average lead make rail a compelling alternative to road transport.

GEOGRAPHY

FIGURE 3-3

Ratio of coast length to landmass[92]

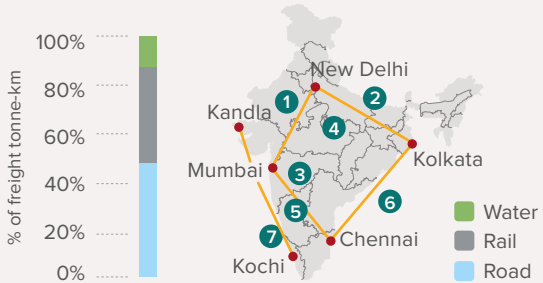


Rail and water are similar modes and often compete with each other. India has a relatively low coast-to-landmass ratio and many major cities in India are not coastal, which limits the potential of water transport, as opposed to the EU and China where economic activity is concentrated in areas with access to navigable water. This suggests that a rail dominant mode share, like in the United States, is appropriate for India. The United States, however, unlike India, does not heavily use passenger rail. India will likely have to invest in a dual network to achieve similar mode shares.

MOVEMENT PATTERNS

FIGURE 3-4

Freight traffic on seven high-density corridors in India[93]

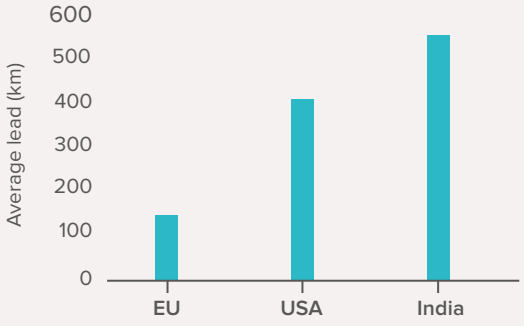


Fifty percent of India's freight movement happens along the Golden Quadrilateral and the two diagonal highway networks connecting Delhi, Mumbai, Chennai, and Kolkata.[93] Almost half of the freight movement on these corridors is done by road, while the rest is by rail and a small share by water. There is a significant potential to shift continuous long-haul freight movements from road to rail due to the length of these corridors and the volume of goods moving along them.

AVERAGE LEAD

FIGURE 3-5

Average lead of freight transport



Average lead refers to the average distance travelled by goods from origin to destination. In India, the average lead of freight transport is around 550 km,[94] which is higher than the EU (130 km)[95] and the United States (~400 km).[96] For long-haul transport on dense corridors, rail transport offers lower cost and lower emissions than road transport. This creates an opportunity to transition a portion of India's freight from road to rail. Especially goods like coal, mineral ores, food grains, and containerised freight which are transported over long distances.

RAIL CAN GAIN MARKET SHARE IN BULK GOODS FIRST, AND LATER THROUGH INTERMODAL TRANSPORT

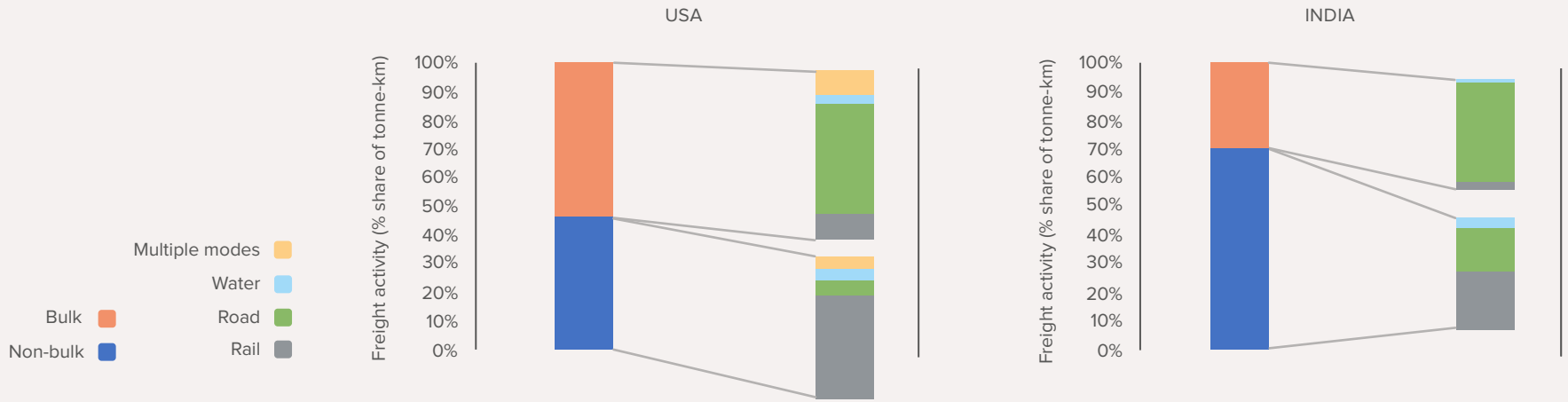
Bulk goods refer to goods that are not containerised and are directly moved through a vessel in large quantities, as opposed to non-bulk goods that are often packaged. Some of the examples of bulk commodities include oil, coal, mineral ores, and grains. Non-bulk goods comprise a broad array of products such as consumer goods, edible oils, paper products, automotive supplies, milk, and other agricultural products.

The composition of India's freight is 70 percent bulk and 30 percent non-bulk.

Furthermore, trucks carry 40 percent of current bulk traffic.[97] International comparisons suggest that India has the potential to transition a portion of the heavy bulk from road to rail, specifically goods like mineral ores, food grains, and coal which are transported over long distances. For example, in the United States, the commodity mix is 45 percent bulk and 55 percent non-bulk. Rail moves 72 percent of the bulk freight.[98] The United States rail has maintained this market share due to the country's prioritisation of rail as the primary mode for long-haul bulk freight transport.

FIGURE 3-6

Freight composition comparison



While there is immense potential to move bulk freight from road to rail, low to medium value non-bulk products can also be moved by rail using intermodal transport. In the United States, which offers a reasonable geographic comparison to India, 66 percent of non-bulk freight moves on road, with 30 percent being moved by rail or rail-intermodal. This is significantly lower than the 92 percent of non-bulk goods moved by truck in India.

INFRASTRUCTURE CONSTRAINTS ARE PREVENTING INDIA FROM REACHING AN EFFICIENT MODE SHARE

FIGURE 3-7

Comparison of share of road and rail freight (% tonne-km)[99]

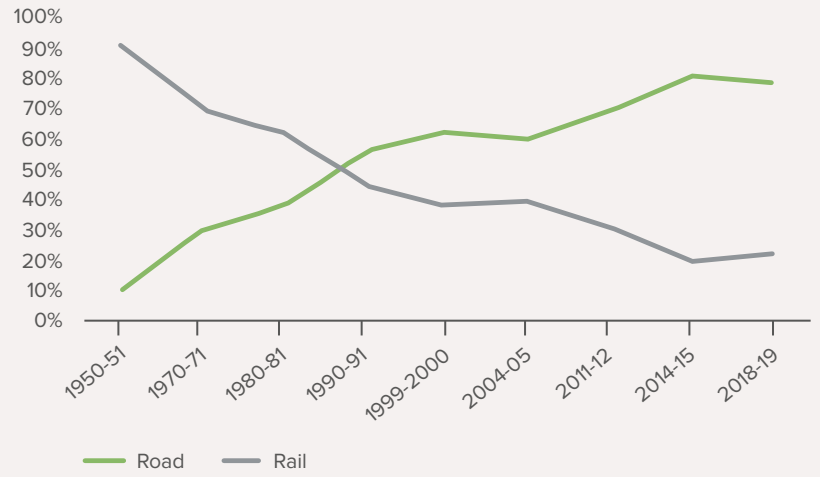
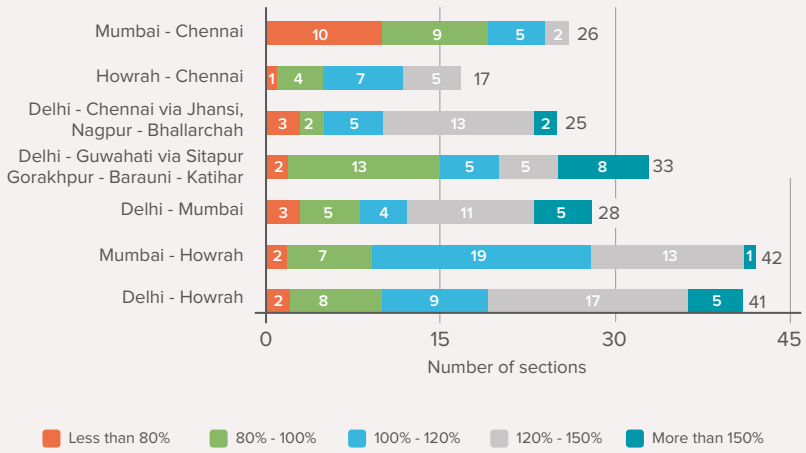


FIGURE 3-8

Line capacity utilisation of sections on High Density Network (2009-2010)[100]



Rail's share of freight transport has been decreasing since 1951, with road transport gaining market share, due to these challenges:

- **Imbalanced capacity distribution:** As shown in figure 3-8, seven main routes contribute to 60 percent of freight traffic yet constitute only 16 percent of India's railway route network. These routes are often overutilised and are not designed to handle high traffic density.
- **Over utilisation:** About two-thirds of India's railway lines are already above 100 percent utilisation when 80 percent capacity utilisation is considered ideal.[101]
- **Track sharing:** Passenger and freight trains share the same tracks, and passenger trains often receive higher priority, increasing lead times for rail-based freight transport and reducing reliability.
- **Lower speeds:** Freight trains in India carry smaller loads and usually travel at lower speeds than global standards. This increases lead times of goods and reduces capacity of the network.
- **Lack of arrangement to aggregate smaller loads:** Currently a shipper has to contract a full train to move freight. There are no standardized processes to aggregate smaller loads for contracting individual or partial wagons. That's why non-bulk commodities such as consumer goods, electronics, automobiles, etc., are being transported through trucks.[102]

Capacity additions on the rail network will help achieve a higher mode share of rail transport and move away from India's current reliance on the road. Additionally, making rail more efficient with a higher share of intermodal transport will also enable the movement of non-bulk goods through rail.

INCREASED CAPACITY AND SHARE OF INTERMODAL FREIGHT WILL BOOST RAIL

The current railway network is highly constrained and under-capacity. For rail to handle a two-fold increase in freight traffic (tonne-km) and gain a 40 percent mode share by 2050, the following solutions need to be implemented:

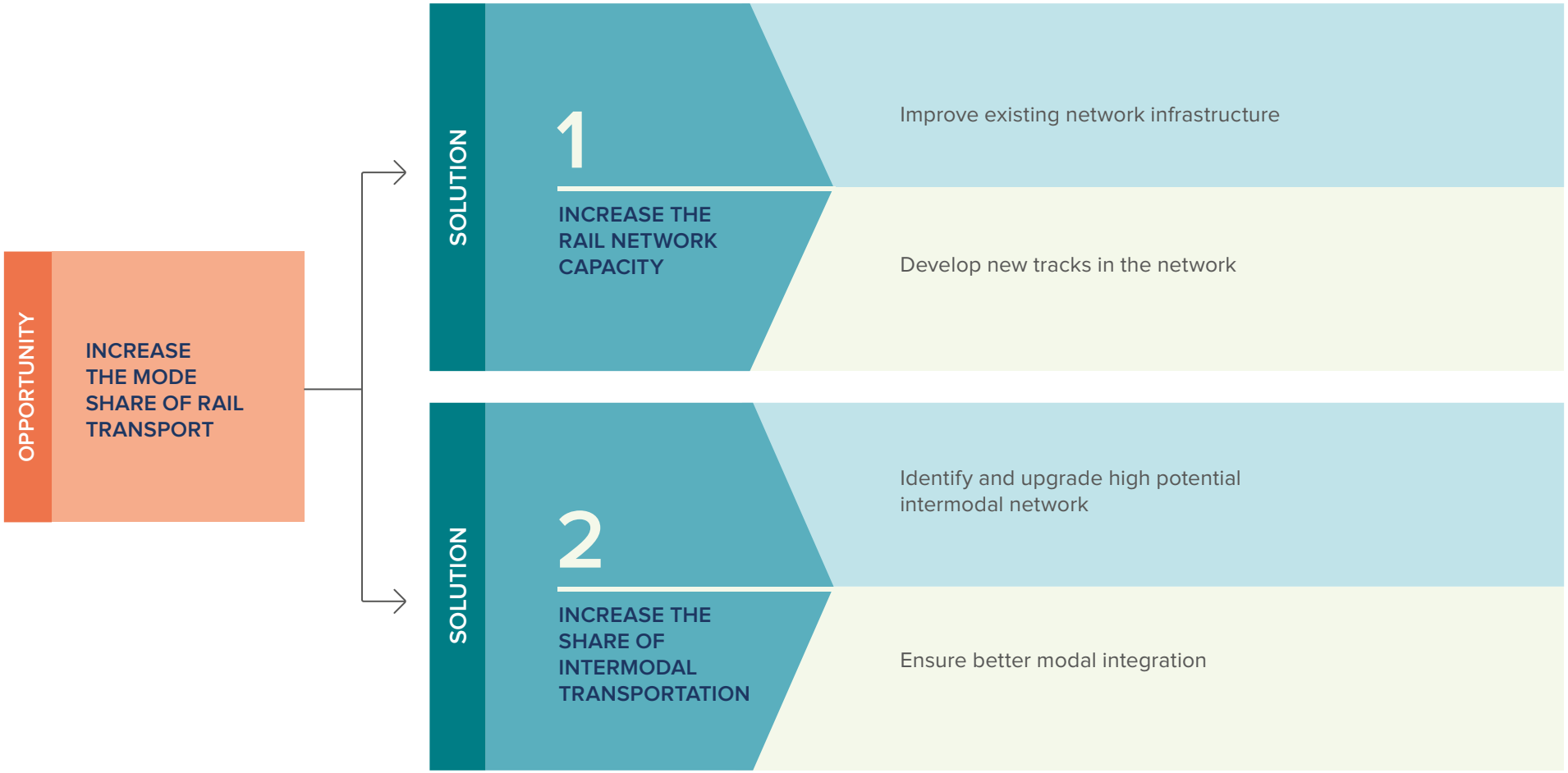
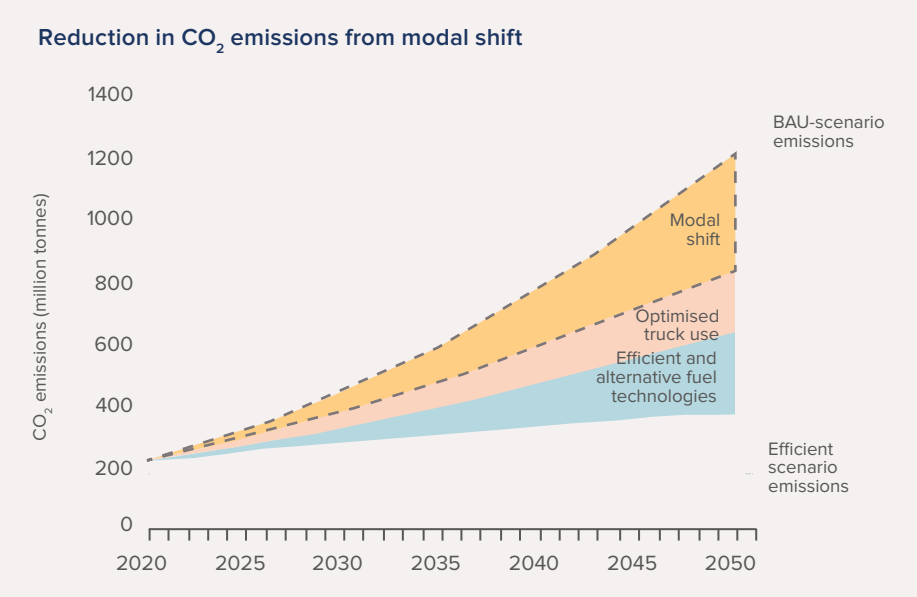


EXHIBIT 3-2 Solutions to increase the mode share of rail transport

INCREASING RAIL'S MODAL SHARE CAN BRING DOWN CO_2 EMISSIONS BY 4.3 GIGA TONNES IN 2050

FIGURE 3-9



CUMULATIVE SAVINGS	2020 TO 2030	2020 TO 2050
NO_x savings (kilo tonnes)	279	4834
PM savings (kilo tonnes)	10.5	171
Trucks off the road (million MDVs and HDVs)	4	76
Cost savings (lakh crore INR)	INR 8	INR 125

Rail mode share will be driven by higher investment in rail capacity augmentation, built-out dedicated freight corridors, improved rail connectivity, and upgrades for intermodal transport. With these levers, India's rail mode share can reach 40 percent by 2050.

Higher rail mode share will have the following impact, as compared to a BAU scenario:

- Annual rail freight activity can grow to 6.2 trillion tonne-km by 2050 compared to 2.7 trillion tonne-km in a BAU scenario.
- This will lead to 70 lakh fewer trucks on the roads in 2050, translating to an annual VKT reduction of one trillion km.
- This can reduce annual CO_2 emissions by 388 million tonnes in 2050.

03 SOLUTION 1A

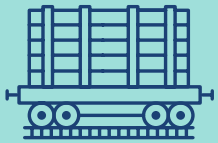
> INCREASE THE RAIL NETWORK CAPACITY

TARGETED INFRASTRUCTURE ENHANCEMENTS CAN INCREASE THE RAIL NETWORK CAPACITY

Three broad solutions exist to increase the rail network's existing capacity:

1 INCREASE AXLE LOADS

Increase the average loading capacity of freight cars

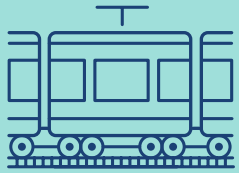


Increasing the loading capacity of the freight cars—also known as "axle loads"— can increase a train's carrying capacity. The following design improvements can support heavier axle loads:

- **Improving wagon quality:** Use of higher quality wagons with better tare to payload ratio by using lightweight materials such as aluminium, and improved braking and suspension solutions can improve the wagon quality.
- **Improving rail quality:** Hardened steel, concrete sleepers, continuously welded tracks, and improved maintenance can enhance the quality of rail and enable it to accommodate increased axle loads.
- **Increasing bridge strength:** Innovative bridge designs and retrofits using steel and concrete can improve bridge strength.[103]

2 INCREASE TRAIN LENGTH

Increase the average number of cars per train



Increasing the train length makes it possible to move the same load in fewer trips. The following design improvements can support longer train length:

- **Increasing siding length:** Longer sidings, including longer tracks at marshalling yards, are necessary to accommodate longer trains with more wagons.
- **Deploying multilocomotive configurations:** For heavy wagons and longer trains, adding a second locomotive (or more) can improve handling, braking, and coupler life.[104]
- **Increasing the capacity of marshalling yards:** Trains and wagons are disassembled, inspected and assembled in a marshalling yard. Increasing the capacity of the marshalling yards can allow more, larger trains to pass through, thereby increasing the throughput.

3 IMPROVE TRAFFIC SPEED AND FLUIDITY

Increase the number of trains accommodated by the network

The following practices can improve train traffic speed and fluidity:

- **Segregating passenger-freight operations:** Freight train operations can be compromised when they share tracks with passenger trains, as passenger trains often receive higher priority. Segregating routes for different use cases can reduce the transit time for rail-based freight transport.
- **Automating blocking and signalling:** Digitisation of blocking and signalling technology can improve traffic fluidity.
- **Elimination of network bottlenecks:** Rail line capacity is equal to that point on the line with the lowest capacity. Finding and improving those points increases the overall line capacity. For example, a bottleneck can be a station, a low-speed turn, areas with regular high winds, or merger points for lines.

INCREASING RAIL NETWORK CAPACITY WILL ALSO REQUIRE BUILDING NEW CORRIDORS

Two broad solutions exist to add new rail capacity:

1 DEVELOP SPECIALISED HEAVY HAUL CORRIDORS

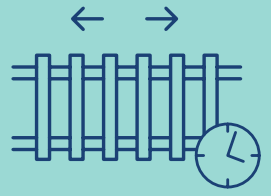
Moving a single type of bulk commodity through heavily loaded trains

Bulk freight often flows on a dense network and typically has limited origin-destination pairs. For example, iron ore is transferred from the mine to a mill and coal from a mine to a power plant. Developing specialised high-capacity rail corridors can serve these use cases more efficiently while decongesting core networks and improving their lifespan. Features of such corridors include:

- **Double tracking:** Double tracking enables faster movement of goods as it allows multiple trains to move at the same time without the need for side tracking, which reduces speed for both trains.
- **Using specialised loading-unloading equipment:** Another feature is the use of customised equipment, designed to the type of freight being moved and also to the type of freight train. For example, dumpers of the same dimensions as the wagons are used for fast loading/unloading of bulk freight.
- **Building capability to handle heavy train loads:** Improving the quality and strength of rail, and the strength of the bridge enables heavier loads to be moved on tracks.

2 DEVELOP DEDICATED FREIGHT CORRIDORS (DFCS)

Dedicating a route to freight movement through faster and bigger trains



DFCs are a dedicated high-capacity rail network for freight movement that eliminate challenges associated with track sharing on lines with a high demand for goods movement. DFCs lead to cost reductions due to higher productivity, lower transit times and increased utilisations. Features of such DFCs are:

- **Faster speeds:** Since freight trains do not share the track with passenger trains on DFCs, they can move at much higher speeds.
- **Ability for double stacking:** These corridors are designed to enable double stacking of containers for intermodal movement. Elevating or removing overhead obstacles such as tunnel ceiling, bridges and overhead wiring, can improve the clearing.
- **Longer trains:** DFCs can be designed to accommodate longer train lengths by improving designs of marshalling yards and sidings.
- **Heavy axle loads:** These corridors enable heavier axle loads due to improved quality of rail and bridges.
- **Double tracking:** DFCs allow ability for double tracking, leading to increased capacity.

A DEDICATED HIGH-CAPACITY RAIL NETWORK FOR FREIGHT MOVEMENT

UPGRADING AND EXPANDING EXISTING CAPACITY

	AVERAGE TRAIN LENGTH[105,106]	AVERAGE TRAIN SPEED[107,108]	GVWR PER WAGON[109,110]
INDIA	700 m	25 km/hr	80 tonnes
USA	2000 m	33 km/hr	130 tonnes

To address the issues of short length, low speed, and low Gross Vehicle Weight Rating (GVWR) per wagon, the GOI recently allocated INR 10.5 lakh crore to upgrade and expand existing rail network capacity.[111]

The government is also addressing network congestion, extending new lines, acquiring new rolling stock, building high-speed networks, and upgrading tracks, bridges, and signalling systems.

One example is the development of the Eastern and Western DFCs. These DFCs will help move most of the freight on these existing corridors to the new ones, freeing up capacity and improving network speed and fluidity. These new corridors will enable rail upgrades like heavier axle loads, double stacking, and higher train speeds.[112]

IDENTIFYING LOCATIONS FOR NEW NETWORK CAPACITY

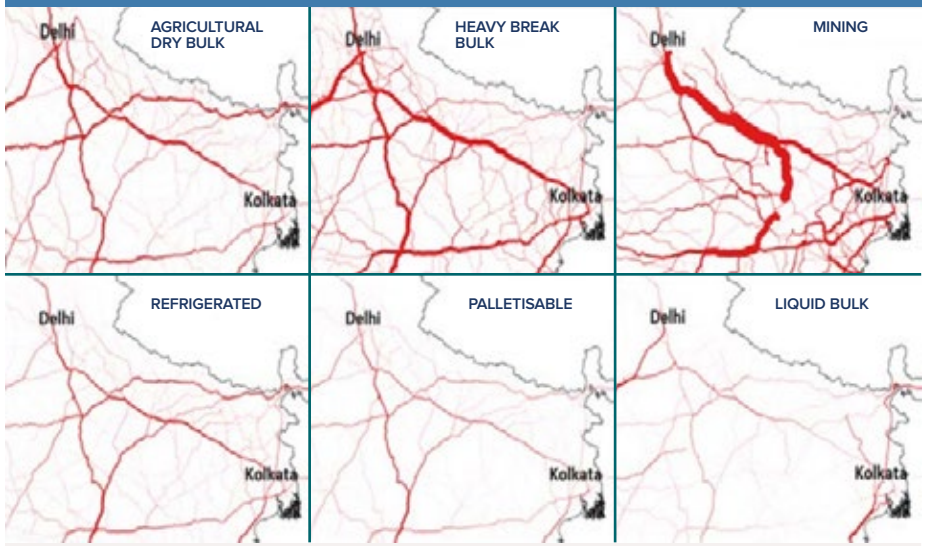


EXHIBIT 3-4 Density of freight movement on the Eastern Corridor[113]

There are a few dedicated heavy-haul rail corridors for commodities such as coal, iron ore, cement, steel, and other heavy-bulk freight. While manufacturing and production capability exist, logistics and rail infrastructure pose a challenge.

Exhibit 3-4 shows an example of the Eastern Corridor region and the density of freight movement on it for several commodities. The mining dry bulk route is the densest and would make a strong candidate for a specialised heavy-haul rail route. Identifying more of these high-density bulk corridors can lead to cost reductions and environmental benefits.

CASE STUDIES: INCREASING RAIL NETWORK CAPACITY

	GEOGRAPHY	TITLE	BEST PRACTICES
1	**USA**	Heavy Axle Loads in the US Class 1 Network	Higher axle loads and longer trains can increase the rail capacity
2	**Australia**	Roy Hill Iron-ore Mining in Pilbara Region	Specialised heavy haul rail allows heavier trains to move more freight – increasing productivity, reducing unit costs, and freeing up capacity on main networks.

CASE STUDY 1: HEAVY AXLE LOADS IN THE US CLASS 1 RAILROAD NETWORK

CONTEXT

In 1988, the Association of American Railroads (AAR) started a research program called Heavy Axle Load (HAL) Research Program to study the feasibility of switching to heavier axle loads on the Class 1 railroad network – the rail network of seven large rail freight companies that own and operate 70 percent of the total track miles in the United States.[114] The research highlighted the economic benefits and improved efficiency as a result of higher axle loads and how those benefits outweighed the associated infrastructure costs. Prior to this research, the United States relied on 64-tonne cars for freight movement. However, post this research, the United States railroads started adopting 130-tonne heavy axle cars.[115]

SOLUTION

The United States railroads achieved heavier axle loads through significant investments leading to the following upgrades:

- Developing better tracks by using improved and hardened steels, developing continuous running surface, upgrading in-rail join configurations and using concrete crossties
- Increasing bridge strength by testing of new lightweight and high strength materials such as hybrid composite beam spans
- Introducing new maintenance techniques like track geometry and track strength inspections, bridge and track condition monitoring, rail joint bar inspections, proper grinding of rail[116]

INCREASED BRIDGE STRENGTH

HIGH-QUALITY RAIL TRACK

NEW MAINTENANCE TECHNIQUES

RESULT

The United States railroads began adopting 130-tonne heavy-axle cars in 1991. By 2010, these cars handled 100 percent of coal traffic and a significant share of non-bulk freight. Over 15 years, HAL operations achieved about USD six billion (INR 40,000 crore) of net benefits, with net capacity increasing by 25 percent.[117]

CASE STUDY 2: ROY HILL IRON-ORE MINING IN PILBARA REGION, AUSTRALIA[118]

CONTEXT

Western Australia's Pilbara region is known for its iron-ore reserve. After mining the iron-ore, heavy loads of deposits move from the mines to the ports. Roy Hill, a mining company in this region, transports its deposits from the Roy Hill mine to Port Hedland. The iron-ore is then exported to China.

SOLUTION

Roy Hill has developed an innovative business model to provide an integrated service for iron-ore mining, rail transport, and port operations. The company transports iron-ore over a specialised heavy-haul rail corridor from the Roy Hill mine to Port Hedland. This corridor allows heavier trains to move more freight, increasing productivity and reducing unit costs.

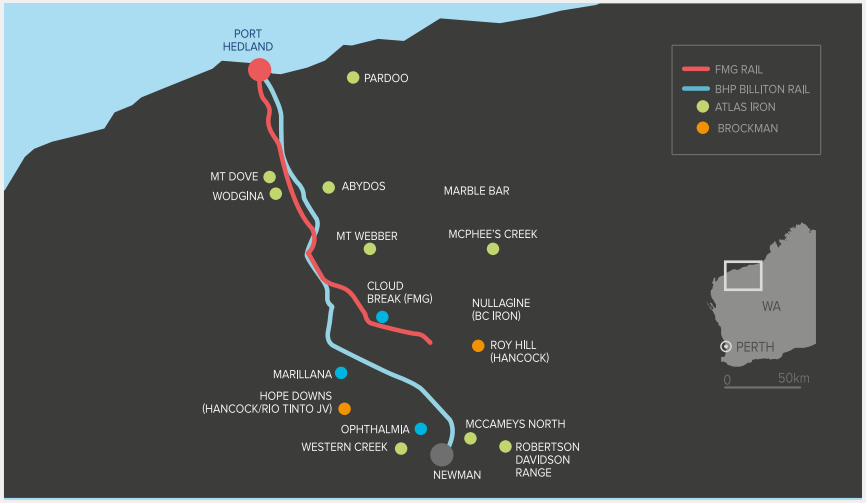


Image source: BS Iron, Atlas Iron, Brockman

Image source: Roy Hil

RESULT

Each day, five iron ore trains utilise this 340-km specialised heavy-haul corridor, carrying payloads of 31,132 tonnes per train per day – accounting for a total of 3.5 billion tonne-km annually. Specialised corridors offer a cost-effective solution to move heavy bulk goods. Identifying potential high-density corridors where industries can unlock the economies of scale makes this solution viable.

SUMMARY: PATHWAYS TO INCREASE THE RAIL NETWORK CAPACITY

Ecosystem of actors to increase rail network capacity

GOVERNMENT

Continue investments to upgrade existing rail infrastructure and build new corridors

- Allocate funds to initiatives supporting the following rail upgrades in the rail-network design: increased axle loads and train lengths, improved network fluidity and specialised heavy-haul corridors
- Encourage build-out of specialised heavy-haul corridors for moving commodities like grains, iron ore, and coal
- Allocate funds for the following upgrades in existing heavy-haul corridors: double tracking, specialised loading and unloading equipment, and improved quality of rail
- Create opportunities for capacity building programmes for senior leadership and the engineering/technical staff to understand the know-how on design and build-out of an advanced rail network
- Encourage use of Internet of Things (IoT) in freight rail operations to improve fluidity
- Evaluate market structure and regulations to enable more investments in the rail network

INDUSTRY

Promote the use of rail over road for long haul goods transport

- Goods manufactures and e-commerce companies can promote sustainability initiatives in their organisations to encourage the move from road to rail
- Industry players can optimise warehouse siting to access rail transport

MULTISTAKEHOLDER COLLABORATION

Explore public-private partnership opportunities to finance rail projects

- Encourage opportunities for public-private partnerships to finance rail improvements that generate a return for private-sector capital

03 SOLUTION 1B

> INCREASE THE SHARE OF INTERMODAL TRANSPORT

INTERMODAL TRANSPORT IS COST-EFFECTIVE, RELIABLE AND FAST

Intermodal freight transport refers to the movement of goods in containers or trailers via successive modes of transportation (usually road-rail-road) without handling the goods while changing modes.[119] Intermodal freight transport allows efficient and cost-effective use of the best characteristics of different transport modes. Currently in India, 90 percent of the non-bulk freight is moved using road transportation.[120] Some of the share from road transport can be combined with rail to create a more efficient system with a better quality of service, more reliability, lower costs and emissions. To enhance intermodal transportation, it is imperative for shippers, truck operators and the Indian railways to work together to form a seamless chain.

Exhibit 3-5 Intermodal transport

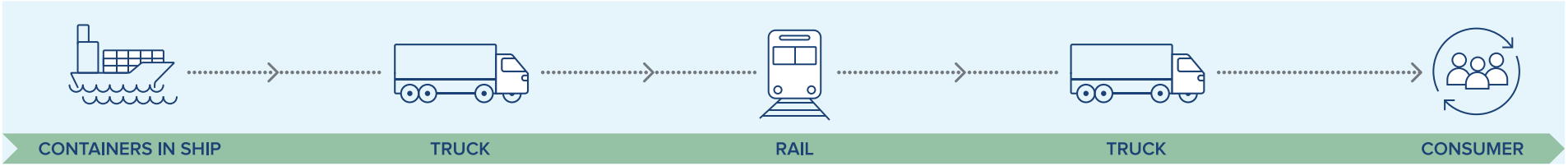
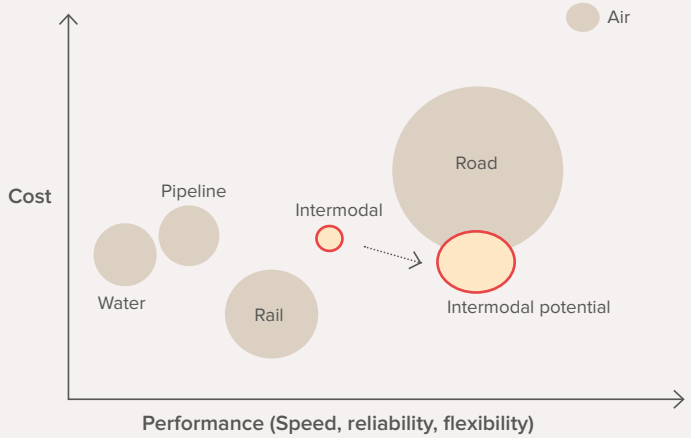


FIGURE 3-10

Cost and performance comparison for freight movement modes[121]



Note: Size of the circle represents relative market share.

Intermodal has lower transport costs than trucks, but can incur other types of costs, particularly inventory carrying costs, which can make it less competitive. Those costs, which are the result of lower speeds and poorer reliability of intermodal, include:

1. **Inventory-in-transit cost:** Costs incurred while the goods are being transported to the store. These costs are directly related to the transit time of the mode and the value of the product.
2. **Safety stock:** Costs associated with additional inventory stock at the store for anomalies. These costs are dependent on uncertainty in sales or supplier's delivery at the expected time.

These hidden costs, if left unaddressed, can hinder the adoption of intermodal by shippers.

EFFICIENT INTERMODAL TRANSPORT IS MORE COST-EFFECTIVE THAN TRUCKING OVER LONG DISTANCES

FIGURE 3-11

Composition of logistics cost

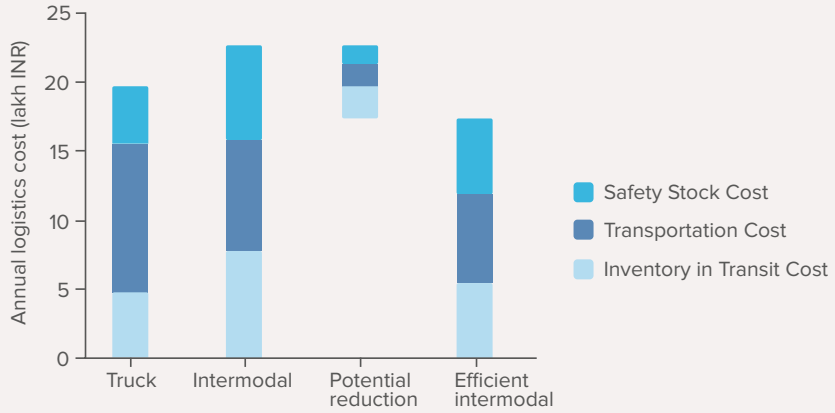
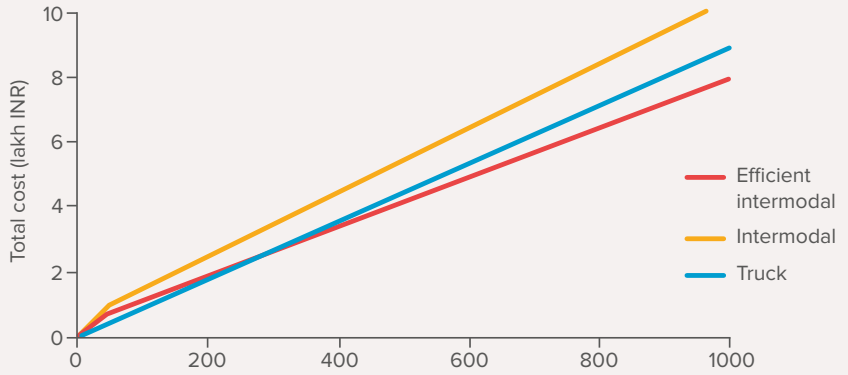


FIGURE 3-12

Total logistics cost relation with distance



The transportation cost of trucking is higher than that of intermodal transport. However, the total logistics cost of intermodal transport is often higher than trucking for two reasons: 1) high transit time and 2) lack of reliability. Both factors contribute to higher-than-necessary inventory-in-transit and safety stock costs. Improving transit times and improving reliability would increase the efficiency of intermodal transport, making its total logistics cost lower than that of trucking (as shown in Figure 3-11).[122]

Some of the ways through which this shift can be achieved are:[123]

1. Reducing wait time for pickup and delivery operations performed by drivers
2. Reducing empty trips
3. Reducing container handling time and container transfers

Example: Consider moving a medium-value, non-bulk product on the Delhi-Chennai route (2,200 km) by two different options: 1) a truck and 2) intermodal transport using truck and rail where the truck carries the goods containers for the first and last 50 kms and rail is used for the intermediate long-haul distance.

Figure 3-12 shows the relationship between the total logistics costs and the distance for truck, intermodal, and efficient intermodal transport on the Delhi-Chennai route. For the first 300 km, both intermodal transport options are more expensive than trucks due to high drayage costs (i.e., the minimum transport and handling costs for moving goods over short distances). However, after 320 km, efficient intermodal is more cost-effective than trucking due to rail's lower logistics cost on a per tonne-km basis.[124] Inefficient intermodal costs continue to increase with distance because of higher inventory and safety stock costs, highlighting the importance of efficient practices in intermodal transport.

INDIA CAN IDENTIFY POTENTIAL INTERMODAL CORRIDORS AND UPGRADE INFRASTRUCTURE

Investing in high-potential intermodal corridors, which can be optimised across road, rail, and waterways, is the key to increasing share of intermodal freight transport. After identifying high-potential corridors, infrastructure upgrades can ensure high-quality, reliable intermodal service that outperforms road-based transport. Finally, better modal integration between road, rail, and water can support more cost-effective and lower-carbon intensive goods' movement.

STEP 1 »

LOCATE THE FLOW OF MEDIUM AND HIGH VALUE FREIGHT

The following steps can help identify high-potential intermodal networks:

- Develop a deeper understanding of how and where freight moves across the country
- Identify corridors or routes where low-or-medium-value non-bulk freight move
- Identify the common origin and destination points for low-and-medium-value freight
- Finalise the densest long-haul corridors

STEP 2 »

INCREASE CLEARANCES TO ENABLE DOUBLE STACKING

The following characteristics can improve the quality and reliability of intermodal service:

- Double stacking of containers allows shippers to move twice as much freight with the same resources, reducing unit costs and emissions, while freeing up capacity
- High clearance along the routes enables double stacking

STEP 3 »

INCREASE NETWORK SPEEDS

Adjusting the following factors can support higher speeds:

- Improve Infrastructure to enable higher speed services, e.g. double tracking, less sharp turns
- Determine dispatch priority that intermodal receives relative to bulk trains, such as coal-freight trains
- Prioritise intermodal trains compared to trains moving heavy bulk freight, since intermodal directly compete with over the road trucks for faster deliveries

A THREE-PHASE APPROACH CAN SUPPORT BETTER MODAL INTEGRATION BETWEEN ROAD, RAIL, AND WATER

1 PLAN

Establish agencies for planning logistics parks

In the planning phase, various planning agencies and advisory councils can work to:

- Identify strategic locations where road and rail infrastructure overlap, specifically in the areas close to industrial hubs.
- Understand the throughput across the network and identify gaps where there is a lack of high-capacity connections.

2 BUILD

Deploy infrastructure to integrate rail, road, and water

Seamless integration requires supportive infrastructure for the two main points of integration: rail-road and rail-water.

- **Rail-road:** Building multimodal logistics parks that provide sufficient access to expressways and rail sides can support rail-road integration. The capacity to stage many trains and move containers quickly is a critical enabling feature of these logistics parks.
- **Rail-water:** To integrate rail and water the infrastructure around the port side is critical to enable the unloading of ships and loading of rail containers.

3 EXECUTE

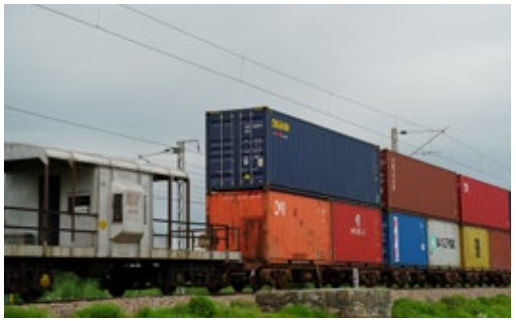
Build capacity for execution through top-tier intermodal service providers

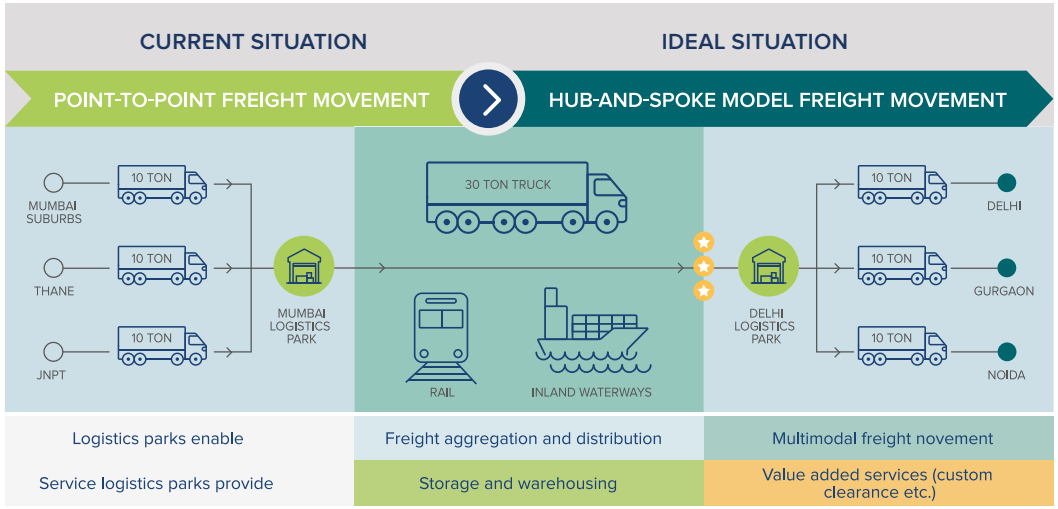
High-quality intermodal service providers are a critical stakeholder group that manage and support reliable operations.

- Top-tier intermodal service providers will typically own and operate intermodal assets such as boxes and chassis and maintain partnerships with rail operators for rail transport. Moreover, they can also aggregate goods and containers for customers.
- They will also track the containers, ensuring the next mode is ready for unloading them as they arrive.

INDIA IS ALREADY TAKING STEPS TO PROMOTE INTERMODAL FREIGHT

Container movement in India is rising. However, the share of intermodal rail freight transport remains relatively low. While the total container traffic in India increased at a CAGR of 9 percent between 2010 and 2018,[125] intermodal transport was responsible for a small share. Over-the-road (OTR) truck transport ferried most of the containers from origin to destination. For example, in the Western region corridors, which account for 70 percent of India's container movement, intermodal rail transport is responsible for only one-third of the share.[126]





Source: Concept Note on Logistics Efficiency Enhancement Program, MoRTH"

EXHIBIT 3-6 Hub and spoke model for freight movement

With supporting government initiatives and market structure, the share of intermodal transport in India is growing.

- **Investing in logistics parks:** In 2017, the government sanctioned INR 2 lakh crore for building 35 multimodal logistics parks across the country.[127] These logistics parks are expected to handle 50 percent of the road freight activity[128] and reduce total logistics costs by 25 percent.
- **Optimising siting of logistics parks:** The Indian government plans to create a central authority called Multi-Modal Logistics Park Authority (MMLPA) with representatives from relevant ministries. They will help identify optimal locations and ensure MMLPs function correctly.[130]
- **Piloting double-stack trains:** Indian Railways recently operated its first double-stack dwarf train,[131] which is shorter in height and can easily pass through the current routes.
- **Building out Inland Container Depots (ICDs):** India has built a network of almost 300 ICDs, which are the key to enable multi-modal transport as they enable better integration between road and rail.[132] The government has announced plans for new rail-side logistics parks and warehouses to upgrade freight terminal infrastructure.[133]
- **Existing stakeholder ecosystem:** Indian Railways' subsidiary Container Corporation of India Limited (CONCOR) is the market leader in intermodal container movement, accounting for about 80 percent of the market share.[134] Apart from CONCOR, there are 20 other private operators in the intermodal business.[135]

CASE STUDIES: INCREASE THE SHARE OF INTERMODAL TRANSPORTATION

	GEOGRAPHY	TITLE	BEST PRACTICES
1	**USA**	Crescent Corridor	Identifying the best location of intermodal lines and investing in the appropriate infrastructure upgrades, is critical to improved uptake of intermodal freight movement
2	**USA**	Schneider: Intermodal Service Provider	Switching to intermodal service providers can lead to reduced costs and more efficient handling of goods
3	**USA**	Alameda Corridor	Optimised rail-port integration can avoid truck trips from the port

CASE STUDY 1: CRESCENT CORRIDOR[136]

CONTEXT

The Crescent Corridor, operated by the Norfolk Southern Railway (NS), is an intermodal corridor in the United States. This corridor is 2,500 miles long, connecting New Jersey to Tennessee and Louisiana.

SOLUTION

NS identified the corridor for potential intermodal upgrades since it had scope for reducing domestic shipment times to compete with the truck shipments. NS identified competitive lanes by analysing truck movement data. After identifying the lanes, NS convinced shippers to switch to their intermodal service by identifying suitable goods and explaining the benefits. NS also worked with federal, state, and local government authorities to receive critical investment. Finally, NS upgraded infrastructure by straightening curves, adding new tracks and signals, and building rail terminals to make it compatible with intermodal transport. The total investment was around about INR 19,000 crore.

Image source: Norfolk Southern

RESULT

NS estimated that the average intermodal train shipment could replace 280 truckloads and transport about 700 tonne-km of freight on about four litres of fuel. The realised and anticipated outcomes of this project also include the following:

- Creation of 1.2 lakh jobs by 2030
- INR 4,122 crore of annual savings related to congestion
- Annual savings of 640 million litres of fuel
- Annual reduction of 1.72 million tonnes of CO_2
- Removal of 1.3 million long-haul truckloads annually from congested highways

CASE STUDY 2: SCHNEIDER: INTERMODAL SERVICE PROVIDER

CONTEXT

Schneider is one of the largest trucking fleet and logistics managers in the United States. Schneider owns a national fleet of drayage trucks, intermodal containers, and chassis. Currently, intermodal transport accounts for 20 percent of their revenue.[137]

SOLUTION

Some of the best practices that Schneider incorporated in its business to ensure successful intermodal service include:

- **Precision scheduled railroading:** Schneider has invested in and regularly uses precision scheduled railroading, meaning that freight directly moves from its origin to its destination, without any reshuffling or redirecting of wagons. This allows for the transport of the same amount of freight with fewer rail cars and locomotives, leading to reduced costs and more reliable service.
- **Shipment visibility:** Schneider's customers receive full end-to-end shipment visibility and expert consulting on mode selection for various shipment types to minimise total cost.[138]

Image source: Schneider

RESULT

Schneider's intermodal service costs are 30 percent below OTR costs with comparable reliability. In one case, Schneider's intermodal solution helped a retailer reduce supply-chain costs by 10 percent through higher payloads, while reducing truck movement by 10 percent.[139]

CASE STUDY 3: ALAMEDA CORRIDOR

CONTEXT

Alameda Corridor is a high-capacity rail freight corridor that connects the port of Los Angeles and Long Beach to intermodal rail terminals. Two major USA railroad companies, BNSF and Union Pacific, operate this corridor. The ports of Los Angeles and Long Beach handle approximately 25 percent of shipping containers entering the United States, creating significant amounts of through-freight in the city of Los Angeles. Before the Alameda Corridor, the port had four low-speed, at-grade branch lines, with approximately 200 level crossings. This limited rail capacity in the city created congestion problems and resulted in air pollution, as urban traffic had to stop to allow slow freight trains to pass.[140]

SOLUTION

A special-purpose entity financed, built, and now manages the Alameda Corridor. A user fee on container shipments finances the corridor. The corridor is well connected through bridges, overpasses, and underpasses, and is separated from local road transportation. It also includes a 16 km below-ground triple-track segment that eliminated the 200 level crossings and replaced antiquated existing rail infrastructure. The line has a daily capacity of 150 trains.[141]

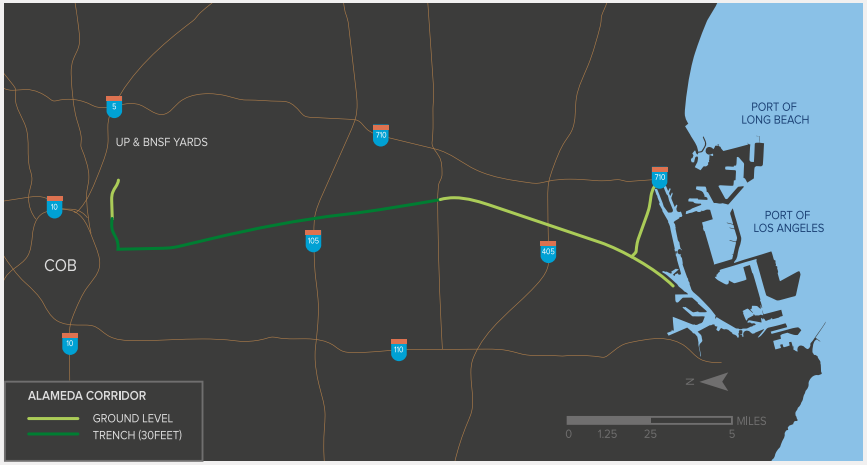


Image source: The Geography of Transport Systems

RESULT

Each train eliminates 250 to 280 truck trips daily, avoiding 1.2 crore truck trips per year.[142] This project resulted in significant air quality benefits due to displaced drayage and reduced congestion from train-level crossings. Reduction in idling of trucks and cars have led to a decrease in air pollution by 54 percent since the start of the corridor in 2003. Rail journey time between the ports and downtown Los Angeles has reduced from 2 hours to 45 minutes.[143]

SUMMARY: PATHWAYS TO INCREASE THE SHARE OF INTERMODAL TRANSPORT

Ecosystem of actors to increase the share of intermodal transport

GOVERNMENT

Continue investment in infrastructure for rail-port-road integration

- Improve rail network to accommodate double stacking and increased network speeds
- Improve port infrastructure for unloading ships and load rail containers by introducing intermodal yard at the port
- Continue building multimodal logistics parks
- Ensure standardisation of containers and associated handling infrastructure
- Standardise data collection and sharing protocol for goods movement across modes

INDUSTRY

Promote digitisation to streamline container movement across modes

- Intermodal service providers to develop business models to ensure smooth movement of containers across different modes through infrastructure upgrades and digitisation
- Fleet aggregators to track the flow of goods movement through digital tools
- E-commerce and manufacturing firms to incorporate rail and intermodal shipping in their sustainability plans

MULTISTAKEHOLDER COLLABORATION

Optimise siting and explore PPP opportunities for the financing of multimodal parks

- Encourage collaboration between government and fleet aggregators to identify routes where freight suitable to intermodal transport is moving
- Collaboration across Ministry of Road Transport and Highways (MoRTH), Ministry of Railways (MOR), Ministry of Shipping (MOS), IN/CONCOR and private sector players to identify optimal locations for logistics parks
- Form stakeholder coalitions to resolve barriers and create a roadmap for seamless intermodal shipping, especially at points of transfer
- Continue investments in logistics parks, while exploring opportunities to leverage multilateral and private investments

04 OPPORTUNITY 2 OVERVIEW

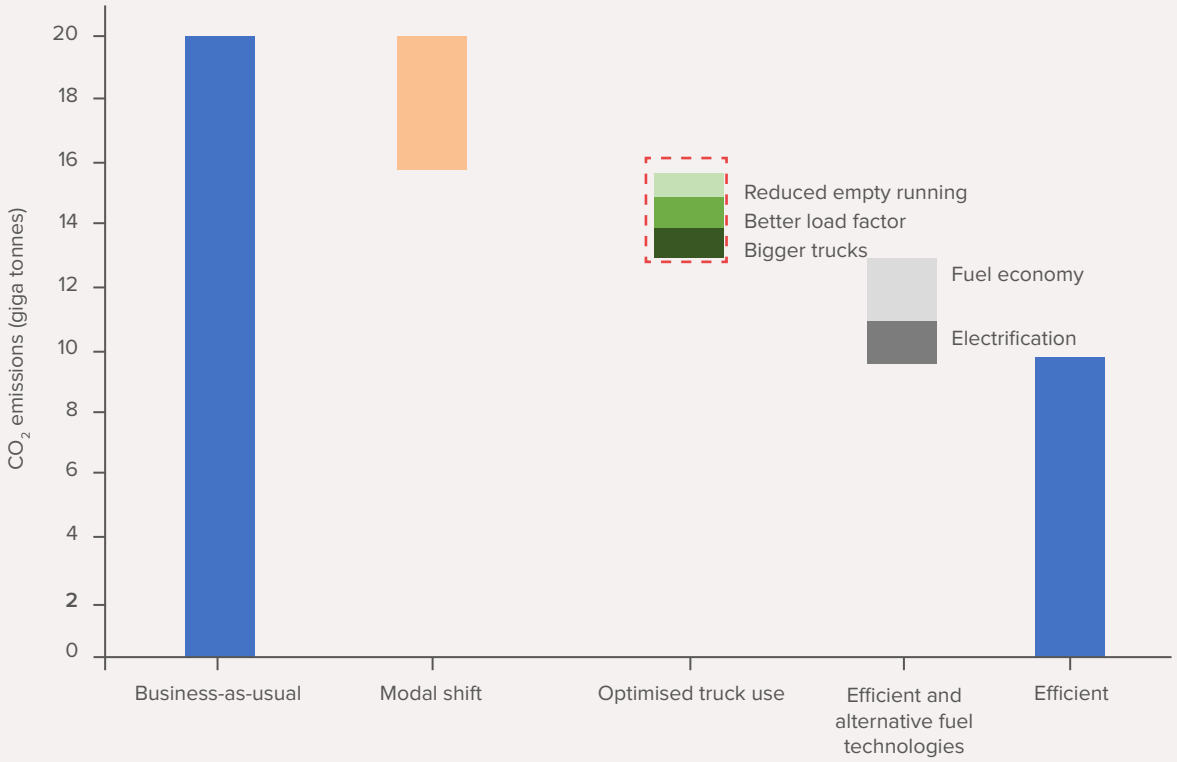
> OPTIMISE TRUCK USE

SNAPSHOT: OPTIMISE TRUCK USE

Potential savings by 2050: 2.7 Giga tonnes of CO_2; INR 85 lakh crore; 150 kilo tonnes of PM; 5.3 million tonnes of NO_x

FIGURE 3-13

Cumulative CO_2 emissions from freight sector in India between 2020-2050



SOLUTIONS/LEVERS

Improve transportation practices

- Improve load matching and truck dispatch
- Promote efficient loading and packaging

Improve warehousing practices

- Improve the siting of warehouses
- Improve the quality of warehouses

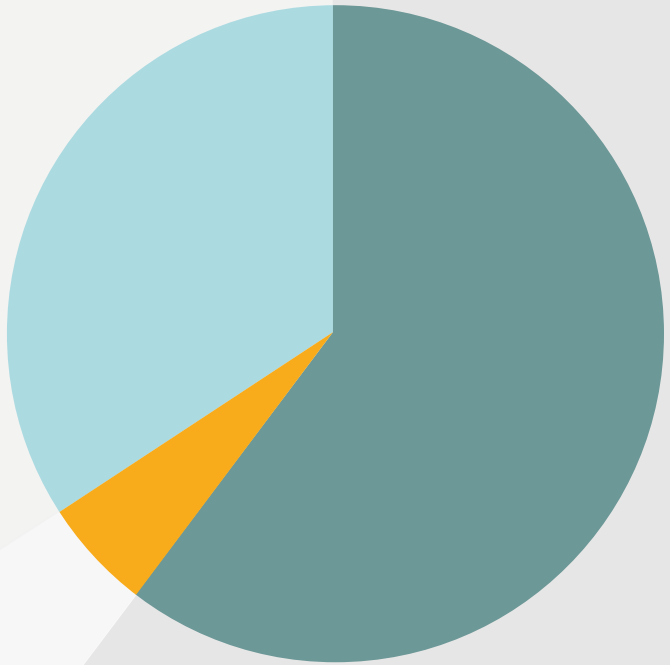
RECOMMENDATIONS

- Continue investments in logistics parks
- Standardise and digitise logistics practices
- Invest in trucking technologies and advanced warehousing infrastructure
- Invest in digitisation and technology improvements of logistics infrastructure
- Introduce sustainability initiatives and practices in companies
- Set standards to promote bigger trucks and improved warehousing

LOGISTICS COSTS ARE HIGH IN INDIA, YET OPPORTUNITIES EXIST FOR REDUCTION BY IMPROVING LOGISTICS EFFICIENCY

FIGURE 3-14

Composition of logistics costs in India[146]



INVENTORY(34%)

To reduce inventory costs, suppliers can reduce inventory loss and excess inventory holdings. This can be done by improving supply-chain design and management.

TRANSPORTATION (62%)

To reduce transportation costs, shippers can optimise mode share and then optimise the efficiency of vehicle use. Optimising vehicle use includes deploying the right vehicle for a particular use case and then maximising the productivity of that vehicle through effective routing and loading.

ADMINISTRATIVE (4%)

Administration costs can be reduced by introducing modern IT and management techniques.

India's logistics costs are currently 14 percent of the GDP—higher than the United States and Europe.[144] As shown in Figure 3-14, over 90 percent of logistics costs are attributable to transportation and inventory management (inventory holding and warehousing).[145] To increase logistics efficiency, it is essential to increase transportation efficiency by optimising truck use and incorporating inventory management best practices in supply chains.

FRAGMENTED MARKETS, OBSOLETE INFRASTRUCTURE, AND TECHNOLOGY HAVE DRIVEN UP COSTS

OBSOLETE INFRASTRUCTURE AND VEHICLES

- **Low carrying-capacity trucks make up the majority of India's truck fleet.** In India, most trucks are MDVs or smaller HDVs.[147] In nations and regions, like the United States and the EU, the truck market mainly consists of HDVs. Trucks in India usually have smaller engines and thus operate at lower speeds.[148]
- **Most of the trucks on the road are old.** About 34 percent of India's truck fleet has been on the road for at least ten years.[149]
- **India's roads are not well-suited for heavy vehicles.** Only 54 percent of roads are surfaced with concrete,[150] limiting the plying of heavy trucks for freight transport. Also, four to six lane national highways are limited.[151]

OBSOLETE TECHNOLOGIES

- **Transportation practices like load planning and vehicle routing are not digitised, standardised and automated.** For example, there is a limited use of radio-frequency identification (RFID) tracking and a lack of real-time visibility into inventory flow.
- **The procedures and equipment to execute processes such as material loading, unloading, and storing are not standardised.** This leads to widespread use of slow, inaccurate manual processes.
- **There is a lack of automation of common warehousing operations.** This leads to excess inventory holdings by decreasing the speed through which the goods move across the supply chain, and inventory loss as operators do not have proper visibility into inventory stocks and locations.

FRAGMENTED MARKET

- **India's trucking market is highly fragmented.** Around 75 percent of the market is run by small owner-operators who own up to five trucks. Only 10 percent of the market is run by big fleet operators who own more than 20 trucks.[152] Small players are unable to optimise driving patterns and have less ability to invest in larger trucks, digital tools and software, and the expertise required to operate them. This market structure leads to lower asset utilisation and overloaded trucks.
- **The warehousing sector in India is also highly fragmented,** with unorganised players owning 90 percent of the market.[153] Most warehouses are small and local instead of regional. Few have accessible connections with national highways and multiple transport modes.

OBSOLETE INFRASTRUCTURE AND MARKET FRAGMENTATION HAS LED TO INEFFICIENT TRUCK USE

The transportation efficiency of a truck is determined by how much distance it can cover daily, how much of that is with and without load and to what extent the truck is loaded. Higher utilisation lowers costs, a load factor close to 100 percent is the most cost effective and safe, and lower share of empty running translates to higher productivity.

	METRIC	DEFINITION	INDIA	PEER NATIONS	IMPLICATIONS
	**Daily utilisation (km)**[154]	The average daily distance covered by a truck	250 to 400 km	**BRICS:** 500 km **USA/Europe:** 700 to 800 km	• Low utilisation increases the total cost of ownership for fleet operators. • It also reduces the attractiveness of fuel-saving technologies, which have longer payback periods with lower utilisation.
	**Empty running (percent)** [155,156]	Percentage of distance travelled by truck without any load	28 to 43 percent	**USA:** 13 to 29 percent **Europe:** 15 to 30 percent	• High empty running increase VKTs, which in turn increases CO_2 and criteria pollutant emissions. • It also increases fuel costs for operators.
	**Load factor (percent)**[157]	The average share of vehicle loading capacity that is productively used	Trucks in India are usually overloaded, meaning the load factors are typically above 100 percent	Trucks in the USA and Europe are not overloaded, meaning their load factors are less than 100 percent. Average load factors in Europe are in the 50 to 80 percent range.	• Overloading is not a safe practice. It can also compromise the integrity of the goods. • As India transitions more towards being a developed economy, where high-value goods will be transported, overloading will likely reduce.

Moreover, around 28% of the current truck fleet is sitting idle due to the dearth of drivers.[158] Factors such as lower salaries, long working hours, time away from families, bad road and driving conditions, poorly maintained vehicles are making the sector unattractive for drivers, and increasing the logistics costs for the country due to poor utilization of the assets.

IMPROVING TRANSPORTATION AND WAREHOUSING PRACTICES WILL OPTIMISE TRUCK USE

To improve the daily utilisation of trucks, reduce empty running and optimise load factors, fhe following solutions need to be implemented:

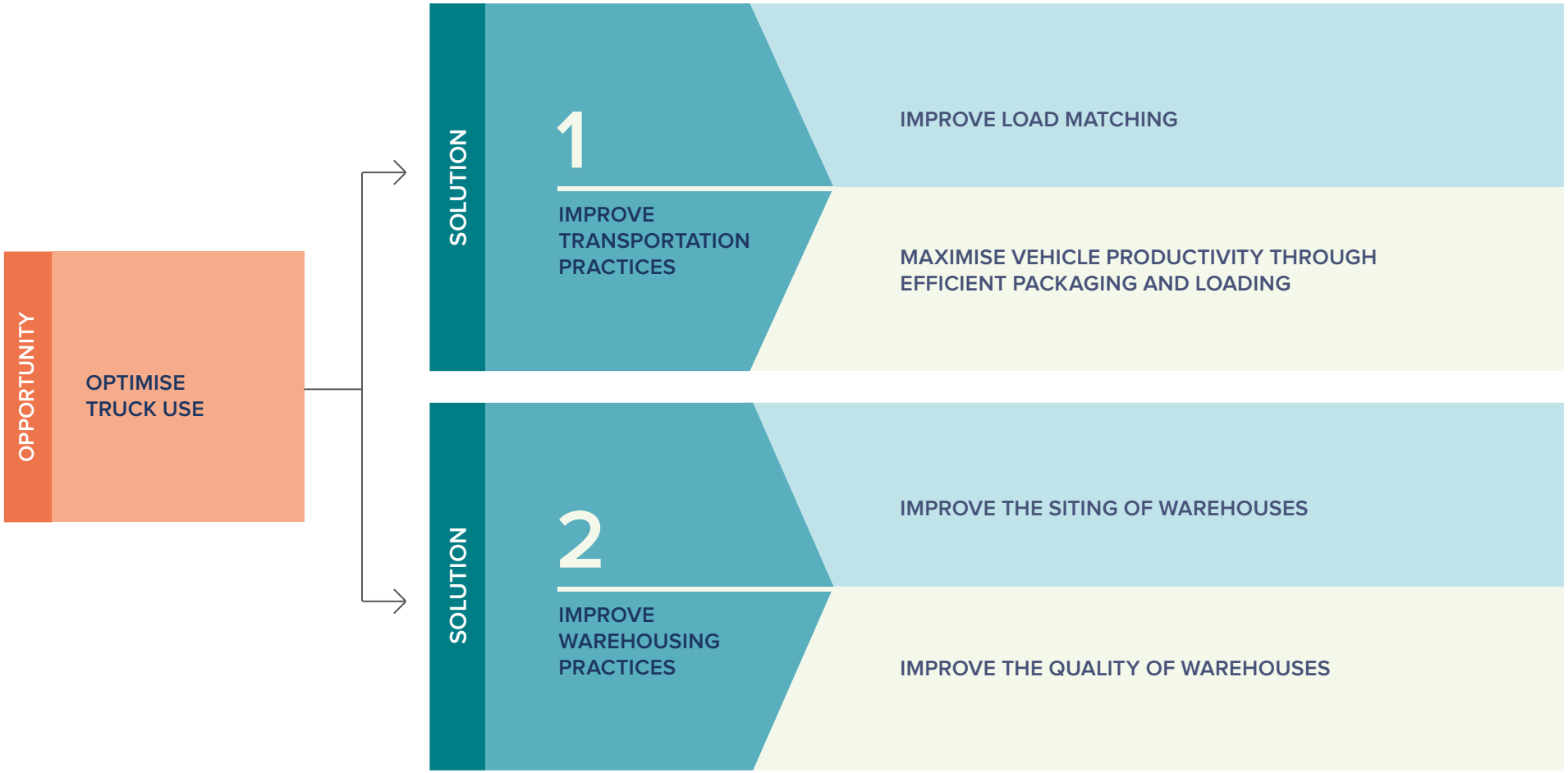
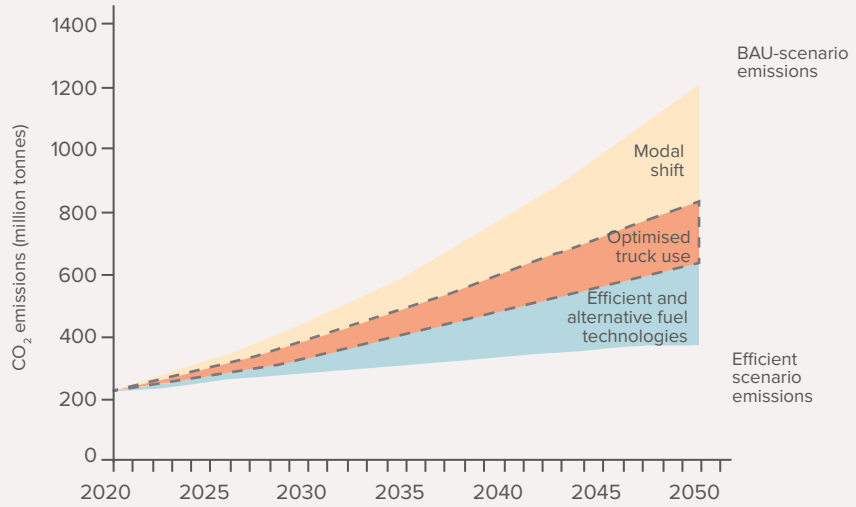


EXHIBIT 3-7 Solutions to optimise truck use

OPTIMISING TRUCK USE CAN REDUCE ANNUAL CO_2 EMISSIONS BY 185 MILLION TONNES IN 2050 OVER A BAU SCENARIO

FIGURE 3-15

Reduction in CO_2 emissions from improved logistics efficiency



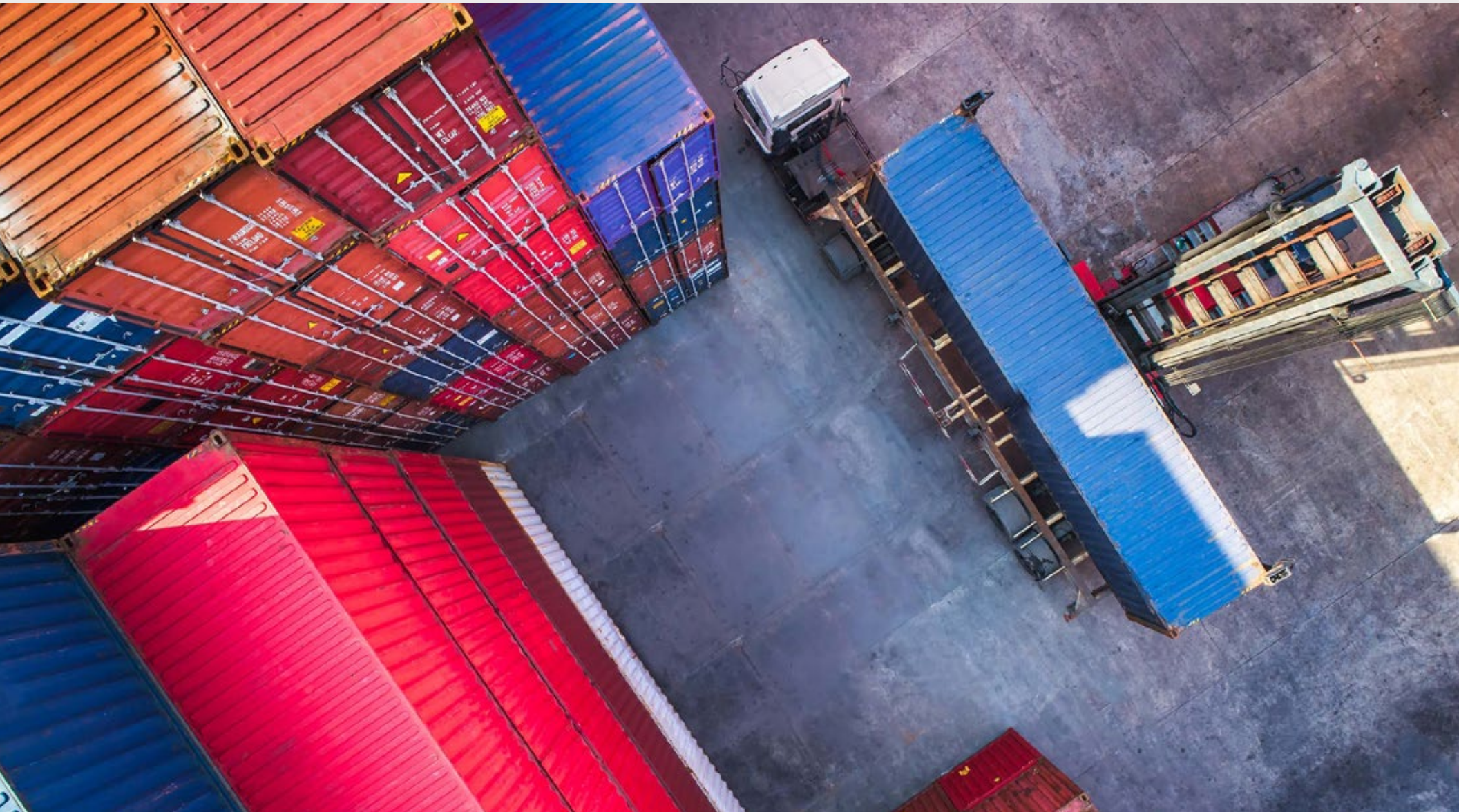
CUMULATIVE SAVINGS	2020 TO 2030	2020 TO 2050
NO_x savings (kilo tonnes)	1,258	5,282
PM savings (kilo tonnes)	43	149
VKT reduction (billion km)	486	5,424
Cost reductions (lakh crore INR)	8	85

By optimising truck use, truck utilisation and load factors will be improved. Key levers to this change include policy moves like tax reform and logistics planning, technological development and deployment, and investment in improved assets such as better trucks and warehouses. The high-level impact of those reforms against a BAU scenario include:

- Annual VKT reduction of 81 billion km and 450 billion km in 2030 and 2050
- Annual cost savings of INR 1.3 lakh crore in 2030 and INR 7 lakh crore in 2050
- Improved air quality and reduced CO_2 emissions

02 SOLUTION 2A

> IMPROVE TRANSPORTATION PRACTICES



TRANSPORTATION PRACTICES INVOLVE PROCESSES LIKE LOAD MATCHING, PACKAGING, LOADING, AND UNLOADING

Transportation operations involve many processes, from vehicle planning to dispatch optimisation. These practices are critical to choosing the right type of vehicle for the use case, optimising the load on the vehicle, minimising the distance that the vehicle travels to transport the goods and ensuring the goods and vehicles are adhering to high standards of safety while minimising waste. Improving these practices will result in:

1. **Reduced empty running –** fewer miles travelled without any load
2. **Better load factors –** closer to 100 percent load factors
3. **Improved vehicle productivity –** reduced vehicular travel to move same amount of goods
4. **Higher vehicle utilisation –** higher distances covered per vehicle per year, resulting in a smaller fleet and lower costs

TRANSPORTATION PRACTICES

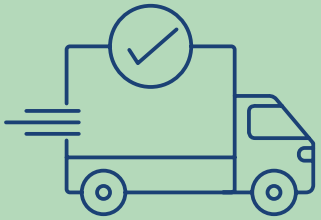
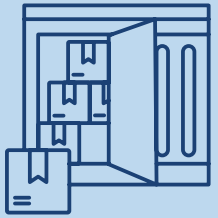
1 » PACKAGING	2 » LOAD MATCHING	3 » VEHICLE SELECTION	4 » LOADING AND UNLOADING
			
After production, goods are packaged and prepared for shipment. Efficient packaging helps in optimising warehouse and truck space.	Then, the load is matched with the vehicle operator for shipment. Reducing the number of intermediaries in this process can reduce time and empty running.	Next, the right type of vehicle is selected based on the use case, load, and distance in order to optimise the load factor.	Finally, the goods are scheduled for dispatch, loaded from the warehouse and unloaded at the destination. This process is critical to improving vehicle productivity by reducing trip distance and travel time.

EXHIBIT 3-9 Transportation practices in product supply chain

OPTIMISED PACKAGING AND LOAD MATCHING IS CRITICAL TO EFFICIENT TRUCKING

1 PACKAGING

Packaging is an essential part of the life cycle of many goods. It protects them from breakage or spoiling, and makes it more attractive for consumers. It also determines how much space an item will take up in a truck or warehouse. Extra packaging may enhance the appearance or the safety of a shipment, but it also incurs hidden costs in shipping. Achieving a balanced trade-off between these different roles of packaging is one of the many optimisations that shippers must navigate.[159]

2 LOAD MATCHING

Load matching or carrier assignment is the process where a shipper chooses a vehicle operator to ship goods. Improving load matching is critical to optimising truck use as it improves the quality of the match, removing wasted time and empty miles from the system. Load matching process can be made more efficient by reducing several intermediaries like transport companies, contractors, agents, and brokers from the system. Some of the alternatives for efficient load matching are:

- **A 3PL (third party logistics)** service that provides transportation-as-a-service model, in which individual carriers are matched with shippers. 3PLs offer services for warehouse and inventory management, transport optimisation, and network design.
- **A digital freight-matching platform,**[160] where a fleet operator or logistics service provider is matched with a shipper using digital tools like web apps.

CHOOSING THE RIGHT VEHICLE AND STANDARDISING LOADING PRACTICES CAN IMPROVE TRANSPORTATION EFFICIENCY

3 VEHICLE SELECTION

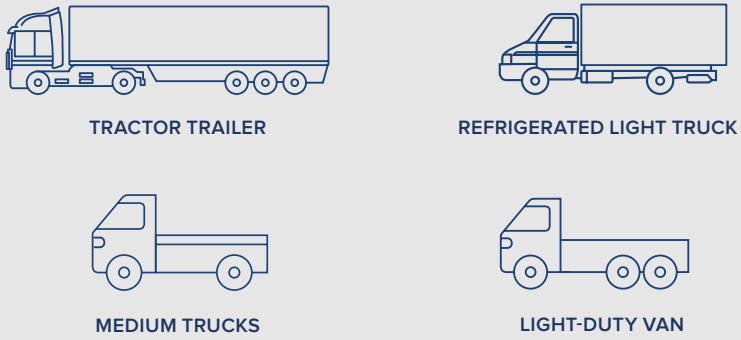


EXHIBIT 3-10 Types of freight vehicles

One of the reasons for the inefficiencies in India's road-based freight transport is the use of older trucks with low carrying capacity.[161] The root cause for that is the fragmented trucking market structure in India where small truck operators cannot afford new, bigger and better trucks. Based on the use case, replacing overloaded smaller trucks with bigger trucks can optimise the load factor, while maintaining safety.

For example, heavy bulk freight movement for short-haul is commonly carried out with overloaded medium trucks. They can be replaced with dumpers or tankers or heavy trucks rated at >31 Mt based on the type of the good. For longer distances, heavy enclosed trucks or tractor-trailers can be used. Medium regional haul from warehouses to distribution centres can be transported with medium trucks rather than overloaded light trucks. Transportation within the urban core can be done using fit-to-purpose vehicles, for example, using electric two- or three-wheelers for congested urban centers, using light refrigerated four-wheeler vehicles to move perishable goods.

4 LOADING AND UNLOADING

Loading and unloading practices not only include moving goods in and out of the vehicle, but also include planning which goods are moved and when. These practices determine how efficiently truck space, delivery times to transfer goods and transportation costs are utilised. As a result, it is essential to make these processes as smooth and efficient as possible. Some of the practices that can improve loading and unloading processes are:

- **Standardise processes and equipment for loading and unloading:** For example, matching pallet size to the truck floor sizes maximizes the capacity
- **Digitise processes:** For example, use RFID to track goods, and introduce standard data protocols to minimise manual inputs in tracking processes[162]
- **Improve warehouse management and shipment staging practices:** For example, improved scheduling enables faster turnaround of trucks, which means more deliveries per truck and a leaner more productive fleet
- **Optimize routes to reduce travel time and distance in the urban core:** This involves optimizing the delivery routes using parameters such as delivery locations, number of stops, delivery time, vehicle speed, traffic, and congestion data to reduce the time and distance traveled.

INDIA IS WITNESSING AN INCREASE IN BEST PRACTICES RELATED TO EFFICIENT TRUCKING OPERATIONS

Although India's current truck fleet has historically been dominated by medium-duty trucks and smaller heavy-duty trucks, recent sales show a higher share of heavy-duty trucks. In 2018, heavy-duty trucks (>16 tonnes) accounted for about 60 percent of annual sales.[164] The government has also increased the limits on maximum loading capacity by 20 to 25 percent for new vehicles, which will have better capabilities and hence can carry additional load.[165] At the same time, the government is also imposing stricter rules for overloading.[166]

Private sector companies in India have accelerated the introduction of efficiency practices in their operation:

- The digital freight matching market in India—dominated by long-haul trucking, which accounts for 90 percent of the market— stood at INR 581 crore in 2016,[167] which is less than 0.1 percent of the total logistics market,[168] but it is likely to grow in the future, with new start-ups also emerging in this space. Start-ups in road freight sector have seen an investment growth rate of 162 percent (CAGR) between 2014 and 2019.[169] Widespread use of digital freight matching will enable improved efficiencies through less empty running of vehicles, and reduction in wait times looking for cargo.
- Corporate players, like e-commerce companies, have started building sustainability visions and goals in logistics in order to increase efficiency and reduce costs and emissions associated with it. Some of the widely adopted practices include efficient packaging to reduce waste and trucking and warehousing space, digitisation and standardisation of practices to improve assets interoperability, efficient route and dispatch planning, etc. These initiatives have helped reduced travel times and improve truck productivity.

CASE STUDIES: IMPROVE TRANSPORTATION PRACTICES

The following case studies highlight the potential of improving transportation practices:

	GEOGRAPHY	TITLE	BEST PRACTICES
1	**UK**	Adoption of 44-tonne GVW trucks in the UK	Increase in the GVWR can reduce the associated VKTs and costs
2	**Global**	United Parcel Service's (UPS) use of big-data analytics for route planning and optimisation	Route optimisation through the use of analytics can reduce the number of trips and associated costs
3	**Sweden**	IKEA's efforts to improve packaging design	Improvement in packaging design and practices can enable higher load factors and hence fewer truck trips
4	**USA**	Walmart's best practices to improve load factors	Improvement in packaging design and how the goods are loaded in trucks can improve load factors
5	**Spain**	Sustainable urban logistics practices in Barcelona, Spain	Adoption of multi-use lanes and nighttime deliveries to enhance urban freight delivery productivity
6	**India**	Porter's digital freight matching platform to improve trucking efficiency	Using digital platforms for load matching can improve the quality of the match and reduce empty miles and wasted time

CASE STUDY 1: ADOPTION OF 44-TONNE GVW TRUCKS IN THE UK[170]

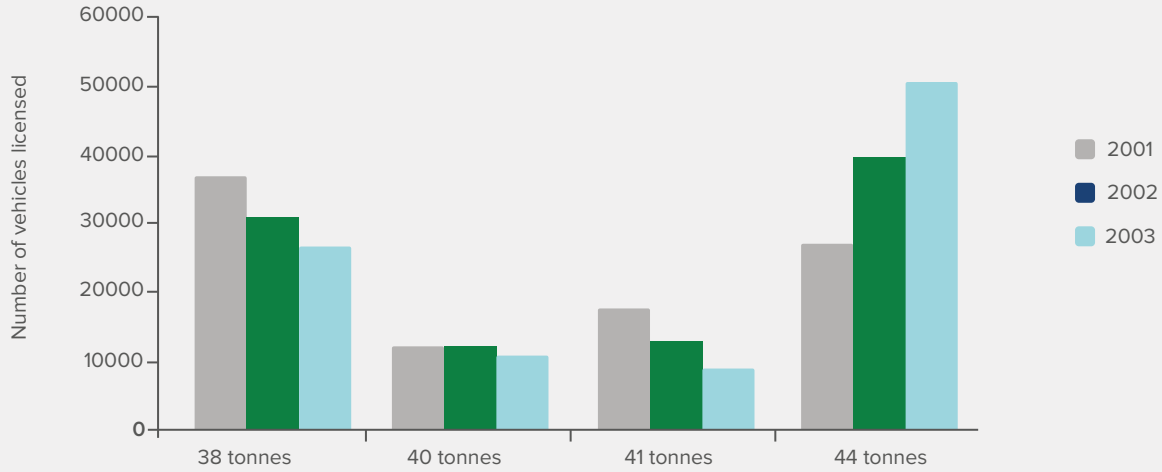
CONTEXT

Moving freight on larger, heavier trucks leads to higher transport efficiencies and reduction in CO_2 emissions, as larger trucks can haul the same amount of freight with fewer VKT.

SOLUTION

In 2001, the UK government decided to increase the maximum gross vehicle weight (GVW) of trucks from the current 41-tonne to 44-tonne. The UK government assessed that the current road and bridge infrastructure would handle the additional stress posed by the 44 tonne trucks.

FIGURE 3-16



RESULT

As figure 3-16 shows, by 2003, 44-tonne trucks became the most common type of heavy-duty truck in the United Kingdom. The major benefits of introducing the 44-tonne trucks between 2001 and 2003 were: 1) a VKT reduction of 29 crores, 2) fuel savings of 11 crore litres of diesel, and 3) avoided 3 lakh tonnes of CO_2 emissions and 1,900 tonnes of NO_x emissions.

CASE STUDY 2: UPS'S USE OF BIG-DATA ANALYTICS FOR ROUTE PLANNING AND OPTIMISATION

CONTEXT

United Parcel Service (UPS) is one of the largest package delivery carriers in the world. It had developed an On-Road Integrated Optimisation and Navigation (ORION) software tool that increases the efficiency of its delivery and pickup operations.

SOLUTION

UPS' ORION software uses big-data analytics from fleet telematics to optimise drivers' delivery routes. After developing and pilot testing the ORION algorithm, UPS tested the algorithm at various UPS sites. In 2014, after rigorous testing and improvements, ORION was fully deployed. By 2016, it was being used on 55,000 routes.[171]

RESULT

With the deployment of ORION, UPS has achieved a reduction in annual VKT of 160 million km,[172] with cost reductions of INR 2,500 crore, CO_2 emissions reductions of one lakh tonnes, and fuel savings of 4 crore litres annually.[173]

CASE STUDY 3: IKEA'S EFFORTS TO IMPROVE PACKAGING DESIGN[174]

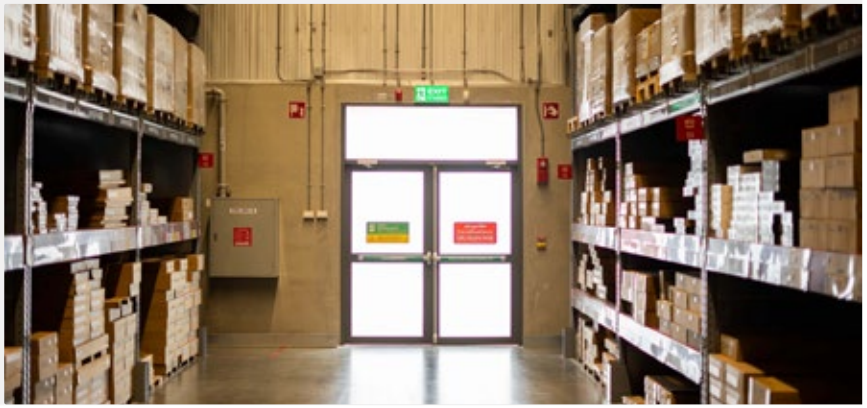
CONTEXT

IKEA is a furniture and home furnishing retail firm headquartered in Netherlands, Europe. A design challenge that IKEA identified in its operations was that its trucks were not being optimally loaded due to inefficient product packaging design. Load factors were low because low-value products with high-volume packaging were using excessive space, leading to more trips and higher costs than necessary.

SOLUTION

IKEA decided to solve this design challenge in several ways:

- They redesigned their product packaging, removing excess air. For example, IKEA increased the load capacity of one of their products, Glimma tea candles, by 30 percent by rearranging them to increase packing density and reduce excess air.
- Following package redesign, they balanced the weight and volume of products in trucks by loading different types of products in the vehicle. For example, with the new packaging design for the candles, IKEA was able to pack more units, but the truck would reach its maximum carrying capacity in terms of weight before its volume was full. To solve this design challenge, IKEA started filling the rest of the space with lightweight products such as pillows and mattresses.



RESULT

IKEA's packaging design improvements led to increased utilisation of transportation resources by 30 percent and more space in warehouses. IKEA was able to decrease the number of containers on the road by 400 and saw significant reductions in VKT.

CASE STUDY 4: WALMART'S BEST PRACTICES TO IMPROVE LOAD FACTORS[175]

CONTEXT

Walmart is one of the largest retail and e-commerce companies in the world. In 2005, Walmart sought to double the efficiency of its fleet by 2015. Improving loading and packaging practices to reduce the VKT of the fleet was one of the efficiency levers targeted by Walmart.

SOLUTION

A key to achieving that efficiency was higher load factors. To achieve higher load factors, Walmart focused on packaging design and loading practices. In 2007, Walmart used to load its trailers with straight pallets. They then experimented with turning the pallets sideways, which could let more pallets fit in the trailer and gain over 10 percent in load factor. They were able to get halfway there with pinwheel configurations. However, a slight overhang beyond the end of the pallet made full use of turned pallets impossible. To address that, Walmart re-evaluated its packaging procedures to eliminate that overhang and enable maximum truck utilisations. By 2009, Walmart was moving trailers with all the pallets turned sideways, hence achieving higher load factors.

RESULT

This new packaging improvement helped Walmart increase shipments by 658 million pallets and reduce truck miles driven by 298 million in five years.

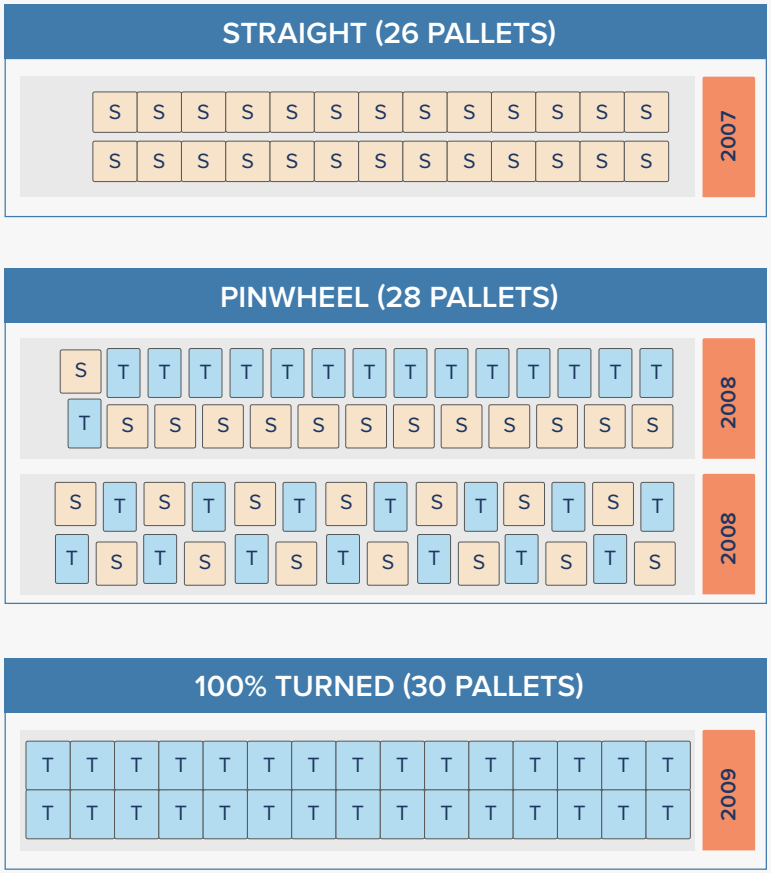


EXHIBIT 3-11 Improved packaging design to enhance loading efficiency[176]

CASE STUDY 5: SUSTAINABLE URBAN LOGISTICS PRACTICES IN BARCELONA, SPAIN[176]

CONTEXT

Many cities and urban centers suffer from high congestion issues, with heavy traffic impacting the productivity of urban freight delivery systems. However, cities across the world are implementing best practices to make the urban freight ecosystem more efficient. One such example is Barcelona, a city in Spain, which has implemented measures to tackle the challenges around congestion and productivity.

SOLUTION

The two measures adopted by Barcelona are: 1) Enhancing parking availability for urban freight vehicles, and 2) Implementing nighttime deliveries for heavy trucks.

To enhance parking availability, the city created multi-use lanes, which serve different purposes depending on the time of the day. During peak hours, the lanes are used by buses for passenger movement. During off-peak hours, these lanes are used by freight vehicles for loading and unloading. During nighttime hours, they are used by residents for parking. The city also modified its building codes for commercial settings that mandated the use of off-street space for loading and unloading of urban freight vehicles.

The city of Barcelona also partnered with key grocery stores to enable nighttime deliveries by heavy trucks, that were modified to generate low or no noise while operating. This reduced noise pollution and displaced multiple trips by small and medium trucks during the day.

RESULT

Barcelona saw major benefits by implementing the two measures. The measure to enhance parking availability through multi-use lanes led to a 12 – 15% reduction in travel time for freight vehicles, while modifying building codes increased the delivery efficiency of the vehicles serving those establishments. The implementation of nighttime deliveries led to a 50% reduction in noise pollution, reduced driving time and improved vehicle utilization.

CASE STUDY 6: PORTER'S DIGITAL FREIGHT MATCHING INTRA-CITY LOGISTICS SERVICES[177]

CONTEXT

Porter is a digital freight matching company focused on urban freight movement. Through Porter's digital platform, users can book goods vehicle by choosing pickup and dropoff location and entering choice of vehicles. Through this platform, users can book minitrucks whenever and wherever they need and track the goods movement. Porter operates in 7 cities and has more than 100,000 driver partner.

SOLUTION

Porter uses a digital app to connect a shipper who wants to ship the load with a driver who can transport that load. This benefits both the shipper and driver and increases the efficiency of the overall urban freight system. For the shipper, the app platform eliminates the need to go through intermediaries to find the right transport mode and driver. Instead, a shipper can instantly select the type of vehicle needed to carry the load and get connected with a nearby driver. Similarly, drivers can get backloads or additional loads to different locations much easily via the app and don't have to rely on unorganized stands to find the load. The added GPS navigation feature in the app also helps them reduce time and vehicle kilometers.

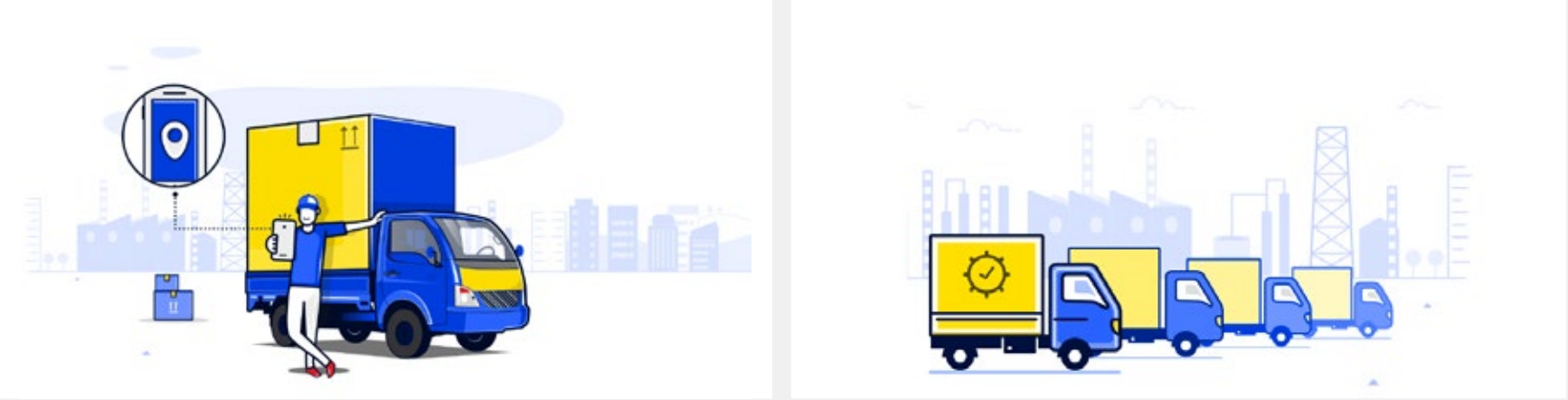


Image source: Porter.in

RESULT

Porter's app based platform helps improve the truck utilisation by reducing idle time and reducing empty vehicular kms, and thus increasing the revenue. This in turn helps improve logistics efficiency and reduce logistics costs.

SUMMARY: PATHWAYS TO IMPROVE TRUCKING PRACTICES

The ecosystem of actors to improve transportation practices

GOVERNMENT

Invest in improvements in trucking infrastructure

- Introduce incentives for improving sizes of trucks by introducing practical, enforceable weight and dimensions limits
- Continue investment in road infrastructure to enable the use of heavier and better trucks
- Initiate grand challenges/ex-prizes to promote sustainable logistics practices across the private sector
- Support manufacturing of larger trucks
- Introduce policies to promote scrapping of obsolete, inefficient trucks

INDUSTRY

Introduce sustainability initiative and practices in the business

- Logistics providers to use big data practices for load matching
- E-commerce and major retailers to revisit their packaging practices to incorporate more sustainable packaging design
- Encourage OEMs to invest in R&D and manufacturing of bigger and better trucks
- Promote consolidation to improve load factors

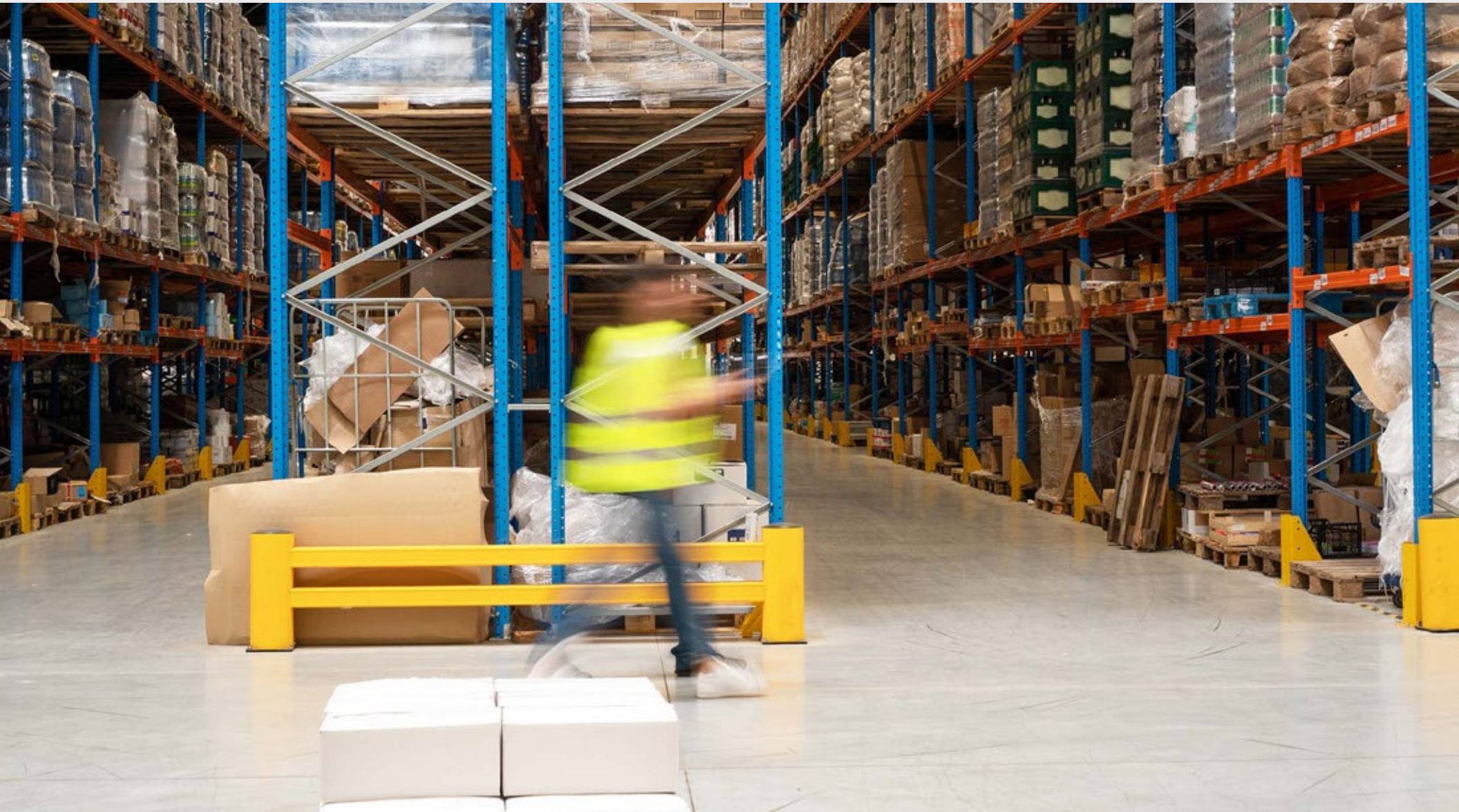
MULTISTAKEHOLDER COLLABORATION

Standardise and digitise transportation practices

- Private sector to build a consortium, in collaboration with the government, to standardise practices across the supply chain to ensure asset interoperability
- Host a convening of transporters, major shippers and digital freight matching providers to discuss experiences and knowledge regarding trucking practices

04 SOLUTION 2B

> IMPROVE WAREHOUSING PRACTICES



INVENTORY MANAGEMENT CAN BE IMPROVED THROUGH HIGH-QUALITY WAREHOUSES AND OPTIMISED SITING

Warehousing is an important part of any supply chain, especially when it comes to inventory management. Depending on the purpose, warehousing infrastructure can include logistics parks, consolidation centres, multimodal parks, regional warehouses, and distribution centres. The size of the warehouses can be managed according to consumer demand. Higher inventory aggregation at large centralised warehouses reduces inventory holdings but also increases lead times. So hitting the right balance is an important part of distribution network design.

There are three factors to consider making warehousing more efficient: 1) Quality, 2) siting, and 3) processes.
The three are interrelated. For example, digitisation can improve the quality of a warehouse, while siting can be simplified through digital processes. Improving quality of warehouses and digitising processes support streamlined loading operations, leading to lower detention time for trucks and improved load factors. Optimised warehouse siting minimises distance to the customer, and hence reduces vehicle travel and lead times. Thus, improving warehousing efficiency supports optimised truck use.

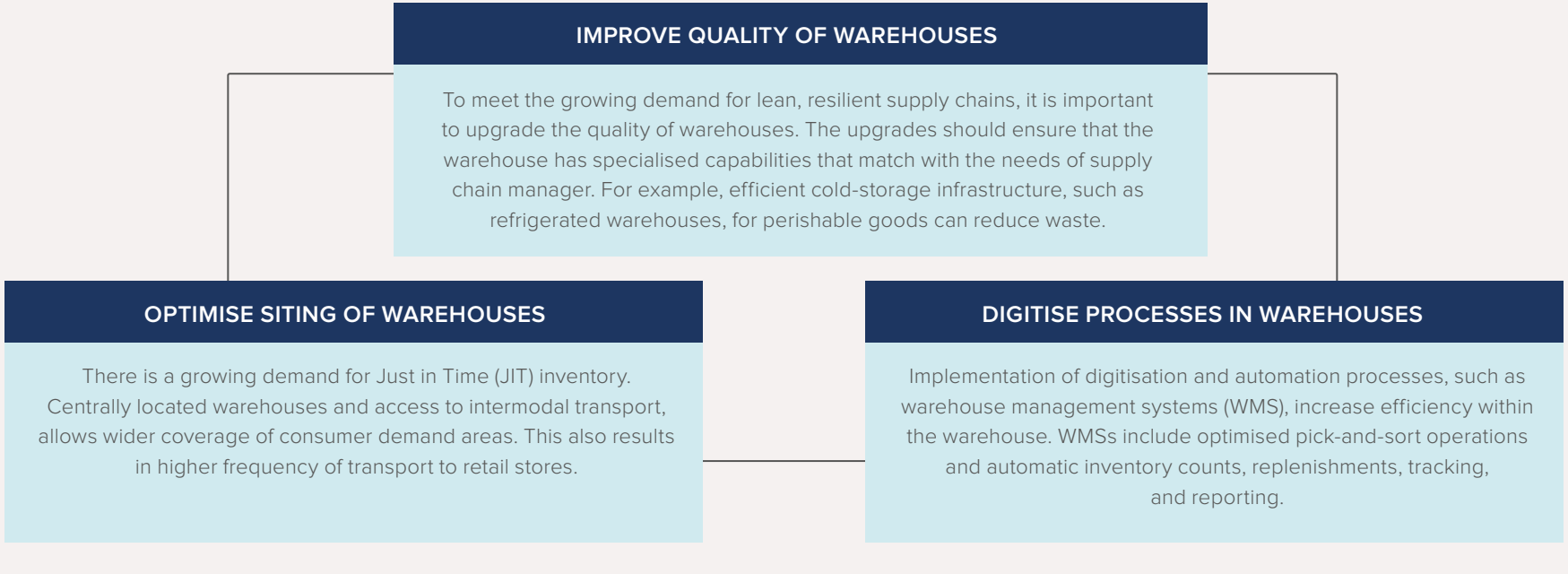


EXHIBIT 3-12 Three pillars for improving warehousing efficiency

SUPPORTIVE POLICY ENVIRONMENT AND EMERGING 3PL PLAYERS HAVE INCREASED WAREHOUSING EFFICIENCY

Policy can impact supply chain efficiency in unexpected ways. For example, moves to streamline tax collection in India through a Goods and Services Tax (GST), have had major impact on how supply chains in India are designed. Prior to the implementation of India's GST, trucks were stopped at borders for physical checking and collection of taxes. Transportation was delayed and truck productivity reduced. To avoid high travel time and costs, companies started setting up small warehouses and distribution centres in every state in which they wanted to deliver products.

With the implementation of GST, state border check posts and taxes no longer exist. This has increased the daily utilisation of trucks and reduced travel times. It has also created an opportunity for companies to setup larger, centralised warehouses and invest in better infrastructure. Consolidation of warehouses also resulted in reduction in excess inventory holdings.

With GST eliminating a major barrier to efficient supply chains, the government is continuing to promote efficient logistics by focusing on three areas highlighted below:

Quality of warehouses:

- The Logistics Efficiency Enhancement Program focuses on freight efficiency improvements through infrastructure, procedural and Information Technology (IT) interventions[178]
- Nationwide, ten states have a dedicated policy for warehousing and logistics[179]

Digitisation of warehouses:

- India's Warehousing Development and Regulatory Authority (WDRA) has set up norms for standardising warehousing practices[180]
- Digital India, a flagship GOI program, promotes digitisation in logistics operations across supply chain[181]

Siting of warehouses:

- Land development plans developed by city governments identify residential and commercial areas to plan warehousing

GROWING INVESTMENT IN WAREHOUSING AND EMERGENCE OF THIRD-PARTY LOGISTICS (3PL) MARKET IN INDIA

India's warehousing sector has started to attract big investments over the past two years. Between 2017 and 2019, investment in India's warehousing sector was INR 25,400 crore, which is expected to reach INR 49,500 crore by 2021.[182] On the supply side, the warehousing space is expected to increase from 169 million sq ft in 2019 to 344 million sq ft in 2022.[183] This growth is a result of market conditions such as increased e-commerce demand and the emergence of 3PL players.

The 3PLs play an important role in shaping the future market. They provide integrated services for warehouse management, network optimisation and dispatch planning. They have expertise in supply chain efficiencies and ability to achieve economies of scale and potential to invest in higher quality warehousing. The 3PL market (with market penetration of 5.7 percent[184]) in India stood at INR 33,000 crore in 2017 and is expected to reach INR 57,000 crore by 2020.[185] With increase in 3PL penetration, India's warehousing market is expected to rapidly deploy world-class infrastructure, technology and processes.[186]

CASE STUDIES: IMPROVE WAREHOUSING PRACTICES

The following case studies highlight the potential to improve warehousing practices:

	GEOGRAPHY	TITLE	BEST PRACTICES
1	**India**	Future Group's centralised warehouse in Nagpur, India	Moving from small, local, poor-quality warehouses to bigger, more centralised, and higher quality warehouses can reduce inventory and transport costs

CASE STUDY 1: FUTURE GROUP'S CENTRALISED WAREHOUSE IN NAGPUR, INDIA[187]

CONTEXT

Future Group in India has businesses in retail, fast-moving consumer goods, fashion, and home furnishings, with an extensive supply chain network across the country. Future Supply Chain, a part of Future Group, handles the supply chain network for all its stores and warehouses.

SOLUTION

In the initial phases, the supply chain network of the Future Group was not optimised. Warehouse practices were not automated or standardised and warehouses were not integrated into the rest of the supply chain. The result was excess inventory holdings and losses, stock shortages at stores, and low utilisation of trucks. Future Supply Chain sought to transform the group's supply-chain practices by 1) improving the quality of warehouses, 2) improving the supply chain structure, and 3) optimising warehouse siting. Warehouses were upgraded with digital tools such as WMS to achieve higher efficiencies. The second major step was to move to a central warehouse location in Nagpur, so that one distribution centre could replace all smaller regional warehouses. Nagpur was selected as the hub because of its central location, with all major consumption centres within a 1,000 km radius. The centralised warehouse supplied products directly to all the big stores. Smaller clusters were developed which would get the products from the centralised warehouse and supply the products to small stores.

Image source: Future Group

RESULT

Inventory holdings decreased by one-fifth, rental charges reduced dramatically (due to a lower number of warehouses), and there were significant savings in transport costs.

SUMMARY:
PATHWAYS TO IMPROVE WAREHOUSING PRACTICES

The ecosystem of actors improve warehousing practices

GOVERNMENT

Continue investments in logistics parks and improved warehousing

- Continue investment in development of logistics parks
- Set safety, performance and efficiency standards for warehouse operations
- Continue digitising toll booths to enable tax and fees collection without stopping trucks at the border
- Promote investment in cold chain and refrigerated vehicles for movement of perishable goods
- Optimise land-use planning to effectively site warehousing infrastructure

INDUSTRY

Invest in warehousing infrastructure

- Fleet aggregators, and goods manufacturers to collaborate to identify optimum siting of warehouses, consolidation centres, and logistics parks
- Warehouse owners to invest in standardisation and digitisation of processes and equipment
- Develop cost-effective business models for 3PL services

MULTISTAKEHOLDER COLLABORATION

Host pilots to test warehouse siting

- State and city government to collaborate with private companies to plan land use for building new warehouses
- Establish communication platforms between public and private sector through discussion forums to improve policies on warehousing efficiency

05 OPPORTUNITY 3 OVERVIEW

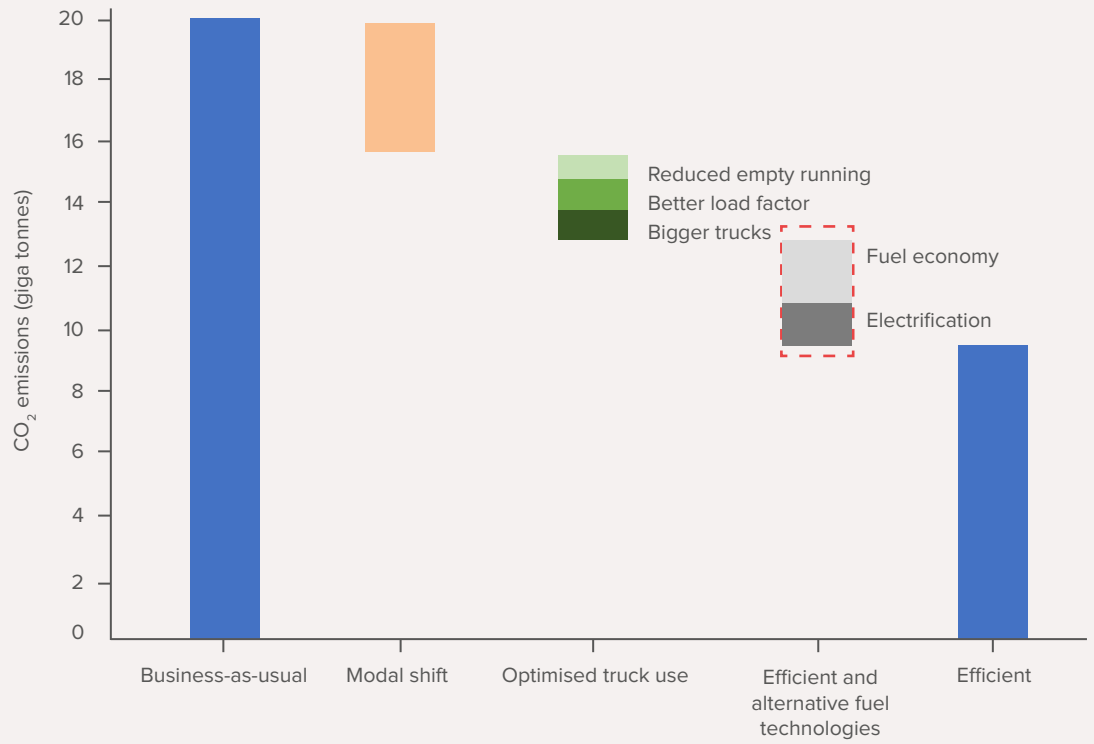
> PROMOTE EFFICIENT AND ALTERNATIVE FUEL TECHNOLOGIES

SNAPSHOT: PROMOTE EFFICIENT AND ALTERNATIVE FUEL TECHNOLOGIES

Potential savings by 2050: 3.3 giga tonnes of CO_2; INR 102 lakh crore; 188 kilo tonnes of PM; 4.6 million tonnes of NO_x

FIGURE 3-17

Cumulative CO_2 emissions from freight sector in India between 2020-2050



SOLUTIONS/LEVERS

Improve fuel economy and reduce ICE vehicles' emissions

- Enhance fuel consumption and emissions standards
- Promote collaboration on technology solutions

Use electric vehicles and cleaner fuels

- Implement supportive policies and pilot projects
- Manufacture high-quality vehicles and create more robust charging infrastructure network

RECOMMENDATIONS

- Collaborate with other industry players to develop a forum to share experiences regarding fuel economy best practices
- Create incentives to improve vehicle design and technology standards
- Design policies and interventions to make clean and electric vehicles more affordable while supporting long-term infrastructure and smooth operations
- Build fit-for-purpose EVs
- Host pilot projects to improve business decision-making and policymaking for clean and EVs

INEFFICIENT ICE TECHNOLOGY HAS NEGATIVE IMPACTS ON COSTS, CLIMATE, AND PUBLIC HEALTH

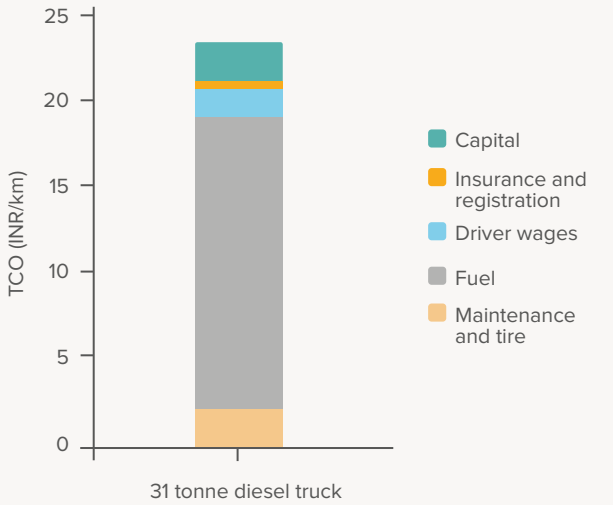
While shifting long-haul bulk freight from road to rail reduces costs and pollution, road transport is an effective choice for moving goods over shorter distances, when flexibility is a priority with respect to origin-destination and volumes. Ensuring that these vehicles are efficient and utilise alternative fuels, is critical for the economy and environment.

ICE-powered road freight vehicles contributed 200 million tonnes of CO_2 emissions in 2019,[188] adversely affecting air quality by emitting NO_x, SO_x and PM emissions. These vehicles also increase logistics cost because of high fuel costs, which is the largest component of the total cost of ownership.

FIGURE 3-18

HIGH COSTS

Total cost of ownership

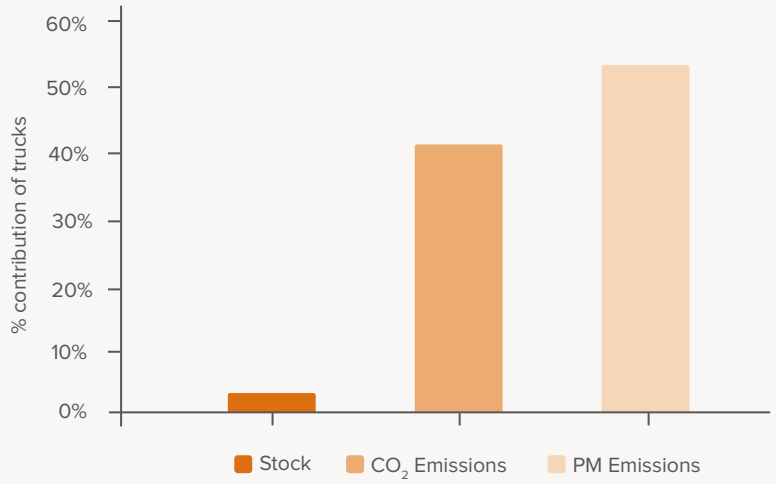


Fuel costs account for about 70 percent of the total cost of ownership of a 31-tonne truck (purchased in 2019).[189] Reducing fuel consumption brings down costs.

FIGURE 3-19

HIGH EMISSIONS

Contribution of trucks towards total vehicle stock and transport emissions



While trucks account for only 3 percent of the total vehicle fleet (passenger + freight) in India, they contribute to 53 percent of PM and 34 percent of CO_2 emissions from the transport sector,[190] highest among all vehicle categories. CO_2 emissions from trucks is expected to grow by 390 percent between 2020 and 2050 and their share of CO_2 emissions will increase from 34-47 percent in the same time frame, highlighting the fact that trucks will remain the disproportionate emitters in the future.[191]

LOW FUEL EFFICIENCY AND ALTERNATIVE FUELS ARE THE REASONS FOR THESE EXTERNALITIES

FIGURE 3-20

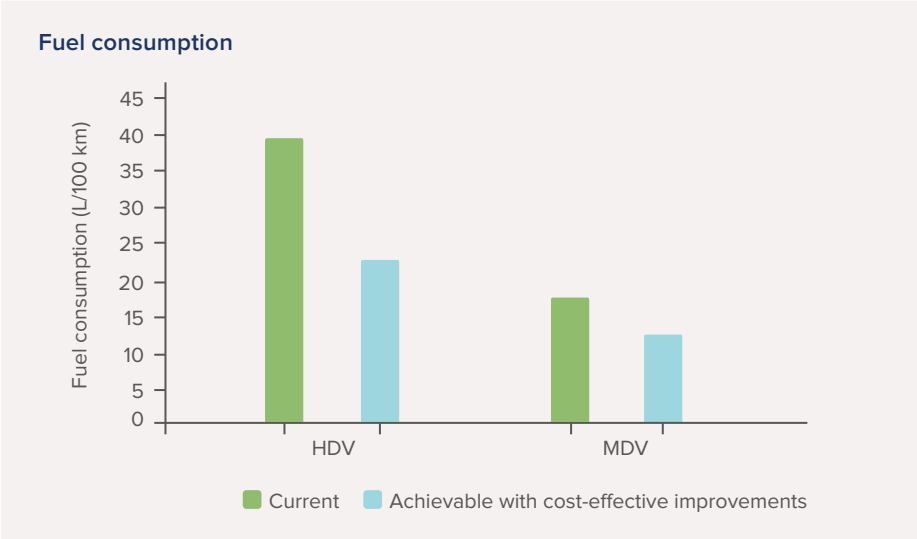
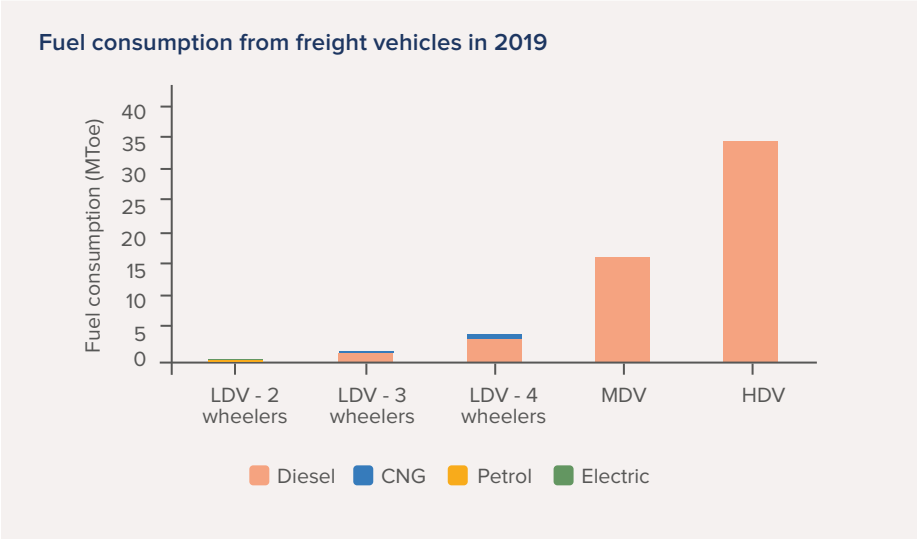


FIGURE 3-21



One of the leading causes of high fuel consumption, and associated costs and emissions in India's road-based freight transport, is the low fuel efficiency of vehicles. HDVs in India consume 39 litres per 100 km, whereas it can achieve 22 litres per 100km.[192] This inefficiency is due to three reasons:

- **Aged fleets:** Older trucks, which predominate in India,[193] use outdated technologies, and have less efficient drivetrains and more wear and tear, thus using more fuel.
- **Lack of information and financing opportunities for small fleet operators:**[194] Small fleet operators are cash constrained, have limited information on fuel saving technologies and lack of access to loans. As a result, they rely on the most basic truck models and are reluctant to spend money on fuel saving technologies.
- **Low availability and adoption of fuel-efficient alternatives:**[195] New fuel-saving technologies such as low rolling resistance tyres, lightweight materials, waste heat recovery, and improved aerodynamics are not fully developed in India and there has been a historic lack of demand.

Currently, diesel fuels 90 percent of the road-based freight vehicular activity in India, followed by petrol and CNG.[196] The share of EVs and other alternative cleaner fuels across all vehicle classes in the freight market is low. For medium- and heavy-duty trucks, the current market share is negligible. For light duty vehicles, including two-, three-, and four-wheeled freight vehicles, the EV penetration is less than 1 percent.[197] This low share is due to the following reasons:

- High capital cost of EVs
- Sparse charging or swapping infrastructure leading to range anxiety
- Operational barriers associated with plying, entry, parking, loading and unloading
- Less vehicle model options for fit-to-purpose vehicles for freight use-cases
- Lack of awareness amongst drivers and other consumers

IMPROVING FUEL ECONOMY, PROMOTING EVS AND CLEANER FUELS CAN REDUCE COSTS AND EMISSIONS

To promote efficient and alternative fuel technologies to reduce costs and emissions, the following solutions need to be implemented:

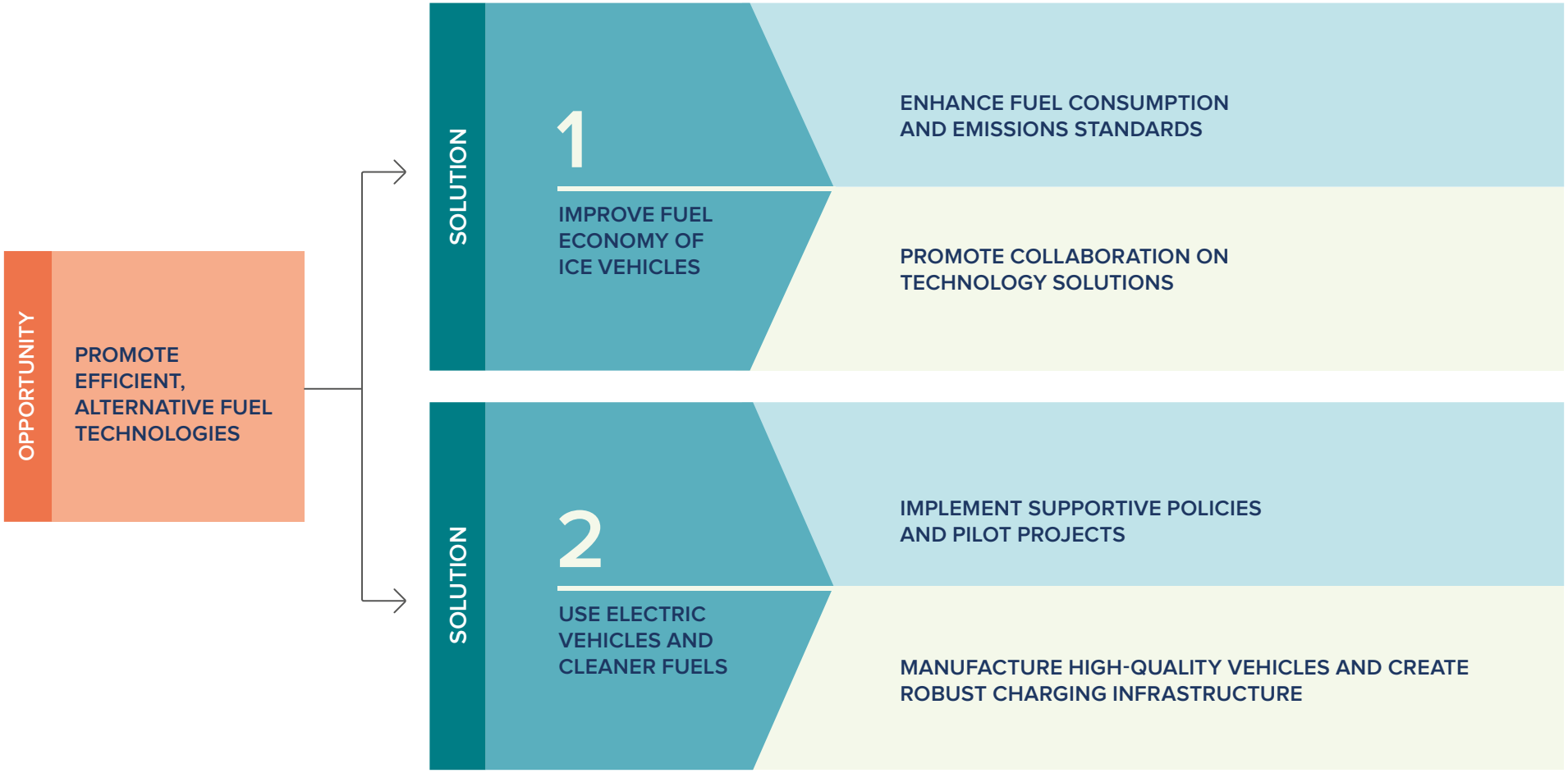
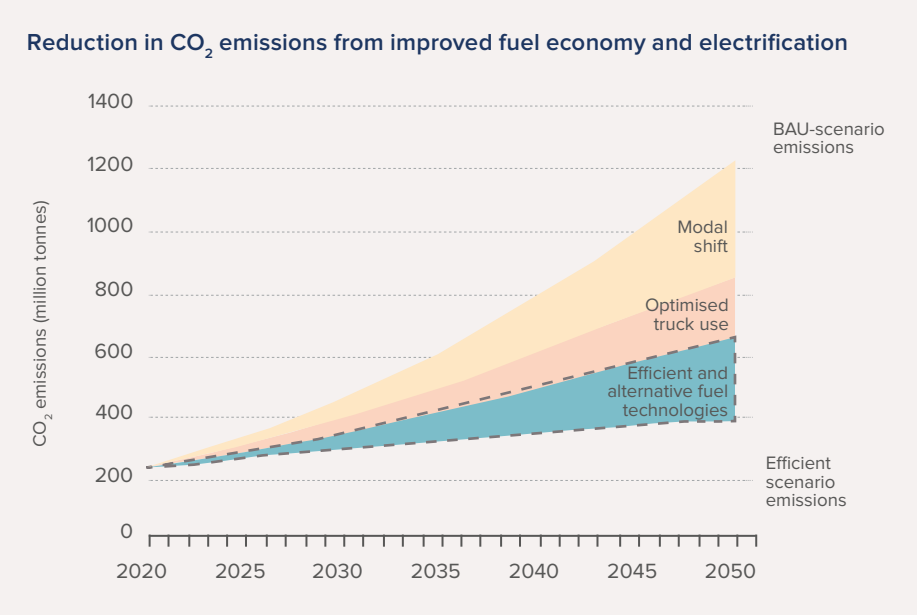


EXHIBIT 3-13 Solutions to promote alternative fuel technologies

PROMOTING EFFICIENT FUEL TECHNOLOGIES CAN REDUCE ANNUAL CO_2 EMISSIONS BY 268 MILLION TONNES BY 2030

FIGURE 3-22



CUMULATIVE SAVINGS	2020 TO 2030	2020 TO 2050
NO_x savings (kilo tonnes)	55	4,626
PM savings (kilo tonnes)	3	188
Oil demand reduction (Mtoe)	52	950
Fuel savings (INR lakh crore)	5	102

EXHIBIT 3-14 Savings from efficient and alternative fuel technologies

Shifting to clean and fuel-efficient technologies will reduce energy consumption, and associated costs and emissions, by vehicles. Pathways to achieve greater fuel economy and wider electrification include stringent fuel economy standards by the government, policies to accelerate the manufacturing and sale of EVs, sustainability goals of organisations, and the potential to lower operating costs. With these measures, India can reach 100 percent electrification of freight sector by 2050 and fuel economy improvement of 60 percent over BAU scenario.

If India moves to support the rapid deployment of alternative technologies, especially EVs, we can have an EV stock of 9,700 eHDVs, 25,400 eMDVs , and 28 lakh eLDVs (two-, three-, and four-wheelers) by 2030. This will translate to an annual e-VKT of 91 billion km in 2030 and 1.2 trillion km in 2050.

05 SOLUTION 3A

> IMPROVE FUEL ECONOMY AND REDUCE ICE VEHICLES' EMISSIONS

VEHICLES LOSE ENERGY THROUGH FIVE DIFFERENT WAYS

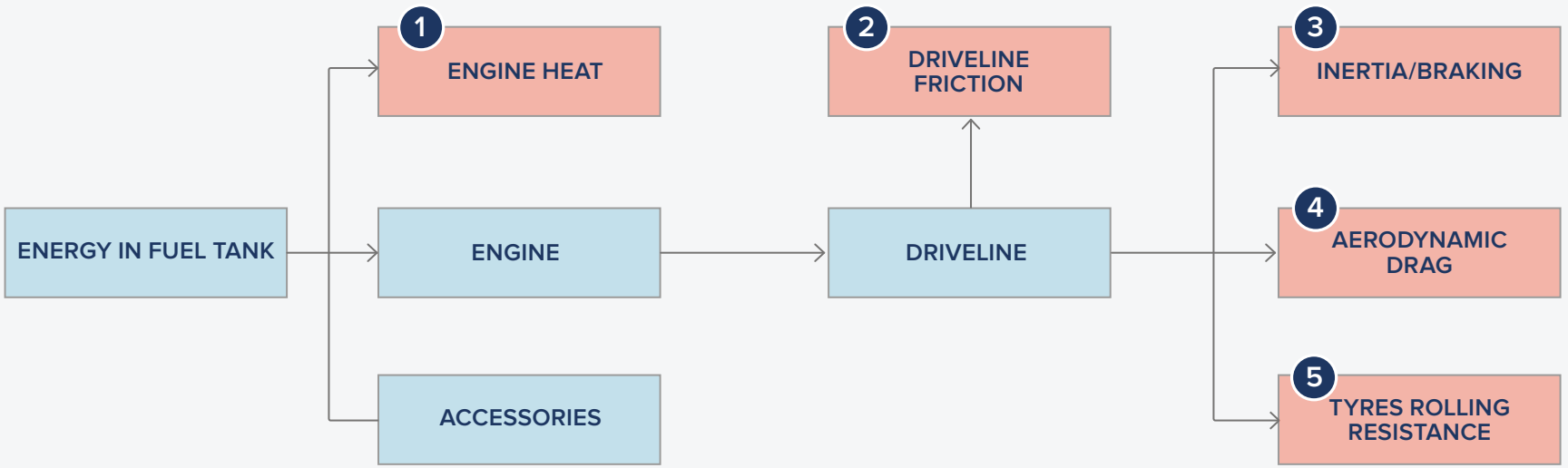


Exhibit 3-15 Energy losses in an ICE Heavy-Duty Truck in India[198]

An ICE vehicle gets its power from combusting fossil fuels like diesel, petrol or CNG. As energy from the engine is passed on to the wheels, much of that energy is wasted. Minimising five sources of energy loss is key to improving fuel efficiency:

- **Engine heat** – Waste heat from the fuel combustion that is never turned into mechanical force to power the truck
- **Driveline friction** – Losses due to friction in driveline
- **Inertia/breaking** – Energy loss due to inertia while accelerating the vehicle, especially after braking. It is proportional to the change in speed and mass of the vehicle with the load
- **Aerodynamic drag** – Energy loss to air resistance, which increases with the vehicle speed
- **Tyres rolling resistance** – Energy lost between tires and the surface of the road. It worsens with low quality tires and poorly surfaced roads

The magnitude of each class of energy loss varies with driving patterns. In India, aerodynamic losses are low due to slow vehicle speeds, limiting the impact of improved vehicle aerodynamics. On the other hand, bias tyres, which have high rolling resistance, are popular in India[199] – making tyres improvement a low hanging fruit.

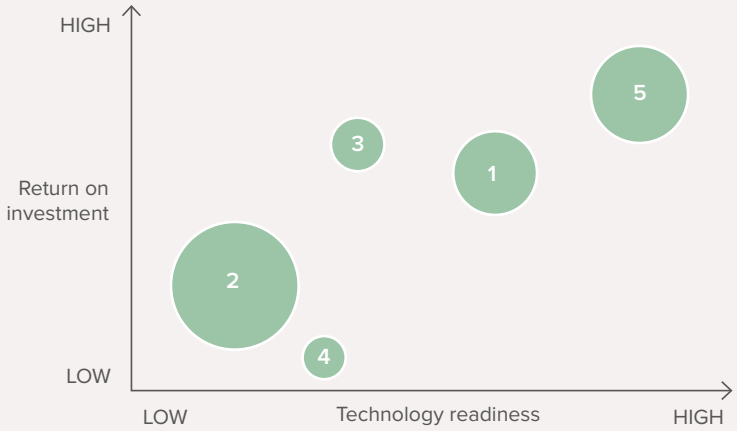
TECHNOLOGY SOLUTIONS OFFER DIFFERENT RETURNS ON INVESTMENT AND FUEL ECONOMY IMPROVEMENT POTENTIAL

A set of technological solutions exist that can improve the fuel economy of trucks by addressing losses described in exhibit 3-16.

- Engine and tyre improvements yield high fuel-economy improvements, return on investment and technology readiness.
- Aerodynamic improvements currently have a low return on investment and fuel-economy improvement potential. However, they are heavily used in other markets and are likely to grow in importance in India.
- Driveline and transmission improvements can deliver the highest fuel economy improvement, but both return on investment and technology readiness are low.

Usage of trucks in India will not remain static and as trucks become faster, relevant fuel-saving technologies will evolve.

EXHIBIT 3-16 Fuel economy improvement potential for a heavy-duty truck in India[208]



Size of the bubble refers to the relative vehicle efficiency improvement potential

1 ENGINE HEAT[200,201]

- Improved design and materials for combustion chamber
- Improvement in turbocharger technology
- Waste heat recovery systems

2 DRIVELINE FRICTION[202]

- Automated manual transmission
- Use of advanced lubricants
- Hybrid-electric drivetrain

3 INERTIA/BREAKING[203,204]

- Light weighting using aluminium composite body panels
- Single cylinder brake compressor
- Light weighting of suspension systems

4 AERODYNAMIC DRAG[205]

- Aerodynamic body shapes
- Aerodynamic designs of fairings, side skirts, tailgates, mud flaps, cab extender

5 TYRE ROLLING RESISTANCE[206,207]

- Low rolling-resistance radial tyres
- Automatic tyre inflation
- Air pressure monitoring systems
- Better tyre-wheel alignment

POLICY INTERVENTIONS AND CONSULTATIONS CAN SUPPORT FASTER ADOPTION OF FUEL-ECONOMY

India's trucking market is fragmented with a large chunk of the sector dominated by small owners. They are hesitant to invest in new technology, because they are time and resource constrained and have limited access to information on new technologies.[209] Even when large fleet operators invest in newer technologies, such as better engine oils and radial tyres, lack of information about their payback periods introduces uncertainty and hesitation.

Two main pathways exist to overcoming these challenges:

- Policy intervention to promote adoption of fuel-saving technologies
- Peer-learning forums through industry collaboration to share knowledge and experiences about fuel-saving technologies

POLICY INTERVENTIONS

Fuel-economy and emissions standards are two of the most effective policy measures to reduce fuel consumption and CO_2 emissions from freight vehicles. They require vehicle manufacturers to adopt fuel-saving technologies. The standards can be applied to the vehicle and to specific components, such as engines, tyres, and transmissions.

PEER LEARNING FORUMS

Gathering and sharing real-world data on fuel-saving technologies for various vehicle categories and insights on payback periods gives truck fleet owners the confidence to invest in improved efficiency. A forum for fleet owners and vehicle manufacturers, focused on shared experience and best practice fuel-saving technologies, is an effective way to enable this collaboration.

INDIA HAS SET FUEL-ECONOMY AND EMISSIONS STANDARDS FOR HDVS AND PLANS TO UPDATE THEM OVER TIME

FIGURE 3-23

CO_2 reduction for heavy-duty tractor trucks due to emissions or fuel consumption standards compared to baseline[210]

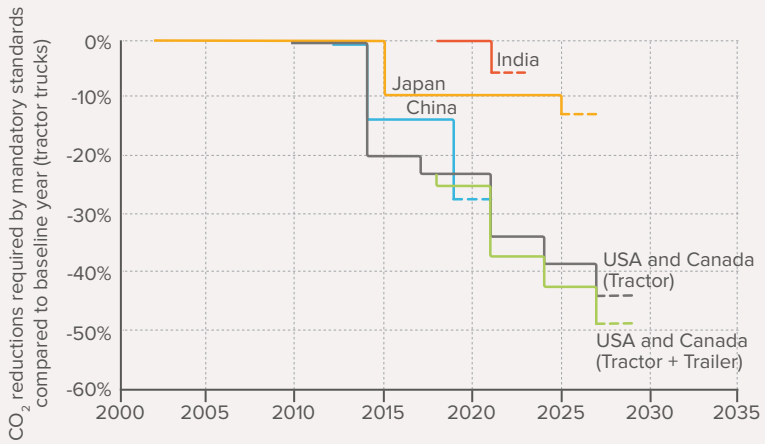


FIGURE 3-24

NO_x emission limit

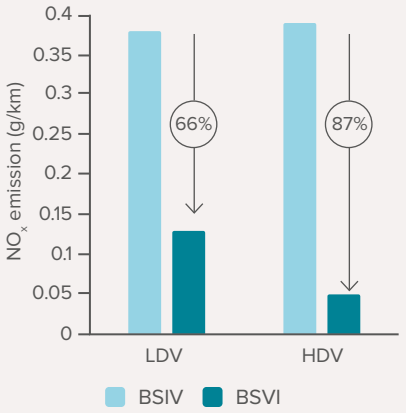
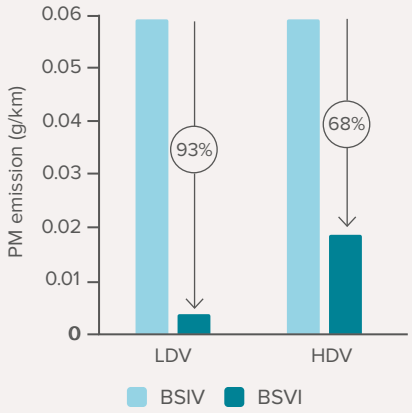


FIGURE 3-25

PM emission limit



Fuel consumption standards

The GOI and the Bureau of Energy Efficiency (BEE) have set fuel consumption standards for medium (3.5-12 tonnes)[211] and heavy-duty (above 12 tonnes)[212] commercial vehicles to bring down oil consumption and associated emissions from the road freight sector. Through these standards, by 2022, GOI targets to reduce oil imports by 10 percent.[213] For HDVs greater than 12 tonnes, these standards will be effective in two phases. Phase 1 began in 2018 and Phase 2 starts in 2021. Average fuel consumption reduction from phase one to phase two is around 10 percent.[214]

Canada, Japan, the United States and Canada are first movers in adopting fuel-economy and greenhouse gas (GHG) emissions standards for trucks.

The United States has the most ambitious target — a 50 percent reduction by 2027 for the tractor-trailer segment.

Bharat stage emissions standards (BSES)

BSES are emissions standards set by the Central Pollution Control Board (CPCB) under the Ministry of Environment, Forest, and Climate Change (MoEFCC). The standards are designed to improve air quality by reducing emissions such as PM and NO_x.

The latest standard, BSVI came into effect in April 2020 and represents a substantial step forward in India's efforts to improve air quality.[215] The changes in BSIV over BSVI require an 87 percent reduction in NO_x for HDV (>3.5 tonnes) and 93 percent reduction in PM limits for LDVs (<3.5 tonnes).

CASE STUDIES: IMPROVE FUEL ECONOMY OF ICE VEHICLES

The following examples from the United States highlight how fuel economy can be improved.

	GEOGRAPHY	TITLE	BEST PRACTICES
1	**USA**	The North American Council on Freight Efficiency	Multistakeholder collaboration inform benefits and scope pathways to adoption of technological solutions
2	**USA**	USA Fuel-economy and GHG Emissions Standards	Fuel-economy standards spur technology improvement and lead to emissions and cost benefits

CASE STUDY 1: THE NORTH AMERICAN COUNCIL ON FREIGHT EFFICIENCY[216,217]

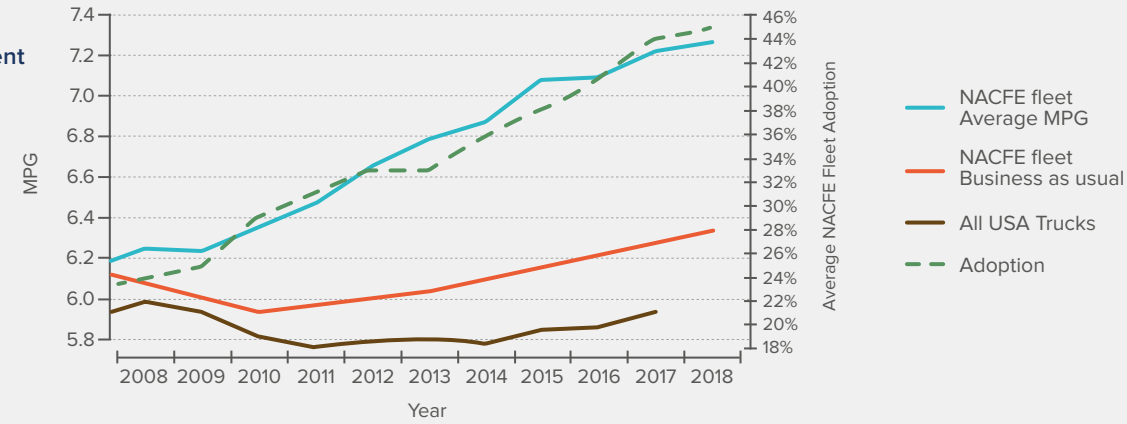
CONTEXT

The North American Council on Freight Efficiency (NACFE) is a nonprofit organisation based in the United States. NACFE specialises in helping fleets adopt existing and new fuel-saving technologies, which are both environmentally friendly and cost-effective. NACFE brings fleets, vehicle manufacturers, government and other organisations together to communicate benefits, challenges and payback periods of various fuel-saving technologies for long-haul trucking. Through this, it aims to make the benefits of these technologies transparent for fleet and truck operators.

SOLUTION

FIGURE 3-26

Trend of fuel economy improvement and technology adoption



By 2018, NACFE was working with 21 fleet operators. Together they identified 85 technologies that are commercially viable and deployable. Some of these technologies included tyre pressure monitoring, low rolling resistance dual tyres, real time driver coaching for fuel economy and predictive cruise control. Beyond this collaboration, NACFE informed fleet operators about pathways to adoption of these fuel-saving technologies and their benefits in terms of lower total cost of ownership. NACFE also organised a real word demonstration event called “Run on Less”, which showcased pathways for vehicle efficiency improvements through a combination of technology improvements, and efficient operational and driving practices.

RESULT

NACFE-affiliated fleets have 20 percent higher fuel efficiencies than the average American truck. In 2015, NACFE fleets saved between INR 4.5 lakh to INR 8 lakh per truck compared to the USA average, with efficiency investments paying back in about 2.5 years.

CASE STUDY 2: UNITED STATES FUEL-ECONOMY AND GHG EMISSION STANDARDS

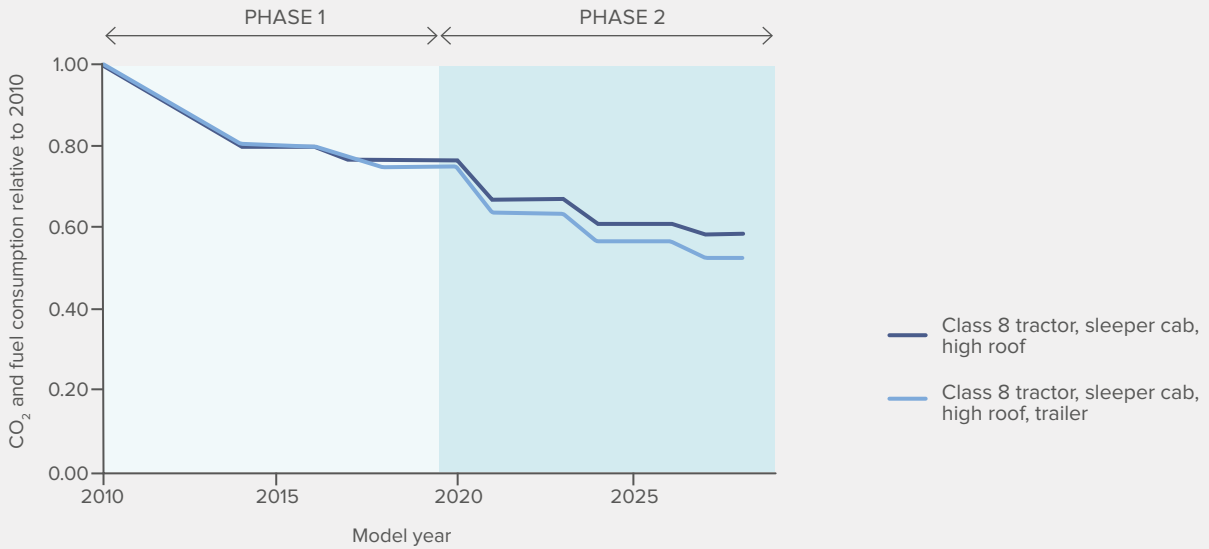
CONTEXT

The United States was one of the first countries to establish GHG and fuel-consumption standards for medium- and heavy-duty trucks. The United States' standards are part of Clean Air Act and are one of the most aggressive standards globally.

SOLUTION

FIGURE 3-27

CO_2 emissions reductions from Class 8 heavy duty trucks due to USA GHG emissions standards[219]



The phase one standards were applicable to models sold from 2014 to 2018. The standards applied to combination tractors, heavy-duty pickup trucks, and vocational vehicles. After successful implementation of phase one, the United States proceeded with phase two standards, which built on previous standards by including trailers. They are applicable to new vehicles sold between 2019 and 2027.[218]

RESULT

For a class 8 tractor sleeper cab, the dominant truck in the United States, phase one led to a 25 percent reduction in CO_2 emissions, while phase two could reduce emissions by 50 percent. A study by Transport and Environment, Europe's leading clean transport campaign group, revealed that the trucks sold in 2017 under phase one standards achieved annual fuel-savings of $8,200 compared to trucks sold in 2011.[220]

SUMMARY: PATHWAYS TO IMPROVE FUEL ECONOMY AND EMISSION FACTORS OF ICE VEHICLES

The ecosystem of actors to improve fuel economy and emission factors of ICEs

GOVERNMENT

Set fuel economy and emissions standards

- Strengthen fuel economy improvement and emissions targets periodically.
- Ensure that fuel consumption targets are met and are effective.

INDUSTRY

Introduce fuel-saving technologies in the vehicles

- Perform research and development to identify cost-effective fuel-saving technologies. Equip vehicles with those technologies.
- Encourage multistakeholder collaboration to develop a consortium of industry players, including OEMs and truck operators, to share experiences and best practices on fuel-efficiency standards.
- Introduce campaigns to highlight best-in-class fuel-saving technology.
- Promote research studies to track real-world data associated with fuel-saving technologies and publish results.

MULTISTAKEHOLDER COLLABORATION

Collaborate to improve vehicle design and technology standards

- Government to consult with OEMS and fleets on the design of future standards to ensure that they are rigorous and meaningful, but also feasible to comply with.

05 SOLUTION 3B

> USE CLEANER FUELS AND ELECTRIC VEHICLES

ALTERNATIVE FUEL TECHNOLOGIES CAN MAKE FREIGHT MOVEMENT MORE EFFICIENT

Making ICEs more fuel efficient leads to lower fuel costs and lower emissions. Switching to cleaner fuels and EVs will further reduce carbon emissions and help achieve major air-quality benefits. Exhibit 3-17 outlines some of the most promising alternative fuels for freight vehicles.

	BATTERY ELECTRIC VEHICLE (BEV)	FUEL CELL ELECTRIC VEHICLE (FCEV)	INTERNAL COMBUSTION ENGINE VEHICLES – ALTERNATIVE FUELS	INTERNAL COMBUSTION ENGINE VEHICLES – DIESEL
Technology description	Propulsion through battery and electric motor	Propulsion through fuel cell, battery and electric motor, powered by hydrogen	Propulsion through engine, powered by bio diesel, ethanol-petrol blend, CNG, LNG	Propulsion through engine powered by petrol or diesel
Fuel cost[221]	₹	₹₹₹	₹₹₹	₹₹₹₹
Emissions	• No tailpipe emissions • Lower carbon emissions (based on the grid)	• No tailpipe emissions • Lower carbon emissions (based on the grid)	• Lower emissions as compared to diesel	• Highest tailpipe and carbon emissions
Refuelling time	0.5-8 hours	10-20 minutes	5-10 minutes	5-10 minutes
Tank-to-wheel efficiency[222]	✓✓✓✓	✓✓✓	✓✓	✓
Other considerations	• Additional weight of battery pack means less freight can be carried • High cost of battery replacement	• Fewer product options • Less mature technology • High cost of hydrogen production	• Longer range • Lower energy density than diesel	• Longer range • Mature technology • Higher products availability

The tick marks and Rupee symbols indicate score between one and four.

EXHIBIT 3-17 Comparison between fuel technologies

Based on the characteristics listed in the table above, different fuel technologies are better suited for different use cases.

Urban haul:

1. BEVs are most suitable for urban movement. Smaller battery requirement due to low travel distances and better tank to wheel efficiency make them competitive for this use case.
2. CNG has a lower energy density as compared to other alternative fuels, hence making it viable only for urban movement.

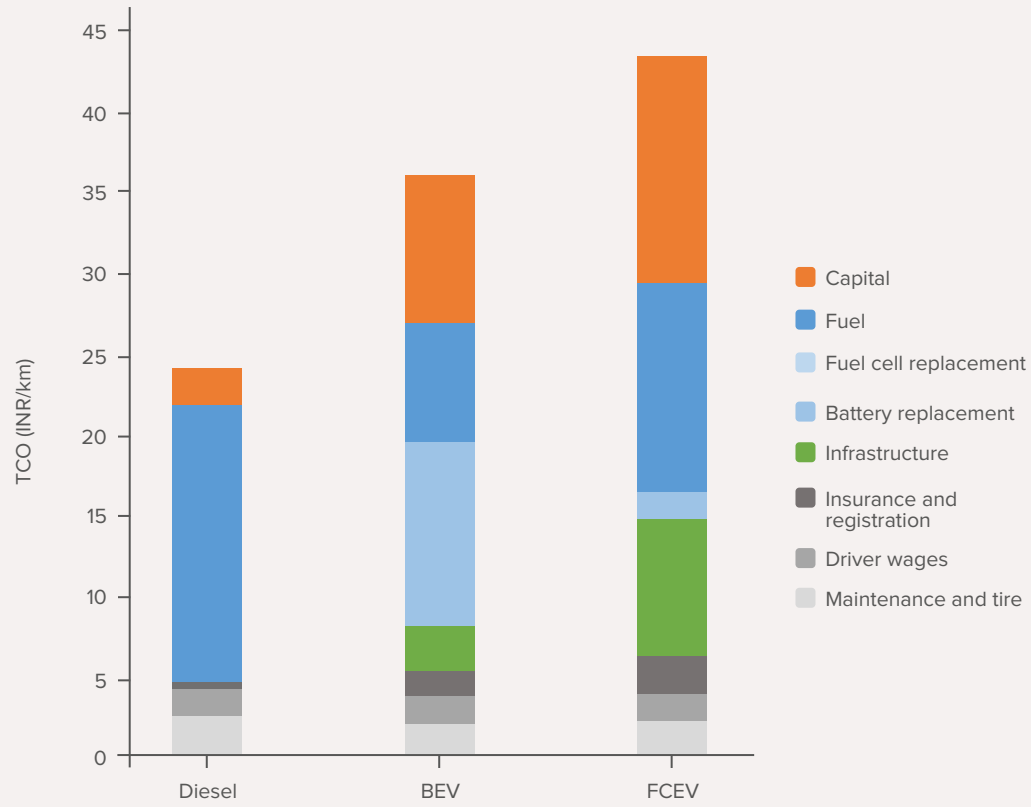
Long haul:

1. Both BEVs and FCEVs are well suited for long haul. BEVs are apt for relatively shorter distances and lower payloads, while FCEVs are a better choice for longer distances with higher payloads.
2. LNG has a much higher energy density than CNG, hence can be used for long haul movement.

WHILE POTENTIAL FOR SAVINGS EXISTS, CURRENTLY THE COSTS OF ELECTRIC FREIGHT VEHICLES ARE HIGHER THAN ICEs

FIGURE 3-28

Total cost of ownership of a 31 tonne truck (in 2019)[223]



Currently, LDV, MDV, and HDV EVs have higher total cost of ownership (TCO) compared to their diesel counterparts. This cost difference is driven by following components:

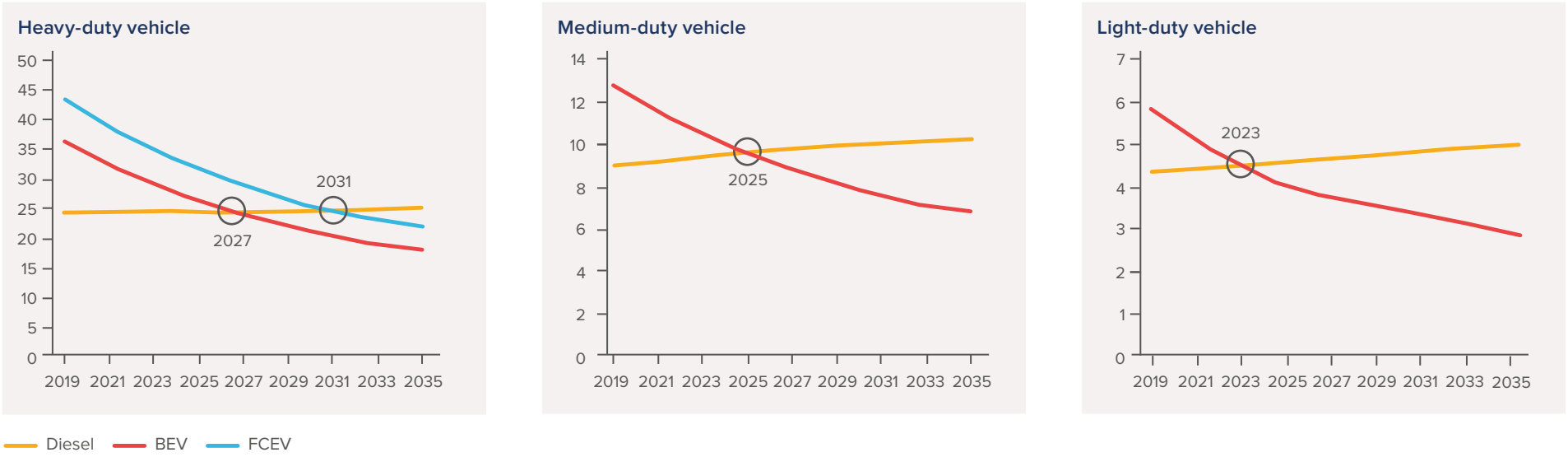
- **Capital and financing costs:** EVs have higher capital costs than ICEs because of the cost of fuel cells and hydrogen tanks for FCEVs and the cost of batteries for BEVs. Capital cost accounts for more than 25 percent of the total cost of ownership of EVs. This becomes more severe if the vehicle was financed, because loans on EVs typically carry higher interest rates.
- **Fuel costs:** Fuel costs are highest for diesel trucks due to lower fuel economy when compared to EVs. Fuel costs for FCEVs are higher than BEVs because of the high cost of producing hydrogen through electrolysis and their lower tank-to-wheel efficiency.
- **Battery replacement and infrastructure costs:** Even though EVs offer fuel-cost advantages, battery replacement costs and infrastructure costs are high. For BEVs, battery replacement is the largest cost component whereas for FCEVs, hydrogen infrastructure costs are the biggest component.

Although fuel cost of EVs is less than that for ICEs, high capital cost outweighs the fuel-cost benefits of EVs, making their TCO higher than their ICE counterparts.

DECLINING BATTERY COSTS, IMPROVED INFRASTRUCTURE AND ECONOMIES OF SCALE WILL REDUCE COST OF EVS

FIGURE 3-29

Total cost of ownership comparison (INR/km)



EVs will reach cost parity with their ICE counterparts in the near future with convergence varying by type of vehicle and duty cycle. The major drivers behind the decreasing TCO of EVs include:

1. **Declining battery and fuel cell prices:** Battery and fuel cell costs are a significant component of TCO of an EV. With advances in battery technologies, battery and fuel cell prices are expected to fall by 64 percent[224] and 61 percent[225] respectively, between 2019 and 2030. This will lead to reducing costs for both vehicle purchase price and battery replacement (for BEVs) and fuel cell replacement (for FCEVs).
2. **Improved infrastructure utilization:** Another big component of TCO of EVs is infrastructure. Setting up DC fast chargers for BEVs and hydrogen refuelling stations for FCEVs is expensive. Low utilisation means higher costs on a per vehicle basis. As station utilisation increases, the fixed costs will spread over a greater number of vehicles.
3. **Economies of scale in manufacturing:** Once production starts to ramp up, economies of scales will drive down the cost of producing EVs and their components.

INVESTMENT IN TECHNOLOGY SUPPORTS THE SCALE UP OF THE EV MARKET AND REDUCTION IN COSTS

The revolution of EVs has created an immense opportunity for Indian startups as well as established OEMs to tap into this market. Various startups are producing purpose-built EVs and charging infrastructure. Some of the areas where more R&D can be performed in order to expand the EV market are:

FIT-TO-PURPOSE VEHICLE DESIGN

Image source: www.electrive.com

Freight use cases often require specialised fit-for-purpose vehicles. For example, for final mile urban deliveries, two-wheelers with swappable batteries and electric three-wheelers with pedal-assist systems and modular freight storage are ideal. OEMs can invest in manufacturing such vehicles to meet customer's needs. There is also an opportunity to domestically manufacture EV components such as microprocessors, controllers, batteries, semi-conductors, and motors.

FAST CHARGERS FOR URBAN AND LONG-HAUL OPERATIONS

India had about 600 public charging stations as of 2019.[226] The EV charging market is expected to grow at a rate of 40 percent in the next five years.[227] As freight operations are time sensitive, DC fast (50kW) and ultra-fast chargers (100kW or more) will need to be built to enhance the business case of EVs. There is also a potential to include renewables and battery storage along with fast chargers to minimise their impact on distribution grids.

NEW BATTERY TECHNOLOGIES

Newer battery chemistries with higher energy density (Wh/kg) will increase the range of EVs and improve vehicles' efficiency. Some of the new innovative batteries in the market are solid-state batteries such as rechargeable zinc alkaline, Li-metal, and Li-sulfur batteries.[228] R&D investment can also accelerate improvement in the fuel cell and electrolyser technologies.

POLICY INTERVENTIONS CAN FURTHER REDUCE THE UPFRONT COST OF EVS AND ACCELERATE THEIR ADOPTION

Introducing nation- or state-wide goals for electrification and providing incentives for EV manufacturing and deployment will promote the growth of EVs in India. The main policy interventions include:

- **Upfront purchase incentives:** Higher upfront costs are one of the biggest barriers to widespread adoption of EVs. Purchase incentives can directly lower the initial capital costs of EVs.
- **Zero Emission Vehicle (ZEV) mandates:** ZEV mandates enforce OEMs to sell EVs. They usually work on a credit-based system, where each EV is given a specific number of credits based on its range, price, and type. The government sets the target for the credits that each OEM must earn by selling the EVs and any OEM that fails to achieve the assigned credit faces financial penalties. California and China have set aggressive ZEV mandate programmes with strong results.
- **Tax incentives/credits:** Another policy measure to bridge the gap between the TCO of EVs and ICEs is to offer tax credits and exemptions from road and toll tax.
- **Scrappage schemes for ICE:** Well-planned scrappage schemes can incentivise current ICE owners to scrap older vehicles and switch to EVs.
- **Low/zero emission zones:** Low or zero-emission zones are regions where certain polluting vehicles are barred. These zones serve two purposes – improving the air quality of that region and promoting the uptake of more zero-emission vehicles such as EVs.
- **Registration, permit and parking fees exemption:** Another policy measure that has been highly successful in leading to wider adoption of EVs is exemption from registration, permit and parking fees.
- **Feebates:** Feebates is a market-based policy, which uses rebates as a reward for energy-efficient and environmentally friendly technologies, and fees to penalise the inefficient and environmentally harmful ones.

The Indian government has realised the role of electrification to reduce carbon emissions and air pollution. To accelerate EV adoption, national and state level policies have been crafted to promote the adoption of EVs.

PUBLIC-PRIVATE SECTOR COLLABORATIONS THROUGH PILOT PROJECTS SHOW THE ROADMAP TO SUCCESSFUL EV ADOPTION

One way to create a replicable roadmap for EV adoption is by demonstrating pathways through public-private sector pilot projects. A well designed and documented pilot can highlight successful tactics for deploying EVs and can also identify the potential challenges in the system and associated solutions.

- Documentation can help public and private sector with better decision-making
- OEMs can make better suited products
- Fleet aggregators can design innovative business models
- Charging infrastructure providers can optimise siting
- Government can design more need-specific policies
- Utilities can plan their investments and rate design more efficiently

Pilot projects will also unlock some other benefits such as:

- **Future technology improvements:** Pilot projects act as a testing ground for existing technologies and provide insights into how technologies can be improved.
- **Better understanding of economics and environmental benefits of EVs:** Pilot projects will help define the cost and emissions reductions benefits through deployment of electric vehicles.
- **Use case prioritisation:** Fleet operators and OEMs will gain real-world insight into the market readiness of electric vehicles for different use cases.
- **Collaboration between EV charging providers and distribution companies:** To locate charging stations optimally there are three main considerations:

  1. Locations which can achieve higher utilisations;

  2. Locations which have enough grid capacity;

  3. Locations where suitable land is available. Finding the ideal locations for installing charging and swapping infrastructure requires collaboration between EVSE providers and DISCOMs.

PRIVATE SECTOR PLAYERS IN INDIA ARE ENTERING THE FREIGHT ELECTRIFICATION MARKET

To compliment the government's efforts, private sector players are launching a number of sustainability initiatives to manufacture and deploy EVs and charging infrastructure. Many e-commerce companies are launching pilots and setting electrification targets. For example, Amazon has pledged to add 10,000 electric delivery vehicles to its fleet by 2025.[229] Flipkart set a target to replace 40 percent of its delivery fleet by March 2020.[230] IKEA is planning to electrify 100 percent of its delivery fleet in India by 2025.[231] Swiggy, online food delivery service provider, has committed to launch EV pilots in ten cities.[232] Big Basket is planning to deploy 1,000 e-vans and 2,000 e-bikes by 2020.[233] Online delivery service Zomato targets to replace 40 percent of its delivery fleet with e-cycles.[234] OEMs have started manufacturing EV variants of their existing freight vehicles and many startups are entering the electric freight vehicle ecosystem.

Between 2017 and 2019, 178 new public charging stations were installed in India, out of which 2 percent were fast charging stations.[235] To increase the uptake of public charging stations across India, the Department of Heavy Industries, under the FAME II scheme, has initiated a further 2,636 public charging stations to be set up across 62 cities in 24 states.[236] The increase in charging stations, especially fast charging, should instil confidence in EV buyers and lead to an increase in EV adoption.

While urban freight electrification and charging is progressing at pace, uptake of medium- and heavy-duty EVs has been slower. Public and private sector players should target heavier trucks as the next frontier in freight electrification.

INDIA HAS A SET OF NATIONAL-LEVEL GOALS AND POLICIES TO CULTIVATE ITS EV ECOSYSTEM

1 NATIONAL ELECTRIC MOBILITY MISSION PLAN (NEMMP) 2020[237]

- A national mission that provides the vision and roadmap for faster adoption and manufacturing of EVs
- Targeted to achieve sales of six to seven million EVs by 2020

2 FASTER ADOPTION AND MANUFACTURING OF ELECTRIC VEHICLES (FAME) SCHEME[238]

- **Phase I:** About 2.8 lakh EVs were supported with total demand incentives of approximately INR 343 Crore
- **Phase II:** INR 10,000 crore for direct purchase incentives for EVs and incentives for setting up charging infrastructure until 2022

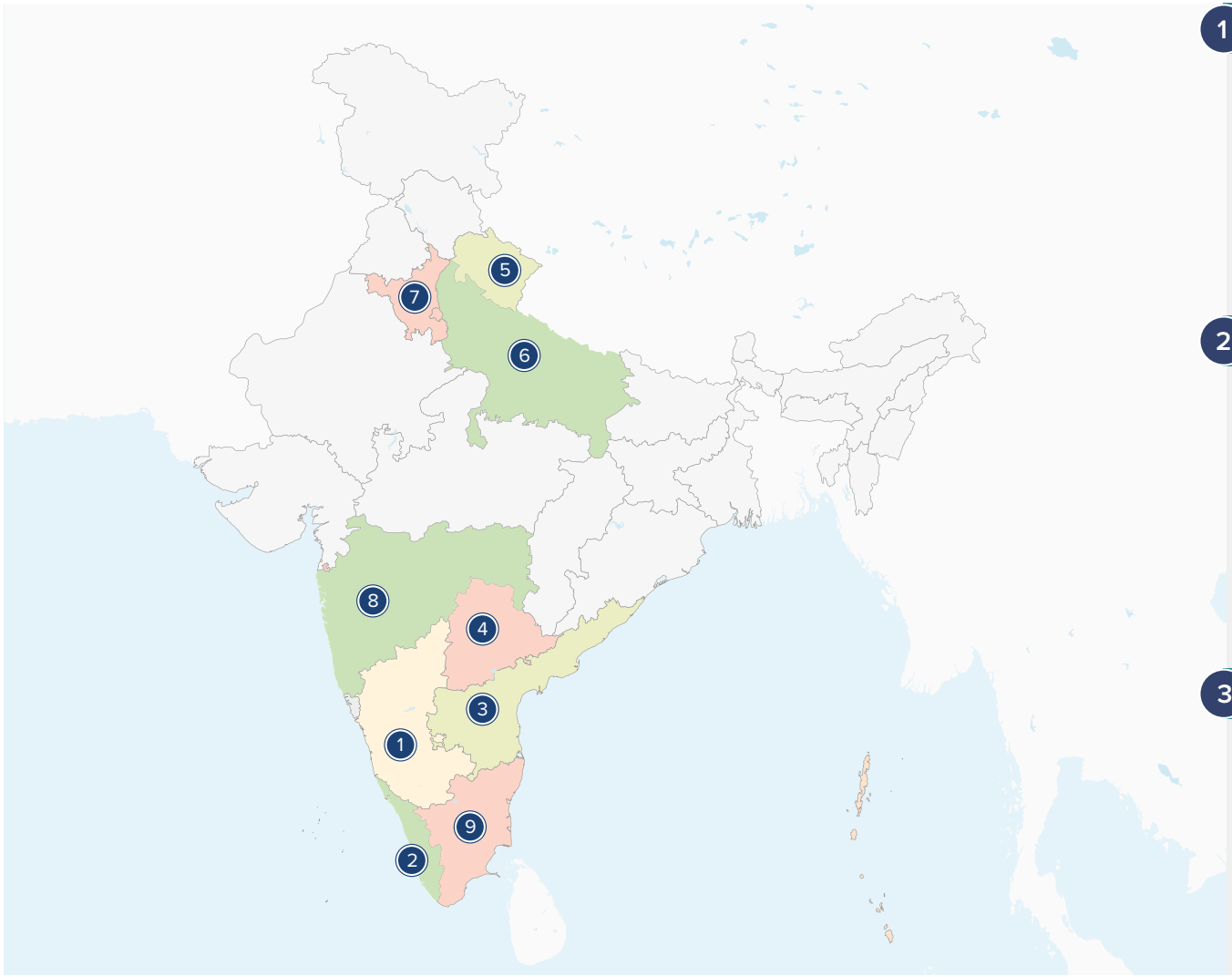
3 EV CHARGING STATION POLICY BY MINISTRY OF POWER[239]

- In 2018, the Ministry of Power (MoP) issued a notification stating that charging EVs is considered a service and not a sale of electricity
- The MoP also released guidelines for public charging infrastructure for long-range heavy-duty EVs

4 PRODUCTION LINKED INCENTIVES SCHEME FOR ADVANCED CELL BATTERIES[240]

- To boost India's EV manufacturing capability, GOI recently approved production linked incentives for 10 key sectors
- Advanced cell battery manufacturing will receive a major chunk worth INR 18,100 crore

STATES ARE INTRODUCING EV POLICIES TO PROMOTE MANUFACTURING AND USE OF EVS



1 KARNATAKA[241]

- 100 percent of three- and four-wheelers moving goods to transition to EVs by 2030
- Tax exemption for EVs
- Investment subsidy for first 100 chargers

2 KERALA[244]

- Aims to have 10 lakh EVs by 2022, including a pilot fleet size of 2 lakh electric two-wheelers and 1,000 electric goods carriers by 2020
- State tax breaks, road tax exemptions, and free permits to fleet drivers

3 TELANGANA[247]

- Incentives amount to 15 percent of the cost of retrofit from ICE to electric variant for goods carriers (three- and four- wheeler)

STATES ARE INTRODUCING EV POLICIES TO PROMOTE MANUFACTURING AND USE OF EVS

4 ANDHRA PRADESH[242]

- Aims to have 10 lakh EVs across vehicle segments on roads by 2024
- Targets to phase out all ICE-based logistics vehicles in top four cities by 2024, and in all cities by 2030
- 25 percent subsidy up to INR 10 lakh for first 50 battery swapping stations, and 100 percent reimbursement of state GST on fast chargers and advanced batteries for EV battery swapping

5 UTTARAKHAND[245]

- First 1 lakh EV purchase to be exempted from motor vehicle taxes and permits for five years

6 UTTAR PRADESH[248]

- To transition to 50 percent of electric goods delivery vehicles (e-3W and e-4W) in 10 cities by 2024 and in all cities by 2030
- Exemption from registration fees and road tax for e-2Ws and 75 percent of the road tax for other EVs

7 DELHI[243]

- All two-wheelers engaged in last-mile deliveries (e.g., food delivery, e-commerce logistics etc.) to transition 50 percent of their fleet to electric by March 2023, and 100 percent of their fleet by March 2025
- Purchase incentives worth INR 30,000 for L5 (goods 3-W autos) and N1 (4-W goods vehicle) vehicle categories

8 MAHARASHTRA[246]

- Subsidy of 15 percent on the vehicle's price for 10,000 e-cars, 70,000 e-2Ws, 20,000 e-3Ws
- Exemption of e-vehicles from road tax and registration charges
- 25 percent subsidy on hardware for public charging stations

9 TAMIL NADU[249]

- 100 percent road tax exemption for electric two-wheelers, auto rickshaws, cars, light goods carriers until December 2022
- Exemption from permit requirement for electric logistics vehicles
- One charging station to be set up at 25 km intervals on both sides of NHAI and State Highways

CASE STUDIES:
USE CLEANER FUELS AND ELECTRIC VEHICLES

The following case studies highlight pathways to accelerated use of cleaner fuels and EVs:

	GEOGRAPHY	TITLE	BEST PRACTICES
1	**Shenzhen, China**	EV policy in Shenzhen	Effective policy measures can spur the adoption of electric freight vehicles
2	**California, USA**	Advanced Clean Trucks Rule and HVIP Initiative	Policy measures that target both the supply side through mandates, and the demand side through incentives are critical for adoption of EVs
3	**Norway**	Electric trucks – The Norway experience	Pilots projects can give insights on implementation barriers and potential solutions for EV adoption
4	**USA**	PG&E's EV fleet program	Government initiatives can spur the adoption of EVs across private sector players
5	**Delhi, India**	Deliver Electric Delhi	A well-designed and well-documented pilot on urban freight electrification can serve as a roadmap for EV deployment in cities

CASE STUDY 1:
EV POLICY IN SHENZHEN, CHINA[250,251]

CONTEXT

Shenzhen, one of the largest cities in China, has achieved strong progress in freight vehicle electrification. Since 2015, the Shenzhen government released a collection of policies to support adoption of EVs for freight transportation.

SOLUTION

The fiscal and non-fiscal incentives and other policy measures in Shenzhen include:

1) **Upfront purchase incentives:** National and city government offered incentives for Electric Logistics Vehicles (ELVs) (ELVs include 4-wheeler vans and light trucks). The national government started subsidising ELVs based on their battery capacity at the rate of 2,000 RMB/kWh in 2013. These incentives were also matched by the city government. As battery prices declined and the capital cost of the vehicles reduced, the subsidy amount was also reduced to 350 RMB/kWh by 2019, while the subsidies were finally phased out in August 2019. These subsidy amounts helped EVs achieve near purchase cost parity. After the phasing out of purchase subsidies, Shenzhen has initiated a scheme for operational subsidies which are applicable for three years.
2) **Special road privilege:** Certain areas in the city limits and roads have been assigned as green zones where ICE vehicles are banned.
3) **EV charging subsidies:** Charging companies that can deploy a total charging capacity of 8MW or more are eligible for subsidies. The subsidies are as follows: 4300 INR/kW for a DC Fast charger, 2100 INR/kW for an AC charger of greater than 40kW capacity and 1000 INR/kW for less than 40kW capacity.
4) **Mandates and targets**: Shenzhen has set targets and goals at provincial and city levels. Some of the targets at the provincial level include mandating 30 percent of the parking space in all new commercial buildings dedicated for EV charging and installing EV chargers. As a result of these mandates, Shenzhen had around 83,000 public chargers by 2019, out of which 36 percent were fast chargers.

RESULT

Between 2015 and 2019, Shenzhen's ELV stock increased from 300 to 70,417.

CASE STUDY 2: CALIFORNIA'S ADVANCED CLEAN TRUCKS RULE AND HVIP INCENTIVE SCHEME

CONTEXT

California has been at the forefront of innovation and big policy moves when it comes to clean energy transition. Transportation has been a key element of its policy, and freight transport is gaining prominence now. One of the key reasons is that majority of the freight traffic is centred around neighbourhoods where people of colour and low-income households are situated. Hence, they are disproportionately affected by the negative externalities of ICE vehicles.[252] The second key reason is around climate. Since transportation is the biggest component of California's GHG emissions, switching ICE freight vehicles to electric will lead to GHG reductions. This will help achieve California's goal of GHG reduction of 40 percent below the 1990 levels by 2030.[253]

SOLUTION

California recently adopted the Advanced Clean Trucks (ACT) Rule, which requires truck manufacturers to sell electric trucks as a certain percentage of their total annual sales beginning from 2024. The target of weighted average sales penetration for electric trucks begins at 6 percent, across all vehicle classes in 2024 to 63 percent by 2035,[254] with a final goal of 100 percent penetration by 2045.[255] On the demand side, California has been running an incentive program for electric trucks and buses called Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP) since 2009. The government works with dealers to enable direct price reduction for a vehicle purchased with end user. There are additional incentives for fleets operating in disadvantaged communities. The incentive amounts go up to INR 2.3 crore, depending upon the vehicle type.[256] The total funding for the incentives between 2009 and 2019 has been around INR 4,200 crore.[257]

Image source: CARB

RESULT

The clean trucks mandate will lead to public health, climate and economic benefits. This includes

- A projected cumulative NO_x reductions of 54,000 tonnes between 2020-2040 over a BAU scenario.[258]
- Additionally, 943 cumulative premature deaths can be avoided in the same 20-year time frame.
- Cumulative CO_2 emissions of 17 million tonnes can be avoided with net cumulative benefits of over INR 80,000 crore.[259]
- California will also see a fleet size of almost 5 lakh electric trucks by 2040 as a result of this mandate.[260]
- The HVIP incentive program has led to purchase of 3,400 zero-emission trucks and buses and 2,600 hybrid trucks. By 2021, this program will enable almost 9000 trucks and buses operating in California.[261]

CASE STUDY 3:
ELECTRIC TRUCK PILOTS IN NORWAY

CONTEXT

The Norwegian government's National Transport Plan (2018-2029) outlines the vision and roadmap to electrify the country's freight segment. It plans that all new light-freight vans sales will be electric by 2025 and for 50 percent of all new trucks to be electric by 2030.[262] To support the successful implementation of the policy, truck operators hosted a broad variety of pilots using the financial support provided by the Norwegian government to test zero-emission technologies.

SOLUTION

Between 2016 and 2019, truck operators designed and operated various pilots to test the feasibility and performance of 21 freight EVs. The vehicle cases included heavy vans, light-duty trucks, heavy trucks and tractors, and served different use cases such as waste collection and recycling, long-haul freight movement, and food distribution. Through the pilot, operators identified a set of barriers to on-the-ground EV deployment and suggested potential solutions.[263]

Barriers included the high upfront costs of EVs, range anxiety, additional battery weight impacting the payload, and lack of fast charging options. Proposed solutions were:[264]

1. **Financial incentives:** Many operators from these pilots emphasised the importance of fiscal support in their purchasing decisions. Incentives such as upfront purchase subsidies, and exemption from toll charges reduce the TCO of electric trucks.
2. **Widespread availability of fast charging:** The operators stressed the need for fast charging networks in addition to overnight depot charging. Focus needs to be on setting up DC fast charging networks in order to reduce range anxiety and spur the adoption of EVs.
3. **Technological advancements:** Advancements in battery technology, vehicle design and manufacturing, reduce capital cost and enable long-term adoption of EVs.
4. **Fit-for-purpose vehicles:** The results from these pilots show some operators were particularly happy with the EV performance, while other vehicles did not perform as intended. This calls for a fit-for-purpose approach, where vehicles are manufactured for particular use cases in order to improve the performance.

RESULT

The pilot showed that EVs are four to five times less energy intensive when compared to their ICE counterparts. EVs reduce operational costs and provide a pleasant and noise-free driving experience. The pilots also created a positive image in terms of sustainability efforts. The Norway experience shows how public-private partnerships help inform better decision making to enable widespread adoption of electric freight vehicles.[265]

CASE STUDY 4:
PG&E'S EV FLEET PROGRAM IN CALIFORNIA

CONTEXT

California is the most populous state in the USA and accounts for seven percent of the nation's GHG emissions annually. Transportation accounts for 41 percent of emissions in the state, making it a major opportunity area for intervention.[267] To tap onto this opportunity, California is introducing a number of initiatives and policies, including stricter emissions standards, mandates, and attractive fiscal incentives to promote vehicle electrification.

SOLUTION

Many private sector organisations have started developing decarbonisation strategies and programmes related to these policies. A notable example is Pacific Gas and Electric (PG&E), an electricity utility and distribution company in California. PG&E's EV fleet programme is aimed at setting up charging infrastructure for medium- and heavy-duty vehicles, especially trucks, to help spur the adoption of EVs in the freight segment. The programme hopes to achieve this goal by applying the following measures:[268]

1. Providing electric infrastructure including new electrical lines and transformers for fast charging at no cost

2. Offering incentives amounting to INR 6.5 lakh per vehicle on the upfront price of a heavy-duty truck

3. Issuing rebates of up to 80 percent for charging stations (INR 10.75 lakh for chargers up to 50 kW to INR 30 lakh for ultra-fast chargers above 150 kW)

4. Establishing an EV tariff for fleet operators based on time-of-use rates with no demand charges

RESULT

The programme intends to aid the deployment at least 6,500 electric MDVs and HDVs (including trucks and buses) and help 700 firms transition their fleet from ICE to EVs by 2024.[269]

CASE STUDY 5:
DELIVER ELECTRIC DELHI PILOT[270]

CONTEXT

The Delhi government approved its EV policy in 2019. It aims to make 25 percent of new vehicle sales electric by 2024. To support electrification of the freight segment, a coalition of 36 companies announced the formation of a working group to launch a first-of-a-kind pilot - Deliver Electric Delhi - to electrify goods-carrier vehicles in Delhi.

SOLUTION

The three-phased pilot aims to support evidence-based policymaking through a phased approach.

Phase 1 – The design phase involved identifying the right stakeholders for the pilot and then convening them to validate specifications and agree to a roadmap.

Phase 2 – The execution phase will involve collaboration among different stakeholders for vehicle and EV charging deployment.

Phase 3 – The documentation phase will involve collection of data for aggregation and analysis to inform key decisions about EV charging deployment.

This three-phased approach will help public sector with better policymaking and the private sector with better decision making about EV procurement and use cases.

DELIVER ELECTRIC DELHI

RESULT

Discussions during the pilot design process were used by the Delhi government to refine their draft EV policy. The first phase also served as a forum to provide a platform for fleet aggregators and e-commerce companies to work with OEMs and for charging infrastructure providers to work with DISCOMs. The pilot has built commitment for 1,000 EVs for last-mile deliveries in Delhi by 2021.

SUMMARY: NEXT STEPS TO SUPPORT THE USE OF CLEANER FUELS AND ELECTRIC VEHICLES

The ecosystem of actors to promote the use of cleaner fuels and EVs

GOVERNMENT

Design policies to make clean and electric vehicles more affordable while supporting long-term infrastructure and smooth operations

- Introduce national-level policy to encourage truck electrification
- Introduce incentives to include research and development (R&D) funding for design and manufacture of electric trucks
- Leverage 'Make in India' to significantly grow India's share of R&D, design, manufacture, and export of vehicles and components for freight EVs
- Introduce policy measures and subsidies, at state and central government level, to incentivise charging infrastructure, especially DC fast charging
- Develop an incentive-based policy to encourage scrapping vehicles more than 15 years old, conditioned upon an EV purchase replacement
- Use the National Energy Storage Mission to support R&D for and manufacture of advanced, low-cost batteries for electric two-wheelers, three-wheelers, and trucks
- Reduce GST on battery packs to lower replacement costs for MDVs and HDVs, which is the largest component of TCO

INDUSTRY

Build fit-for-purpose vehicles and host pilots for clean and EV adoption

- Encourage corporations to develop fleet transition strategies to deploy initial EV fleets at scale
- Design fit-for-purpose EVs for freight use cases
- Build coalitions to host pilots in different cities and scale to cohorts of cities
- Utilities to support freight electrification by introducing EV tariffs

MULTISTAKEHOLDER COLLABORATION

Collaborate through pilot projects to improve business decision-making and policymaking for clean and electric vehicles

- Develop a medium- or long-haul electric trucking corridor in the country to understand the operational and economic feasibility of electric trucks
- Promote multistakeholder pilot projects with government ministries, DISCOMs, charging station providers, and truck operators to study how to optimise charging times and duration in order to fully utilise renewable electricity for EV charging
- Identify hotspots for EV charging of freight vehicles through an information sharing platform between DISCOMs, charging station providers, and truck operators and plan potential charging infrastructure

06 PATH FORWARD

> A ROADMAP FOR THE TRANSITION

A ROADMAP WITH INTERMEDIATE MILESTONES WILL TRACK INDIA'S PROGRESS TOWARDS THE NEW FREIGHT PARADIGM

Freight transportation sector in India is growing rapidly. Growing demand and scale has brought policymakers' and industry's attention to improving the efficiency of assets and operations. With the three opportunity areas outlined in the report, India can achieve a clean, efficient and cost-effective paradigm. Intermediate goals can set a clear and ambitious vision for the country and track the progress towards the vision.

	NEAR-TERM GOALS	MEDIUM-TERM GOALS	LONG-TERM GOALS
01 OPPORTUNITY Increase the mode share of rail transport	✓ Fully upgraded rail infrastructure ✓ Establishment of logistics parks	✓ Establishment heavy haul corridors and dedicated freight corridors ✓ Standardisation across different modes of transport	✓ 40% of freight demand served by rail in 2050
02 OPPORTUNITY Optimise truck use	✓ Digitised warehousing practices ✓ Sustainability initiatives and goals by corporates ✓ No overloaded trucks	✓ High interoperability between transportation assets and practices	✓ Best in class logistics practices
03 OPPORTUNITY Promote clean and efficient vehicle technologies	✓ State EV policies focusing on freight electrification ✓ Compliance to BSVI standards ✓ Phase out ICEs in light duty urban freight ✓ Establishment of EV freight corridor	✓ National-level heavy truck electrification policy ✓ Widespread charging infrastructure network	✓ 100% freight electrification of freight vehicles

PHASE 1: NOTCH THE ARROW

A phased approach will unlock the benefits discussed in the previous sections. Phase 1 taps into the solutions that are already economically feasible and near-term solutions that are critical to ensuring success for the long-term projects.

01 OPPORTUNITY

INCREASE THE MODE SHARE OF RAIL TRANSPORT

- ✓ Continue investments in rail infrastructure and multimodal logistics parks
- ✓ Build capacity among leaders and technical workers to develop advanced rail network

02 OPPORTUNITY

OPTIMISE TRUCK USE

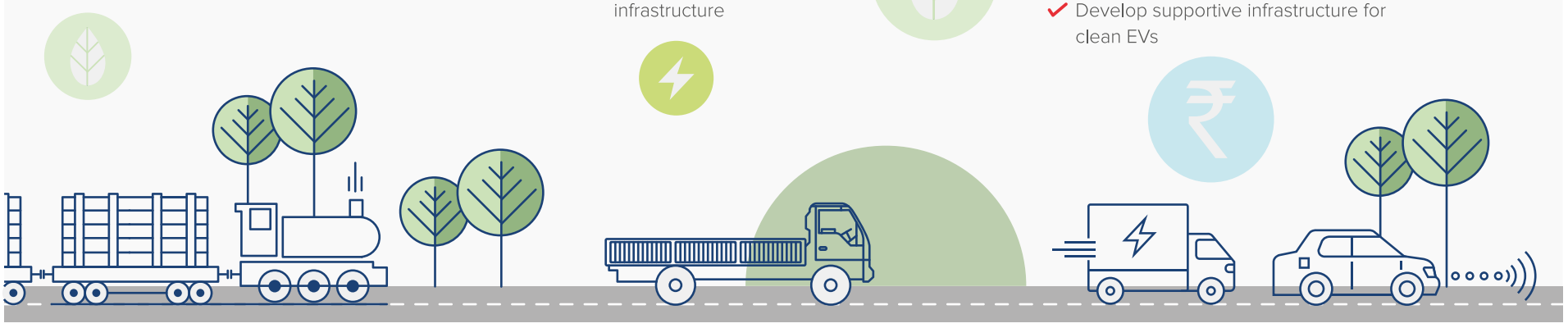
- ✓ Invest in manufacturing of bigger and better trucks
- ✓ Introduce corporate sustainability initiatives across the supply chain
- ✓ Improve the quality of warehousing infrastructure

03 OPPORTUNITY

PROMOTE CLEAN AND EFFICIENT VEHICLE TECHNOLOGIES

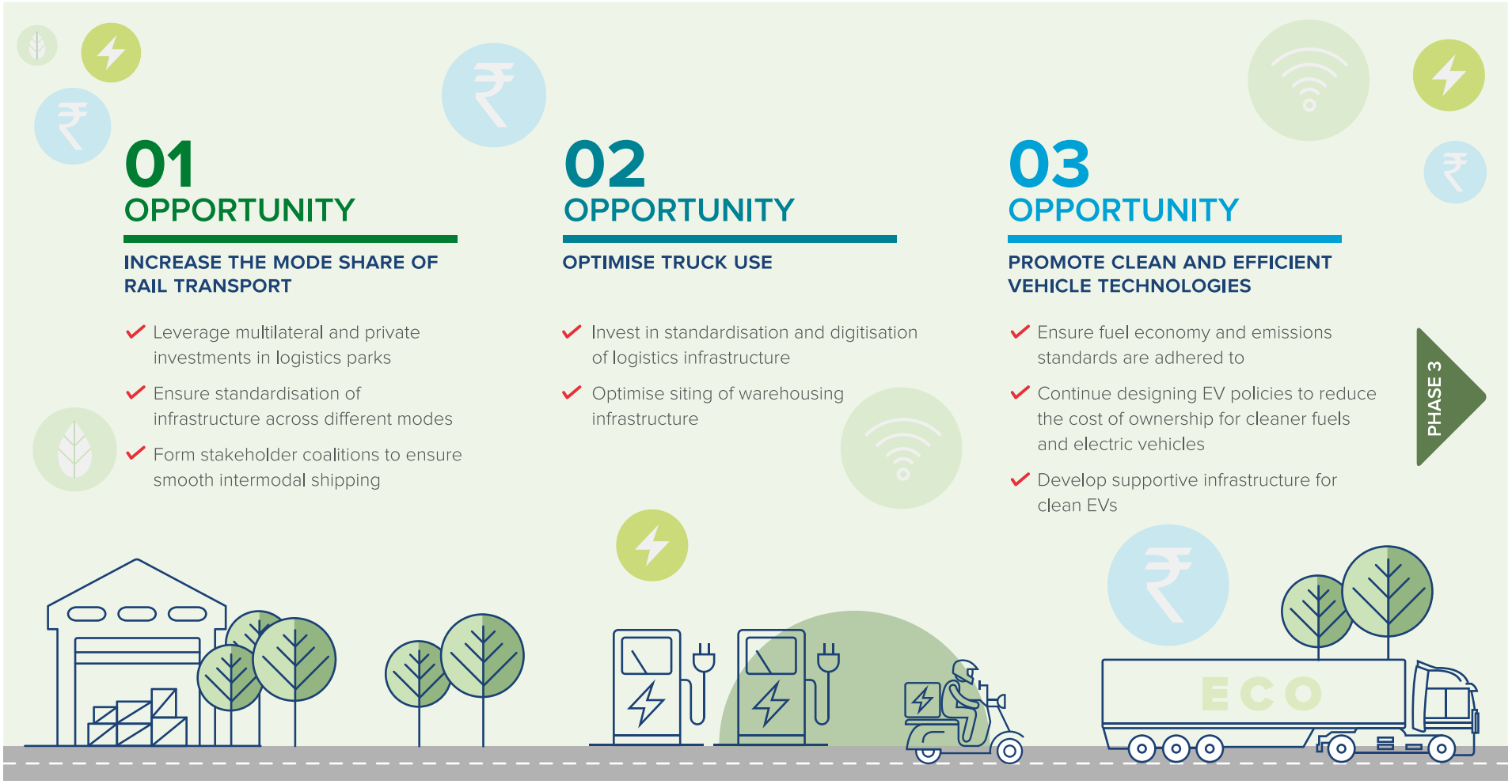
- ✓ Ensure fuel economy and emissions standards are adhered to
- ✓ Continue designing EV policies to reduce the cost of ownership for cleaner fuels and electric vehicles
- ✓ Develop supportive infrastructure for clean EVs

PHASE 2



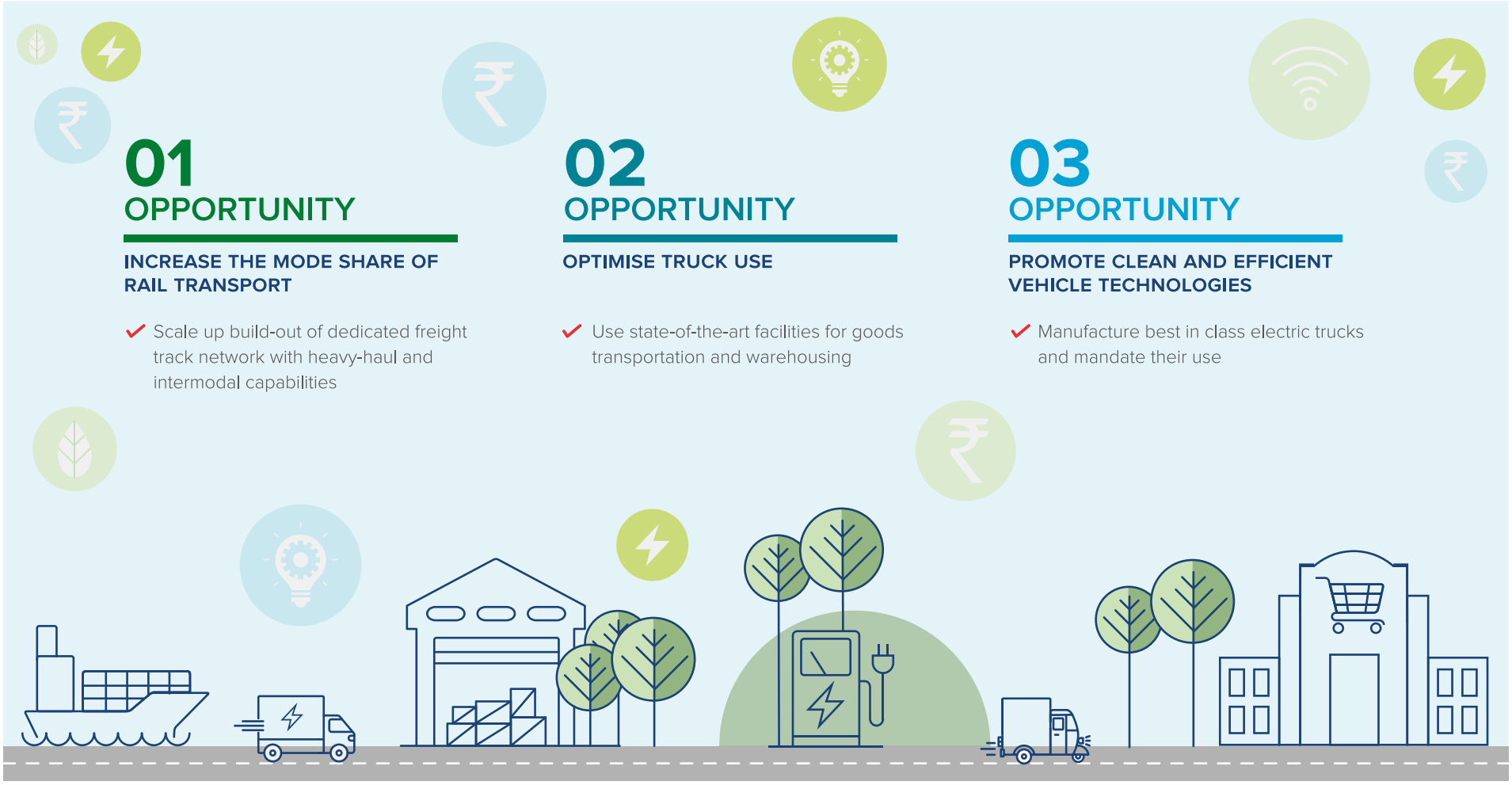
PHASE 2: DRAW THE BOW

Phase 2 builds on the scale-up of solutions from phase 1 and focuses on infrastructure and policy interventions through public-private collaboration.



PHASE 3: LET THE ARROW FLY

Phase 3 sees cost and emission savings as solutions become economically feasible and practically implementable.



INDIA'S NEW LOGISTICS PARADIGM IS WITHIN REACH

Covid-19 has highlighted the critical role of freight transport to India's economy. It connects citizens to the goods and services that they need every day. As India's leadership outlines policies and programmes to support short-term economic recovery and long-term resilience, a new logistics model must be among the nation's priorities.

India benefits from general alignment on this vision and recognises the significant benefits of a whole-system transformation. Yet there is a need to accelerate and build on existing efforts to turn shared vision into shared opportunity at scale. Commitment and coordinated planning, action, and investment from the public and private sectors are required to:

- Elevate the role of freight transport in national and regional dialogues
- Pilot and scale innovative business models to demonstrate the competitive advantage of optimised logistics and clean EVs
- Use collaborative platforms to document insights, share lessons learned, resolve system barriers, and build stakeholder capacity
- To reap the benefits of the new freight paradigm through a phased approach, integration across the ecosystem is critical

By unlocking a cost-effective, clean, and optimised freight transport system through a higher share of rail and a combination of multimodal logistics and EV operations, India can be a leader in advanced freight transport globally. This approach will bolster domestic manufacturing, enhance international competitiveness, improve air quality and road safety, meet India's ambitious climate targets, and support the livelihoods of millions of citizens.

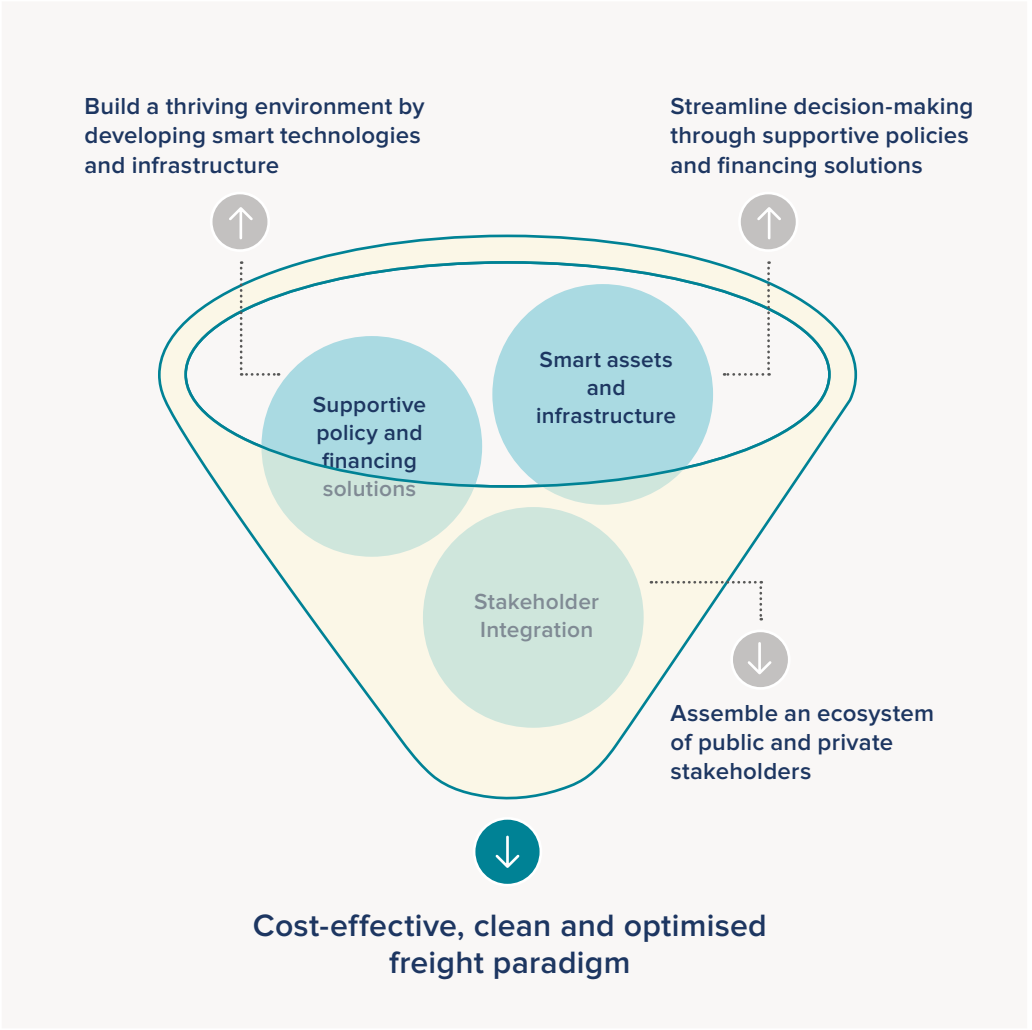


EXHIBIT 4-1 Pillars to achieving new freight paradigm

07 MODELLING METHODOLOGY

SCOPE OF THE MODEL

RMI and NITI Aayog have developed a quantitative tool to analyse the impact of various opportunities to make freight transport in India more cost-effective, efficient and clean. The tool calculates market size of freight, impact of efficiency levers on costs, CO_2, PM and NO_x emissions, oil imports and energy consumption. The model serves three main purposes:

1. Help stakeholders such as policymakers, government ministries, logistics providers and other relevant parties understand the future growth of India's freight transport sector
2. Quantify the emission savings from key efficiency measures
3. Inform private sector participants about the key fuel-saving technologies and associated payback periods to inform total cost of ownership of EVs

The scope of the model includes:

1. **Modes of freight transport:** Road, rail, water, air and pipeline
2. **Types of freight movement:** Long-haul, regional and urban

Model outputs include:

- Vehicle kms travelled
- Vehicle sales and stocks
- Total cost of ownership
- Energy consumption
- Oil consumption
- CO_2, PM and NO_x emissions.

INPUTS AND ASSUMPTIONS	OUTPUTS
• GDP • Freight intensity of GDP • Mode share • Vehicle utilisation and life • Load factor, GVWR, empty running • Vehicle efficiency • EV sales penetration levels • Grid emission factor • Vehicle cost (Capital and O&M)	• Tonne-km freight movement • VKT by vehicle type • Vehicle sales and stock • VKT by vehicle and fuel type • CO_2 emissions • PM and NO_x emissions • Total cost of ownership by vehicle type

The model considers two scenarios:

1. **Business as usual (BAU):** The BAU scenario assumes that the pace and adoption of technology and policy decisions remain the same as in 2020. In this scenario there are no significant policy or market accelerators to move towards a more efficient ecosystem. For example, all new vehicles sold from 2020 onwards will be BSVI, minor improvements in vehicle efficiency, grid emission factor, slow rate of EV sales penetration.
2. **Efficient:** The efficient scenario assumes that the pace and adoption of technology are high, and favourable policies are being pushed through. For example, high penetration of EVs, more focus on rail capacity to improve mode share, widespread availability and adoption of fuel-saving technologies, better truck utilisation, and efficient logistics practices.

CRITICAL ASSUMPTIONS

Some of the critical assumptions in the model for BAU and efficient scenario include:

	ASSUMPTION PARAMETER		BAU		EFFICIENT	
			2030	2050	2030	2050
INCREASE THE MODE SHARE OF RAIL TRANSPORT	Mode share (% of tonne-km)	Rail	16	17	28	40
		Road	73	70	60	47
OPTIMISE TRUCK USE	Empty running km (% of VKT)		34-38	25-35	29-31	15-20
PROMOTE CLEAN AND EFFICIENT VEHICLE TECHNOLOGIES	EV sales penetration (% of new sales)	LDVs	5	47	70	100
		MDVs	0.5	27	9	100
		HDVs	0.1	14	4	76
	Grid emissions factor (gCO_2/kWh)		683	480	597	75

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