DECARBONISING TRANSPORT

What Does It Mean for India?

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Writer: Anumita Roychoudhury

Research support: Vivek Chattopadhyay, Moushumi Mohanty, Sayan Roy, Anannya Das, Shubham Srivastava and Meshak Bandela

Editor: Archana Shankar

Cover: Ajit Bajaj

Production: Rakesh Shrivastava and Gundhar Das

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41, Tughlakabad Institutional Area
New Delhi 110 062
Phones: 91-11-40616000
Fax: 91-11-29955879
E-mail: sales@cseindia.org
Website: www.cseindia.org

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India's net-zero goal by 2070 and the promise of reducing carbon intensity of its economy to less than 45 per cent by 2030 sets new terms of growth for the country's transportation sector. This, combined with India's signing of the declaration on 100 per cent transition to zero-emission vehicles by 2030–40 at the 26th Conference of Parties in Glasgow—with special focus on two- and three-wheelers—foreshadows more disruptive and transformative changes in the sector.

The full force of this change needs to unfold within this decade. But is India really prepared to walk the talk?

Reducing transport emissions has remained one of the toughest battles locally as well as globally and is turning out to be a "hard to abate" sector. Regions around the world, including India, are failing to build solutions to scale. These solutions are expected to be a complex web of vehicle technology, low-carbon fuels, transportation and mobility strategies, city design and commuting behaviour, and long-range transportation solutions for both freight and passenger segments that include roadways, aviation, railways and waterways. Each of these segments requires scaled-up interventions for the big solution.

Challenges and opportunities for change differ across the landscapes of developed and developing countries. They requires a better understanding of the regional imperatives and a global mechanism to reduce transport-sector emissions in all regions of the world.

It is even more important at this moment in time as the COP 27 Presidency of Egypt has identified transport as an issue of particular importance for the upcoming Conference. In its statement of September 2022, it stated that this time the stakeholders would be brought together to make commitments to achieve equitable, healthy, green and resilient transport in Africa and the rest of the developing world. The focus of COP 27 would be on implementation.

COP 27 was expected to ensure commitment towards creating Specific, Measurable, Achievable, Relevant and Time-bound (SMART) outcomes "to identify gaps, build on previous initiatives that feed back into these efforts to ensure continuous alignment and scaling up". The Conference would be aiming for high level commitments and relevant announcements to develop roadmaps, funding and governance mechanisms.

This statement from the COP 27 Presidency has come against the backdrop of the IPCC report of 2022 that has warned that transport is responsible for 15 per cent of global GHG emissions and is the fastest growing source of emissions. GHG emissions attributed to urban areas are increasing—from 62 per cent in 2015 to about 67–72 per cent in 2020. The problem is seen as the result of the growth of car-centric cities. But transport sector emissions mitigation is an under-prioritised climate agenda, says the statement.

Initially, on November 17, 2022, at the climate conference COP27 in Sharm el-Sheikh, Egypt, a transport day was planned to get transport community to commit to the solutions for the sector. But such a dedicated transport day could not be organised even though the conversation on transport had picked up. However, the Egyptian COP Presidency launched its Low Carbon Transport for Urban Sustainability (L$^{c}O_2$TUS) initiative to decarbonise urban transport systems worldwide, especially in the Global South. This initiative has taken on board the strategies to avoid travel and reduce distances, shift to efficient modes and improve vehicle technologies, link with the goal of sustainable development, and enhance financing. While this has drawn in several non-state actor organisations, no government has joined this initiative so far.[1] In contrast, the forums created for electric vehicle transition in the COP platform have attracted several governments to sign pledges. But mobility and transport initiatives have not seen similar traction. This is a worrying trend.

It remains to be seen how the global community will address this issue to enable ambitious global and regional trajectories while addressing the imperatives of developed as well as developing countries. While the focus is on the Global South which, after a long latency period, is witnessing an unlocking of demand for travel and growth in vehicle ownership and usage, the Global North is already locked into a car-centric growth paradigm. Cities in developed nations require massive scaling down of their car-centric growth.

To this is added the challenge of freight and long-range transport, with limited short-term options, which will play out differently in different regions and demand a more nuanced approach towards building up ambitious and meaningful action.

This has made this review of how people travel and trade in different regions of the world, and what the local and/or regional strengths and gaps are, critical for informing the solutions that need to be built with scale and speed to meet the 1.5^{o}C global temperature stabilisation target. Within this framework, India's transportation and mobility strategy has also started formulating its transport-sector interventions.

India's Long-Term Low-Carbon Development Strategy was submitted to the United Nations Framework Convention on Climate Change at the 27th Conference of Parties in Sharm el-Sheikh.[2] The Strategy emphasises on the development of an integrated, efficient and inclusive low-carbon transport system. It has taken transport on board and indicated ongoing action and plans for the future. While emphasising integrated, efficient and inclusive low-carbon transport system, it has highlighted the current policies and programmes that are expected to contribute towards its attainment. It has asked for significant expansion of low-carbon options across transportation modes for passenger and freight mobility. This includes improved fuel efficiency, phased transition to cleaner fuels, modal shift towards public and less polluting modes of transport, electrification across multiple

modes, demand-side management, and traffic management and intelligent transport systems. It has highlighted the current policies and targets that include leapfrogging directly to Bharat Stage VI emissions from Bharat Stage IV levels, vehicle scrappage policy, comprehensive package for electric vehicles, and making Indian Railways net-zero by 2030.

India's Long-Term Low-Carbon Growth Strategy has asked for improved fuel efficiency standards, optimised networks, improved technologies, fleet modernisation, phased adoption of cleaner fuels—including hydrogen—modal shift towards public and less polluting modes of transport to integrate transport with urban planning, multi-modal connectivity, and enhanced railway capacity. Electrification is planned across multiple modes supported by programmes, policies and measures and electrification of railways and modal shift in favour of railways for long-range freight and passenger transport.

Transport is expected to contribute significantly towards the total financing requirements for the energy sector, including industry, buildings and transport, running into trillions of dollars by 2050. However, this requires measurable and verifiable indicators to ensure the planned transition.

India has also launched Mission Life 2022–23 to nudge individuals, communities and institutions to practise environmentally friendly actions such as use of public transport, ride sharing and use of bicycles, electric vehicles and vehicles running on clean fuels. This creates an opportunity for a public movement for sustainable mobility that can strengthen demand for supportive policies, requisite infrastructure and enabling mechanisms.

These developments require a deep-dive assessment of the challenges and opportunities and the mechanism needed to build solutions to scale at the local and global levels.

INTRODUCTION

TRANSPORTATION ACTION: GLOBAL CONTEXT

GLOBAL TRANSPORT EMISSION TRENDS

Globally, carbon emissions from the transport sector have remained obstinate and difficult to abate. According to *ITF Transport Outlook 2021* estimates, carbon dioxide (CO_2) emissions from the transport sector have grown steadily since 1990, with only temporary dips during the 2008 financial crisis and the Covid-19 pandemic shutdown in 2020 (see *Graph 1: Global CO_2 emissions from fuel combustion by end-use sector*).

Future action will depend a lot on understanding the emission trends before, during and after the pandemic-induced disruption to refine the roadmap for recovery. During the pre-pandemic period, a sector-wise analysis of CO_2 emissions from transportation reveals that they were second only to emissions from electricity and heat generation. The data available for 2016 shows that while electricity and heat generation contributed nearly 41 per cent of global CO_2 emissions (around 15 billion tonne in 2016), transport was responsible for 21 per cent (around 7.8 billion tonne) (see *Graph 2: Sector-wise global CO_2 emissions in 2016*). Most other sectors have shown either an arrested or declining trend (see *Graph 3: Pre-pandemic sector-wise percentage change in global CO_2 emissions in 2010–16*).

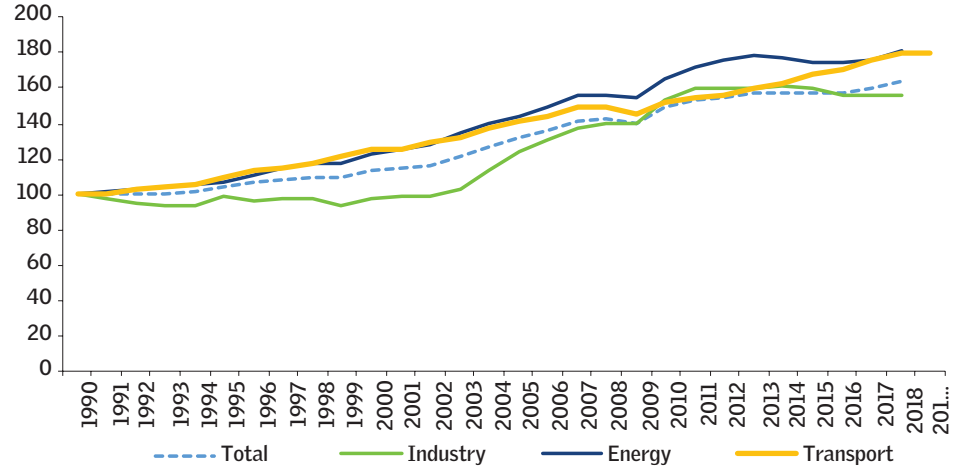
PANDEMIC-LED DISRUPTION AND TRANSPORT-SECTOR EMISSIONS

Even in the post-pandemic period, the transport-sector emissions trend is expected to stay bullish as transport activities will continue to grow with economic development and urbanisation. The *ITF Transport Outlook 2021* predicted that based on current efforts that the world is making, total transport activity will more than double by 2050 compared to 2015. Passenger transport will increase 2.3-fold and freight transport 2.6-fold. CO_2 emissions from transport will increase by 16 per cent by 2050 even if current commitments to decarbonise transport are fully implemented.

ITF Transport Outlook 2021 estimates that globally post-pandemic daily travel will contribute nearly three-quarters of total passenger demand by 2050. Most urban and regional activities accounted for two-thirds of the demand in 2015; this is expected to increase to three-quarters by 2050. After a temporary reduction in 2020, passenger transport demand will double between 2015 and 2050.

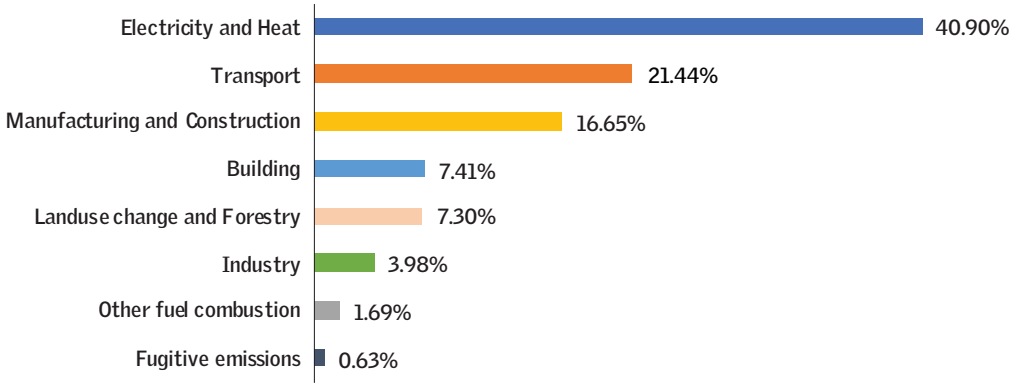
Graph 1: Global CO_2 emissions from fuel combustion by end-use sector

Evolution of CO_2 emissions, 1990 = 100



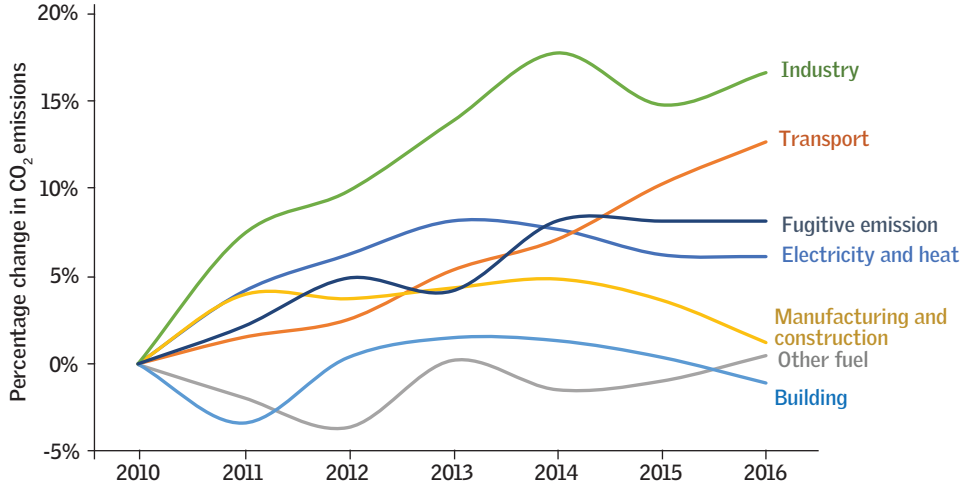
Note: Data for 2019 are estimates. Energy includes "electricity and heat producers" and "other energy industries". Documentation for the data can be found at: https://iea.blob.core.windows.net/assets/474cf91a-636b-4fde-b416-56064e0c7042/WorldCO2_Documentation.pdf Source: Data from 1990 to 2018 are from IEA (2020[1]), CO_2 Emissions from Fuel Combustion, https://www.iea.org/subscribe-to-dataservices/co2-emissions-statistics. Transport emissions in 2019 are from IEA (2020[29]), Tracking Clean Energy Progress: Transport, https://www.iea.org/reports/tracking-transport-2020.

Graph 2: Sector-wise global CO_2 emissions in 2016



Source: ourworldindata.org

Graph 3: Pre-pandemic sector-wise percentage change in global CO_2 emissions (2010–16)



Source: ourworldindata.org

Naturally, this growth is expected to have a huge impact on transport energy demand and emissions. According to the International Energy Agency's (IEA) *Tracking Transport 2020* report,[3] in 2018, the final energy used in vehicles was responsible for about 25 per cent of direct CO_2 emissions from fuel combustion. IEA also says that the global transport sector energy intensity (total energy consumed per unit of GDP) dropped by 2.3 per cent in 2019 after falling at an average rate of 1.4 per cent per year in 2000–18.

But despite this, energy intensity will continue to remain a challenge—it must drop by 3.2 per cent on average annually in 2020–30, more than double the annual average rate of decrease since 2000. Global transport carbon emissions increased by less than 0.5 per cent in 2019 compared with 1.9 per cent annually since 2000.[4] But despite this improvement, it is still responsible for 24 per cent of direct CO_2 emissions from fuel combustion.

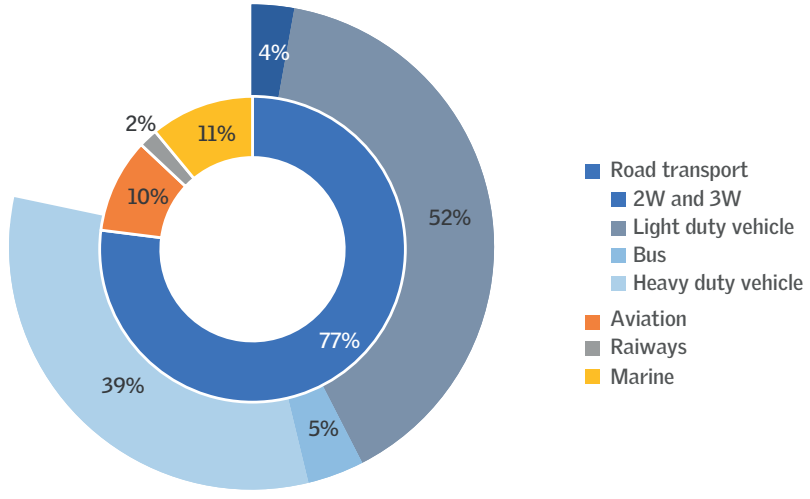
Road vehicles account for nearly three-quarters of the CO_2 emissions from transport, even as emissions from aviation and shipping continue to rise. According to International Council of

Clean Transportation (ICCT) estimates, globally, road transport dominates as a major contributing mode for overall transport sector emissions—covering roughly 77 per cent of the total—followed by marine (11 per cent), aviation (10 per cent) and rail (2 per cent)[5] (see *Graph 4: Share of well-to-wheel CO_2 emissions from transportation by mode*).

Almost all transport modes, irrespective of whether they are involved in passenger or freight transport, are powered by internal combustion (IC) propulsion systems that burn fossil fuels. Light- and medium-sized passenger road vehicles are highly dependent on petrol/gasoline, while heavy-duty goods transport vehicles like trucks and buses rely on diesel. Maritime transport vehicles use mainly low-quality bunker fuel, and air transport depends on high-quality specialised fuel. Only railways largely operate on electric power, although electric power generation involves burning of fossil fuels—mainly coal—though some sectors of railways continue to use diesel.

According to IEA's *World Energy Outlook 2022* report,[6] the global transport sector is responsible for a quarter of the total final

Graph 4: Share of well-to-wheel CO_2 emissions from transportation by mode



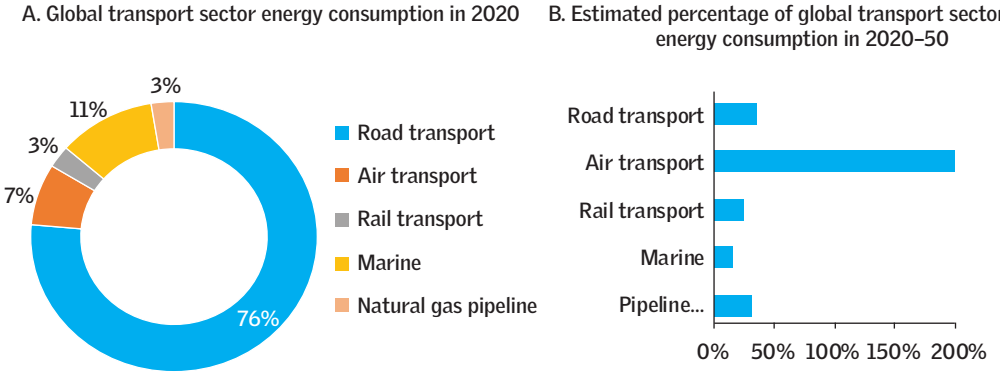
Source: ICCT

energy consumption currently and accounts for nearly 40 per cent of emissions from end-use sectors. Oil dominates in transport, accounting for 90 per cent of the consumption. An increasing demand for passenger and goods mobility in 2010–19 has caused the largest growth in transport emissions among all end-use sectors. In a scenario in which governments are saying what they are actually doing, the transport energy demand is projected to go up by 15 per cent in 2030 compared to 2021, and this will be dominated by oil.[7]

The ***International Energy Outlook 2021,*** which provides a granular view of global transport sector emissions, predicted an increase in global transport sector energy consumption by 69 per cent (155 quadrillion British thermal units) in 2050 from the 2020 level. In 2020, road transport consumed about 76 per cent of the total energy used[8]—almost identical to its emission contribution (see ***Graph 5: Trends in global transport sector energy consumption by modes of transport***).

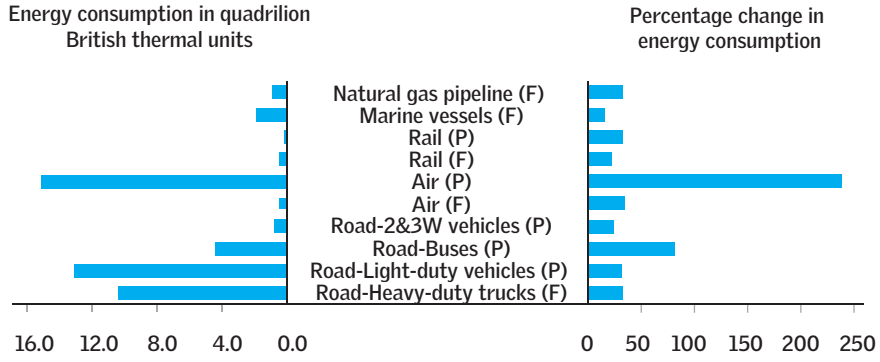
Globally, almost half the cars sold today are SUVs. The *World Energy Outlook 2022* estimates that under the stated policies of governments, this will rise to 55 per cent by 2030. SUV ownership

Graph 5: Trends in global transport sector energy consumption by mode of transport



Source: International Energy Outlook 2021

Graph 6: Mode-wise global transport sector energy consumption in 2020–50



Note: (P)—Passenger transport and (F)—Freight transport
Source: International Energy Outlook 2021

is highly concentrated—in 2021, almost five times more SUVs were sold per capita in advanced economies than in developing economies. This trend needs to be discouraged. SUVs are around one-quarter less fuel efficient than standard cars.

Although, as depicted, the rate of increase is not equal for all modes: air transport will increase drastically—by almost 200 per cent—in 2020–50. Though energy consumption from road transport is predicted to increase by 35 per cent, the actual increase (heavy-duty trucks, light-duty vehicles, buses and two- and three-wheeled vehicles combined) in this period is more than the combined increase of all other modes.

The passenger air and light-duty vehicles, along with heavy-duty trucks, are predicted to account for 80 per cent of overall transport-sector energy consumption (see *Graph 6: Mode-wise global transport sector energy consumption in 2020–50*).

IEA projections of 2020 see the global private passenger vehicle fleet growing by more than 30 per cent in 2020–30, reaching 1.4 billion vehicles by 2050. In 2015, more than a third of passenger trips were made by private vehicles—2.5 times more than those made with public transport. These trips accounted for more than half of all urban passenger-kilometres in that year. This is mostly

the result of continued growth in both private vehicle ownership and increasing average vehicle size.

PANDEMIC RECOVERY AND TRANSPORT EMISSIONS

Transport sector emissions reduced substantially during the hard lockdown phases of the pandemic (see *Box: How the pandemic affected transport-sector emissions*). There is considerable interest globally and locally in the pandemic recovery to stimulate investments in the appropriate solutions.

The 2021 emissions gap report of the UNEP[9] has warned against carbon-intensive recovery. It has made a categorical distinction between vehicle-centric traditional transport and clean transport (including electric vehicle incentives and public transport modernisation). Its review of multi-sector global recovery packages shows that of the US $250 billion spending globally, spending on traditional transport is 9.9 per cent, which is triple of the 3.3 per cent spending on clean transport. Most regions have spent very little on clean transport.

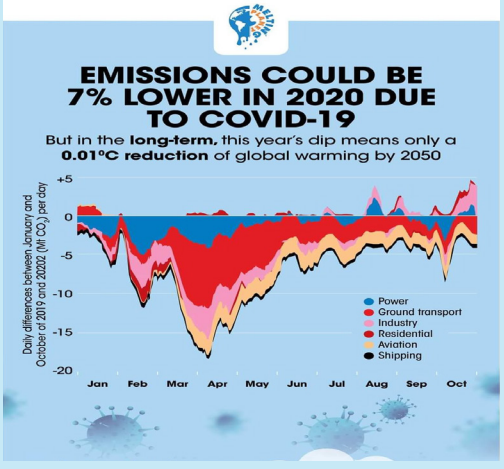
HOW THE PANDEMIC AFFECTED TRANSPORT-SECTOR EMISSIONS

Predictably, during the hard lockdown phases in 2020, overall activity levels plummeted. This is starkly evident from the Google and Apple Mobility Trends. Among all sectors, the transport sector experienced the maximum reduction as is also evident from the UNEP Emissions Gap Report of 2020 (see *Graph: Pandemic and global CO_2 emissions*).

ITF Transport Outlook 2021 further showed the global dip in different modes of transport—personal vehicles, public transport and walking and cycling (see *Graph: Pandemic and impacts on travel for users of Apple devices*).

India has also witnessed a similar trend as is evident from the CSE's analysis of Google activity data (see *Graph: India in lockdown phase--changes in activity patterns*).

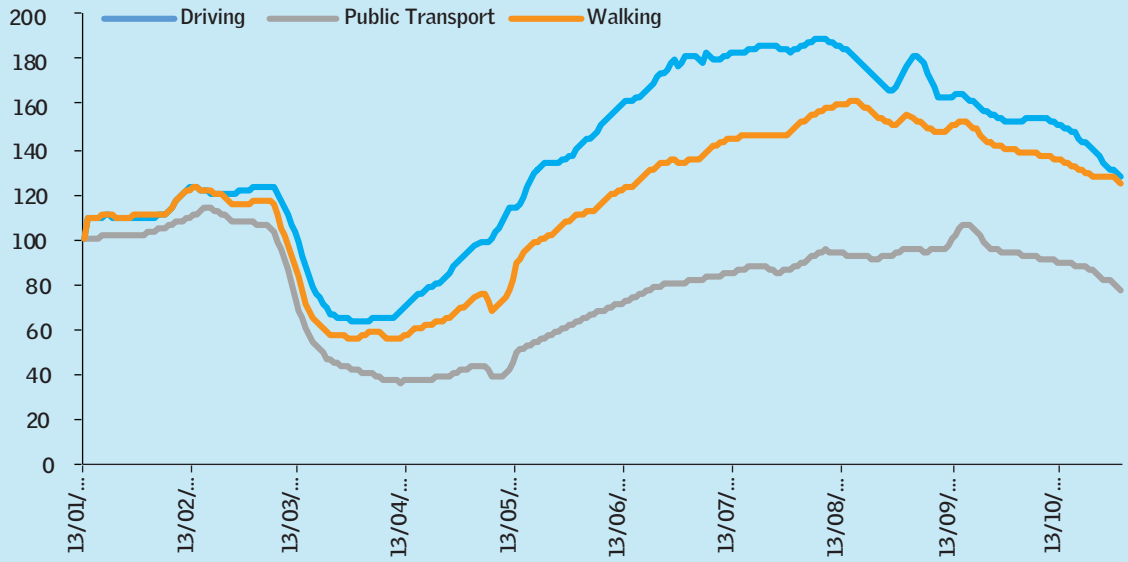
Pandemic and global CO_2 emissions



Source: Emissions Gap report 2020

Pandemic and impacts on travel for users of Apple devices

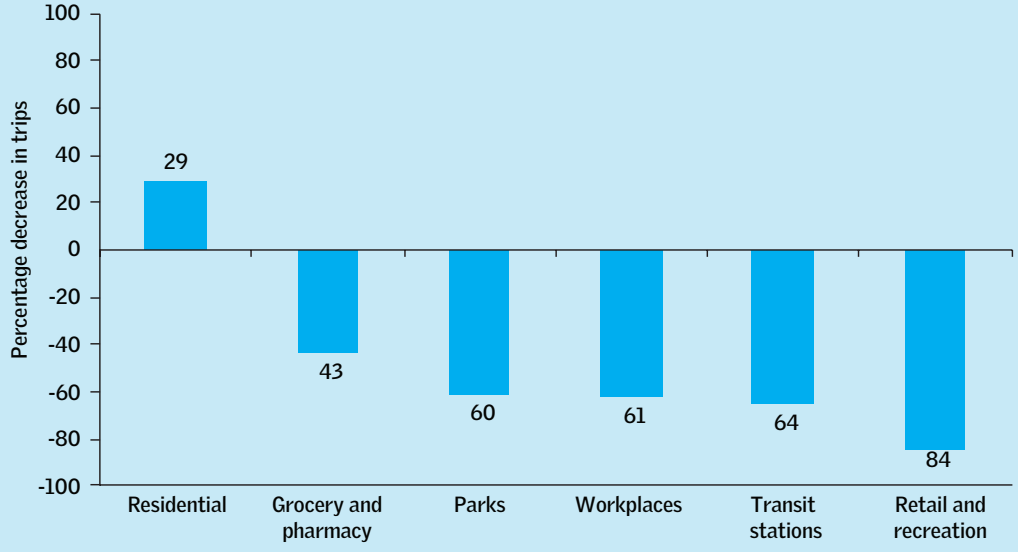
January 2020–February 2021, January 13, 2020 = 100, seven-day moving average



Note: Seven-day average plotted from January 19, 2020. Data is missing for May 11 and 12, 2020, and is therefore exempted from the global average. Routing requests are a proxy for travel demand and do not include most habitual trips. They give an indication of the scale of travel demand contraction where Apple devices are present and Apple routing services are used. The sample is biased—therefore this image is meant to be an illustrative example and not representative of the global population.

Source: Global averages computed based on Apple (2021[56]), Apple Mobility Trends

India in lockdown phase: Changes in activity patterns



Source: CSE computation based on Google activity data

This is worrying as the *UNEP Emissions Gap Report 2020* had warned about transport sector CO_2 emissions bouncing back and threatening to exceed the 2019 level after an over 10 per cent drop during the lockdown phases.

In absolute terms, the regional imperatives of this transition will be widely different, especially between developed and developing countries. IEA's tracking of transport web series 2019, which measures national transport sector energy intensity in terms of final energy consumption per unit of GDP, shows much higher transport energy intensity in developed countries.

NORTH VERSUS SOUTH: DIFFERING TRENDS

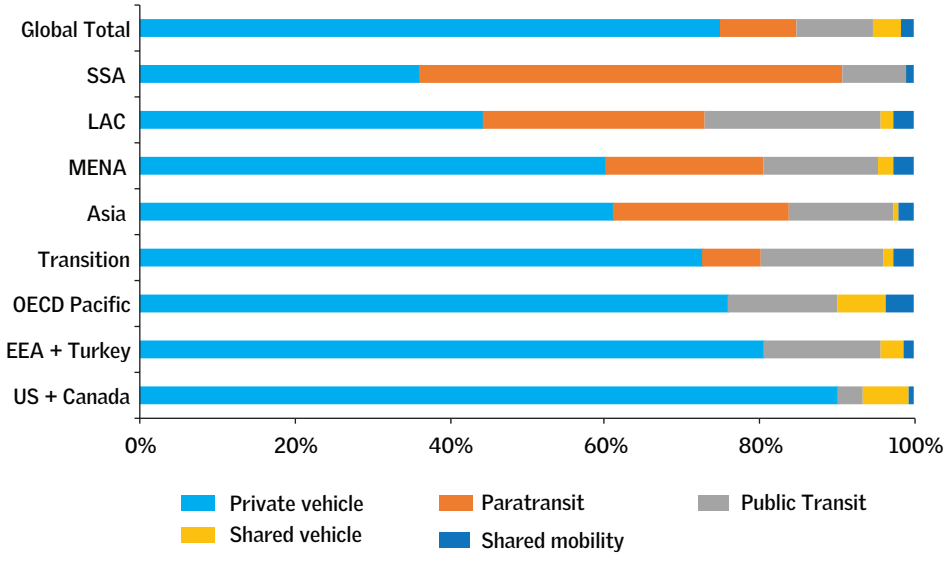
There is considerable divergence in the commuting patterns of the Global North and the South. The way people commute in different urban regions of the world determines the share of CO_2 emissions from the different modes. Globally, about 75 per cent of urban passenger CO_2 emissions are from private vehicles.

Predictably, automobile dependence has been the highest in the rich world, which has locked in enormous carbon so far. Region-wise, the US and Canada lead, followed by the European Economic Area and the Organization of Economic Cooperation and Development (OECD) countries (see *Graph 7: Mode share of urban passenger CO_2 emissions by world regions in 2015*).

It is evident from *ITF Transport Outlook 2021* that the highest-emitting cities produce 28 times more CO_2 than the least-emitting ones. Per capita transport CO_2 emissions of urban dwellers in the OECD countries is among the highest as opposed to Africa and some parts of Asia, that emit the least (see *Graph 8: CO_2 emissions per capita of urban passenger transport in 2015*).

In 2015, USA and Canada generated 2.7 times more passenger-kilometres per person on an average than individuals in Asia, the region with the largest total urban passenger demand. Urban

Graph 7: Mode share of urban passenger CO_2 emissions by world regions in 2015



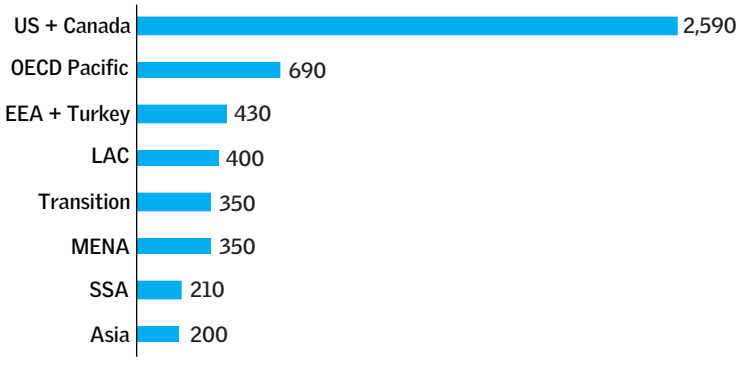
Notes: Figure depicts ITF modelled estimates. Active mobility and micro-mobility include walking, biking, scooter-sharing, and bike-sharing. Public transport includes PT rail, metro, bus, LRT, and BRT. Paratransit includes informal buses and PT three-wheeler. Shared vehicle includes motorcycle and car-sharing. Private vehicles include motorcycles and cars. Shared mobility includes taxis, ridesharing, and taxi buses.

EEA: European Economic Area; LAC: Latin America and the Caribbean; MENA: Middle East and North Africa; OECD Pacific: Australia, Japan, New Zealand, South Korea; SSA: Sub-Saharan Africa; Transition economies: Former Soviet Union and non-EU South-Eastern Europe.

Source: ITF Transport Outlook 2021

Graph 8: CO_2 emissions per capita of urban passenger transport in 2015

Kilogramme CO_2 emissions per capita



Note: Figure depicts ITF modelled estimates. Averages by region are calculated as averages across all urban areas.
Source: ITF Transport Outlook 2021

mobility per inhabitant in the OECD Pacific region (Australia, Japan, South Korea and New Zealand) is also significantly higher than in Asia, by a factor of 1.7. Compared to Sub-Saharan Africa, the region with the lowest urban travel per inhabitant, the average city-dweller in the US and Canada generates 3.8 times as much demand, and individual travel in the OECD Pacific region is 2.3 times higher.

This gap is expected to narrow by 2050, but USA and Canada will still generate 2.3 times the per capita travel demand of Sub-Saharan Africa, and 1.9 times that of the OECD Pacific region.

The total transport sector energy consumption (in barrels of oil equivalent or Boe per unit of GDP per US $1,000) is the highest in North America and Canada (0.19–0.23 Boe), high in Europe (0.12–0.15 Boe) and the least in India (0.06–0.09 Boe).[10, 11, 12] Predictably, the rich countries show a strong correlation between their GDP and motorisation. The US and Australia have a car ownership of more than 700–800 per 1,000 inhabitants; UK, Japan and Switzerland have more than 500–600 per 1,000.

Currently, developing countries have a lower baseline of transport sector emissions and energy consumption though this is expected to increase in the coming decades. In India, the transport sector accounts for 16.6 per cent of the total final consumption of energy. The respective share in developed countries is much higher: in USA it is 41.1 per cent; in Europe, 25.5 per cent; in Germany, 25.4 per cent; and in the UK, it is 32.5 per cent.[13] India's transport sector emissions are lower than that of countries and regions such as USA and the EU (both USA and EU transport sectors contribute 27 per cent of the total GHG emissions in their respective regions).[14, 15] In India, transport sector emissions are 9.7 per cent of the country's total GHG emissions.[16]

URBAN COMMUTING IN DEVELOPING AND DEVELOPED CITIES

How people travel in different cities around the world is not an

easy dataset to access. Such assessments are normally available only if specific studies are conducted from time to time. The jigsaw of such data available from some of the key global cities indicate the divergent trend.

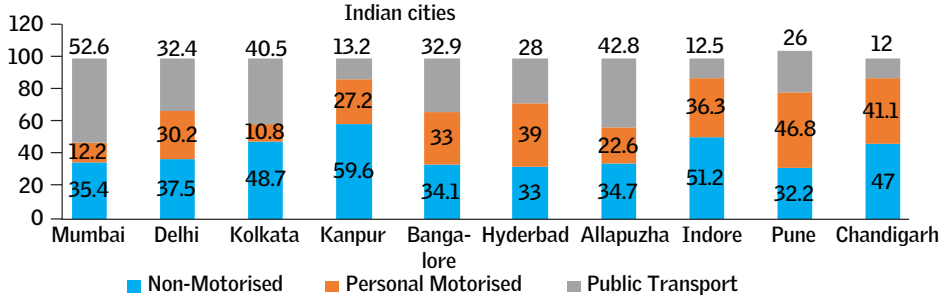
The *Global Mobility Report 2017*[17] prepared under the aegis of the World Bank shows a significant divergence between the modal share of public transport in urban areas in developed and developing cities. More than half of daily urban commuting in selected developed cities is by cars, 21 per cent by public transport and 26 per cent by walking and cycling. In contrast, combined mode share of public transport and walking and cycling is 67 per cent in selected developing cities.[18] This share could be higher in some cities of Asia and Africa (see *Graph 9: How people move in different cities of India and the world—i. India, ii. Europe, iii. USA, iv. China*).

Predictably, developing country cities show high usage of walking and cycling and public transport. The share of personal mode is also noticeable but with a difference. Most personal vehicles in several Asian and Indian cities are two-wheelers. Two-wheelers are considered to be the stepping stone to personal mobility that ultimately moves to car ownership. Also, the good baseline of walking, cycling and public transport usage in developing country cities is the result of lower per capita incomes as well as traditionally designed compact cities that make them more accessible. This is the reason why most cities of Asia and Africa with much lower GDPs have less than 100 cars per 1,000 population.

The baseline of high share of walking, cycling and using public transport in developing cities of Asia and Africa has created the ecological space that can contribute towards stabilising global emissions. Cities such as Addis Ababa report a 91 per cent walking share. Johannesburg in South Africa, Lagos in Nigeria, Dar es Salaam in Tanzania, Nairobi in Kenya, Addis Ababa in Ethiopia, and many others have implemented bus rapid transit

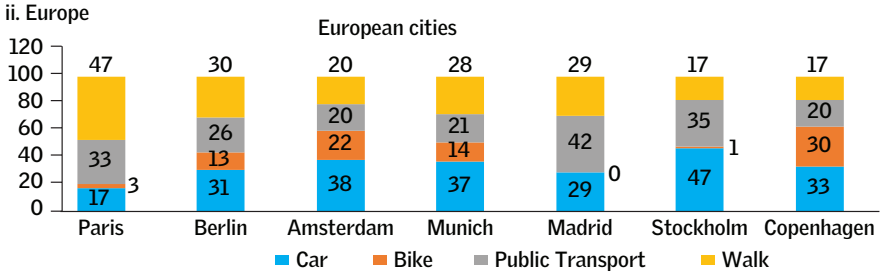
Graph 9: How people move in different cities of India and the world

i. India



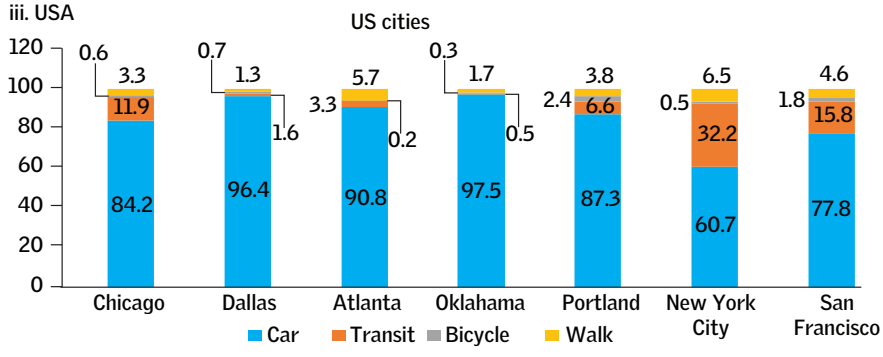
Source: Census of India, 2011

ii. Europe



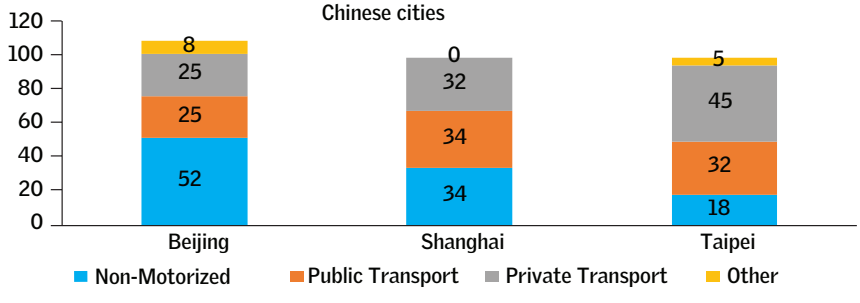
Source: European Platform Mobility Management Modal Split tool

iii. USA



Source: US Department of Transportation, https://www.transportation.gov/mission/health/transportation-and-health-tool-data-excel as accessed on 13 July 2018

iv. China



Source: US Department of Transportation, https://www.transportation.gov/mission/health/transportation-and-health-tool-data-excel as accessed on 13 July 2018

systems and are putting in place walking and cycling strategies that need leveraging and support to build scale.

The unique advantage of developing country cities is the extensive use of paratransit or intermediate public transport systems, which include a range of formal and informal services provided by small vehicles like three-wheelers, small vans etc. These low-occupancy and high-frequency services provide the bulk of public transport services, especially in smaller towns and cities. In African cities, these can meet up to 70 per cent of the travel demand. But in the global narrative of the sustainable transportation, the importance of their role and need for their integration is not recognised adequately.

Often these are seen in conflict with the more formal systems like bus rapid transit systems and subways that are implemented with international finances. These services are withdrawn or diverted from the main travel corridors to reduce competition with the bigger formal systems or to reduce car congestion. This can be detrimental to improving and retaining public transport ridership in developing cities as these are most efficient modes for providing direct connectivity to destinations and feeder services for multi-modal integration. At the global level, it is necessary to assess the magnitude of their modal share and to design solutions for their modernisation, integration and electrification. Otherwise, a big solution can be compromised in the developing South.

European cities, on the other hand, have begun to see a reversal of auto-mobility due to active policies and infrastructure development as well as the compactness of the core cities that favour walking, cycling, public transport and vehicle-restraint measures. Paris, Berlin, Amsterdam, Madrid, Stockholm and Copenhagen have a combined share of walking, cycling and public transport usage in the range of 60–87 per cent. Climate policies in Europe have adopted a combined strategy of vehicle

technology development to reduce CO_2 emissions and improve fuel economy, as well as scaling up of mobility strategies.

Cities in USA, on the other hand, have very high auto-mobility. Only a few cities such as New York and San Francisco have been able to achieve about 40 per cent or close to a quarter of commuting on sustainable modes, respectively. In the rest, the share of personal cars is 90 per cent or even more. Lack of investment in public transport, inadequate strategies for transit-oriented development, and highly sprawled cities block such development. This locks in enormous carbon and energy intensity in commuting. While USA is stepping up initiatives to decarbonise its automobile fleet with technology improvement and fleet electrification, its overall nation-wide transportation agenda is still slow.

USA and Canada together have 733 vehicles per 1,000 persons and the highest share of emissions from private car use if compared globally. According to the IEA 2019, nearly half of all cars sold in USA in 2018 were SUVs, and its worldwide share of new SUVs has doubled compared to a decade ago.

Key Chinese cities that were in the grip of high levels of motorisation have also witnessed arresting or reversal of car dependence with active policies. As part of the five-year plan to reduce local air pollution, multi-modal public transport infrastructure has been scaled up in a large number of cities. Several cities like Beijing and Shanghai have also put direct restraints in terms of vehicle quota systems that limit the number of cars that can be sold in a year.

The global experience also demonstrates that even with affluence and wealth it is possible to restrain automobile dependence with active policies and early interventions. The *Global Mobility Report 2017*[19] shows that even rich countries like Singapore and Hong Kong, despite having nearly the same GDP as other developed countries, have a much lower car ownership—less than 200 per

1,000 persons. They have invested in public transport adequately and kept the urban form compact with additional restraint measures. But this has a limited global multiplier effect and is confined to only a few pockets.

The hard lockdown phase has also helped reinforce the need for active transportation that has induced more walking and cycling and expansion of infrastructure in cities of Europe, USA and Australia. This needs to be sustained.

TILTING THE BALANCE BETWEEN RICH AND POOR CITIES

Future trends will, however, play out differently across rich and developing countries. The *International Energy Outlook 2019*[20] indicates that significant change is expected in the pattern of transport energy use globally. In the developed countries of OECD, energy used for passenger travel will decline until 2030s because of slower economic and population growth and greater impact of energy efficiency improvement in vehicles compared to the impact of increased travel. But energy used in air travel will nearly double in rich OECD countries.[21]

This is corroborated by the recent report of the IPCC that states it is possible for light-duty vehicle travel per capita in OECD countries—which is currently high—to peak around 2035.

In contrast, given the growth trajectory in developing countries, travel demand activity across all passenger modes will increase; this will outpace improvements in the fuel efficiency level of vehicles. Vehicle numbers will rise substantially from a very low average today. With more industry and improvement in road infrastructure, freight intensity will also increase.

This race has started when the rich world has just about begun to accelerate pace to achieve higher fuel efficiency and electrification of the vehicle stock, but has not yet been able to show scale of action in transforming urban mobility patterns.

Net-zero goals have to change the game plan to build ambition for public transport, walking and cycling and carbon neutral targets for freight and non-road transport as well.

A recent 2021 assessment of major global cities by the management consultancy McKinsey and Company shows that the share of public transport, walking and cycling has begun to increase in cities that are doing better on the sustainable development index. Cities with public transport, walking and cycling share in the range of 75–84 per cent include Hong Kong, Singapore, Beijing and Shenzhen. In the 60–69 per cent range are London, Shanghai, Berlin, Madrid, Paris, Milan, Buenos Aires, Moscow and St Petersburg. In the 50–59 per cent range are Tokyo, New York, Mexico City, Istanbul, Bangkok, Seoul and Sao Paulo. Cities with a range of 30–48 per cent include Sydney, Toronto, Chicago, Los Angeles and Johannesburg.[22]

But a large number of cities and towns are still without adequate public transport infrastructure and are battling auto-mobility.

Even though future travel demand and dependence on personal vehicles are expected to worsen, there is a chance to contain the trend. This is evident from the 2020 IPCC report which says that transport activities may plateau at lower GDP levels in non-OECD countries due to high urban densities and greater infrastructure constraint. A lot will depend on the choices governments make to prevent car-dependent infrastructure planning.

ENERGY EFFICIENCY GAINS

The *World Energy Outlook 2022* states that even if substantial electrification of new car sales—up to 60 per cent—is achieved by 2030, ICE vehicles will still account for nearly 80 per cent of the stock of cars. This makes fuel economy improvement very important. Fuel efficiency or CO_2 emissions standards for vehicles directly influence mileage and carbon emissions per litre of fuel burnt. CO_2 emissions are directly related to the carbon content of the fuel.

Globally, fuel efficiency or fuel economy regulations are evolving to improve vehicle technology trajectories to maximise energy efficiency gains from IC engines as well as batteries of electric vehicles. While this is expected to reduce oil demand and emissions of heat-trapping gases, protect consumers from rising oil prices and strengthen energy security, stringent targets can also drive rapid electrification of the vehicle fleet.

Stringent fuel-efficiency norms combined with a well-designed super-credit system for the most efficient and zero emissions technology can speed up technology transformation and electrification of the fleet, as has been seen in Europe.

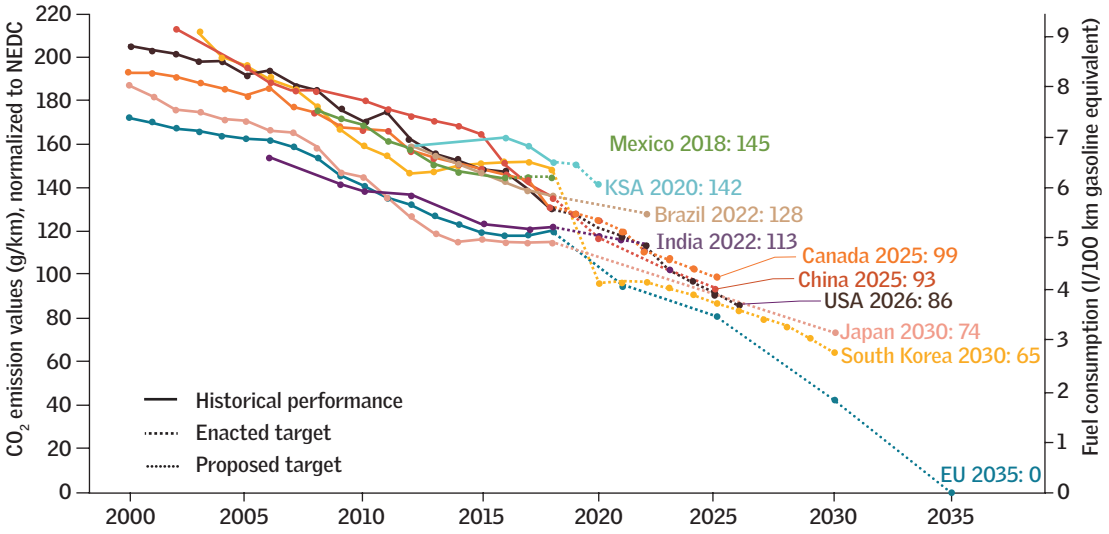
The frontrunner in this race is the European Union, which has tightened fuel economy substantially and has set tougher targets—95 CO_2 g/km in 2020, 80 CO_2 g/km in 2025, and 33 CO_2 g/km in 2030, and 0 CO_2 g/km in 2035 when ICE light-duty vehicles will be phased out in Europe. The US had lagged behind for a considerable length of time, but has now begun to tighten the target to meet 86 CO_2 g/km by 2027 (see *Graph 10: India lags behind in the global race*).

In India, the fuel economy target for passenger cars is 113 CO_2 g/km by 2023; the country is yet to set the next standard. Given the advantage of the small car domination, this target could have been much tighter. Despite having heavier vehicles, Europe's current CO_2 standard is 95 CO_2 g/km in 2020–21—20 per cent tighter than that of India. The average weight of the car fleet in Europe is about 1,400 kg as against 1,083 kg in India. This has accelerated electrification of the European car fleet despite the pandemic-led economic downturn. Countries like Australia are yet to adopt fuel economy regulations.

Fuel economy regulations are an underutilised instrument globally and particularly in developing countries. A large number of developing countries in Asia and Africa are vehicle-importing nations; several of them import old and used vehicles. This also

Graph 10: India lags behind in the global race

Passenger car CO_2 emissions and fuel consumption values normalised to NEDC test cycle*



* For the sake of simplicity, it is necessary to explain that fuel efficiency regulations are interpreted and presented differently in different countries. Broadly, the term "fuel efficiency" is used generically and is understood as "kilometre per litre" by most consumers to gauge the mileage of a car. But several countries regulate fuel efficiency as a "fuel economy standard" or in litres per 100 km basis. This is commonly used to compare standards between regions with different units for fuel consumption and distance travelled. The other approach is to set the standard as gram of CO2 emissions per kilometre (CO_2 g/ km). CO_2 emissions are linked to the carbon content of the fuel and the amount of fuel burnt.

This is a direct measure. Moreover, vehicles are tested for CO_2 emissions that are converted to fuel economy or mileage numbers. In India, these standards are called Corporate Average Fuel Consumption Standards (CAFCS), which are mentioned in both fuel economy terms (litres per 100 km) and also in terms of CO_2 emissions (CO_2 g/km). Therefore, to simplify things for the reader, this paper will broadly refer to these regulations as fuel efficiency standards, but provide specific target numbers in CO_2 g/km unless fuel economy numbers need to be mentioned separately.

Source: ICCT, https://cdn.cseindia.org/attachments/0.04188200_1629874738_anup-bandivadekar_fuelefficiency_cse_aug2021.pdf

needs to be linked with mandatory requirement of emissions standards and fuel economy standards. Some African countries, including Mauritius and Ethiopia, have adopted the approach of linking higher import taxes with bigger engine size or—as in the case of Mauritius—with CO_2 emissions. These instruments need to be developed further to be able to reduce energy impacts of motorisation.

FLEET ELECTRIFICATION FOR ZERO-EMISSIONS TRANSITION

In COP 26 held in Glasgow in 2021, 28 countries, 44 cities, 10 automobile companies, 26 fleet owners, 15 financial institutions

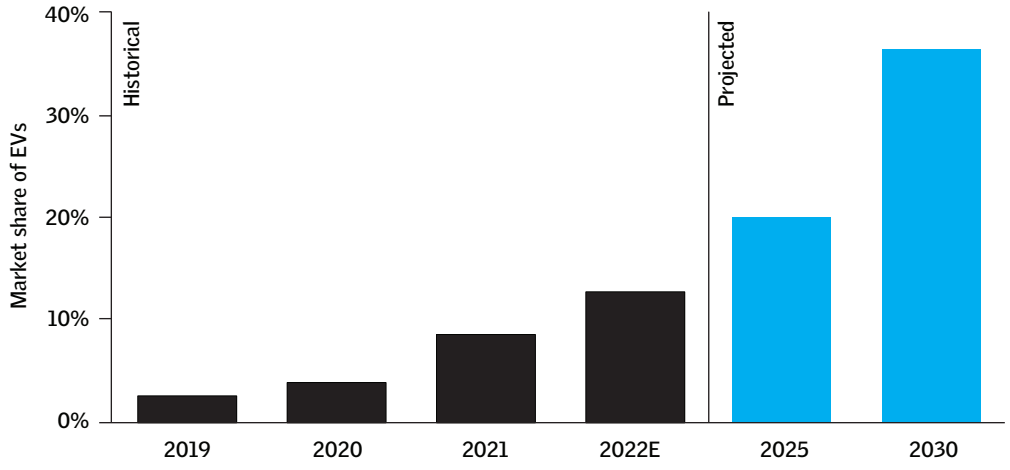
and 21 organisations—representing a sizeable share of the global vehicle market—came together to sign the declaration for 100 per cent transition to zero emissions by 2030–40. While signing the declaration, India also made the statement: "Two-wheelers and three-wheelers constitute more than 70 per cent of global sales and more than 80 per cent in India. All governments should also support the transition of these light vehicles to zero emission vehicles." This ambition is expected to shape the zero emissions trajectory in India in the coming years.

India is among 200 countries that have pledged to take action against climate change, and the total net-zero commitments globally cover 90[23] per cent of the world's GDP. Towards this decarbonisation goal, about 30[24] countries have already announced targets of 100 per cent zero-emission vehicles (ZEVs) and phasing out of internal combustion engine (ICE) vehicles in the time horizon of 2040–50. More countries are to follow. This scale of change can be hugely disruptive and will also impact India's automotive market.

Moreover, the ZEV Transition Council set up with representatives from 17 largest vehicle markets and ZEV alliances, represents 50 per cent of the global car market. IEA estimates that electric vehicles' stock will jump from around 5 per cent of global car sales in 2020 to a range of 40 to over 60 per cent in different policy scenarios by 2030. As per IEA estimates, by 2030, one out of every two cars sold in China, the EU and USA are expected to be electric (see *Graph 11: Share of EVs in the global car market to grow dramatically*).

According to *IEA's Global EV Outlook 2021*,[25] electric cars sold globally is about 4.6 per cent of the share of sales; notably, Europe overtook China as the largest electric vehicle market for the first time. Electric bus and truck registrations also expanded in major markets, reaching global stocks of 600,000 and 31,000, respectively. Electric bus and electric heavy-duty truck registrations have also increased in 2020 in China, Europe and North America.

Graph II: Share of EVs in the global car market to grow dramatically



Source: IEA

Automotive lithium-ion (Li-Ion) battery production was 160 gigawatt hours (GWh) in 2020—i.e. 33 per cent higher than in 2019. Publicly accessible chargers also reached 1.3 million units in 2020, of which 30 per cent were fast chargers.

The *World Energy Outlook 2022* has further estimated that the annual demand for automotive lithium-ion battery was 340 gigawatt-hours (GWh) in 2021. This will increase to 5,600 GWh by 2030 if policies for net-zero goal are implemented. But the Benchmark Mineral Intelligence in 2022 has estimated that battery production capacity announced by private companies for EVs in 2030 amounts to over 4,700 GWh. This would be about 15 per cent lower than the estimated battery demand in 2030.

Post-pandemic recovery will be critical for the pace of acceleration of the EV market. Policy measures need to be well designed for incentives to address the total cost of ownership, environmental and emissions performance standards, differentiated taxation systems for revenue neutrality, supply mandates and lifecycle emissions management, supported by industry reskilling and travel demand management measures.

Predictably, the pace of change is slow in developing countries; but these countries have the opportunity to side-step the complex and expensive technology trajectory of IC engines and leapfrog to electrification.

Developing country cities can leapfrog to the zero-emissions paradigm by leveraging some of their unique advantages. There are opportunities in early electrification of the smaller vehicle segments including two-wheelers, paratransit and public transport vehicles. Light-weight and shorter travel distances of two- and three-wheelers that require smaller batteries with less demanding charging facilities can be a game changer. These vehicles, which dominate the Asian fleet, will attain price parity and affordable total cost of ownership quicker. Electrification of urban buses, ride-hailing services and aggregators can make a substantial share of urban commuting carbon-neutral.

Electrification programmes have taken roots in cities across Asia and Africa. This action needs strategic roadmaps, well-designed regulations, incentive programmes and a fiscal strategy for up-scaled transition.

Electrification of trucks and commercial vehicles is still negligible globally. The existing fleet is largely meant for short-range deliveries in urban centres. Long-haul trucking requires advanced technologies for high power charging and/or large batteries. This has stymied the regulations for this segment in terms of weaker fuel economy standards and a lack of ZEV mandates.

Rapid electrification will also require substantial reduction in battery size and improvement in battery chemistry to reduce the battery footprint. The *World Energy Outlook 2022* estimates that average battery sizes increased by 60 per cent in 2015–21, and may increase by a further 45 per cent by 2030. This needs to be curbed by linking purchasing incentives to vehicle weight, expanding charging infrastructure to reduce range anxiety, and

improving energy density of batteries. This is also needed to reduce mineral demand from EV batteries.

The electric vehicle market and production are still very skewed and concentrated. Demand for electric vehicles and automotive batteries is the highest in China with almost 200 GWh of battery demand in 2021. The demand has also more than doubled in the US and Europe in 2021 from a lower base. Battery prices have come down by 86 per cent over the decade.[26]

However, electric vehicle programmes have taken root in developing countries in Asia and Africa. Even though the majority of them are importing countries, several have started setting up assembly lines for smaller electric vehicles like two-wheelers and public transport vehicles. Many are crafting import policies to promote electrification: Nepal, Bhutan and Sri Lanka in South Asia are examples. In Africa, Nigeria has established an assembly line for configuring electric vehicles. Rwanda has announced incentives that include rent-free land for charging stations, lower electricity tariffs for charging, tax exemptions, investor incentives etc. This transition will have to be enabled.

LIFE-CYCLE EMISSIONS MATTER

When the world is facing the challenge of 1.5°C stabilisation goal, merely taming tailpipe emissions from vehicles will not suffice. It has been estimated by McKinsey that with growing electrification, emissions from material production for vehicles may reach 60 per cent of life-cycle emissions by 2040.

This requires accounting for life-cycle emissions that involves GHG emissions from the entire value chain. This includes direct emissions from facilities and vehicles owned and operated; indirect emissions from the use of energy or electricity by the primary company; and indirect emissions that occur in the primary company's value chain—operations by suppliers, distribution, logistics, business travel, investment by the company in the supply chain, and use of sold products.

Global car companies, including Toyota, Mercedes-Benz, Volvo, Volkswagen, Renault and Fiat Chrysler among others, have started to set voluntary and time-bound targets for reducing lifecycle emissions to become climate-neutral; targets are being set for their supply chains. They are aiming to reduce embedded energy and energy intensity of vehicles, adopt renewable energy, and increase uptake of recycled material.

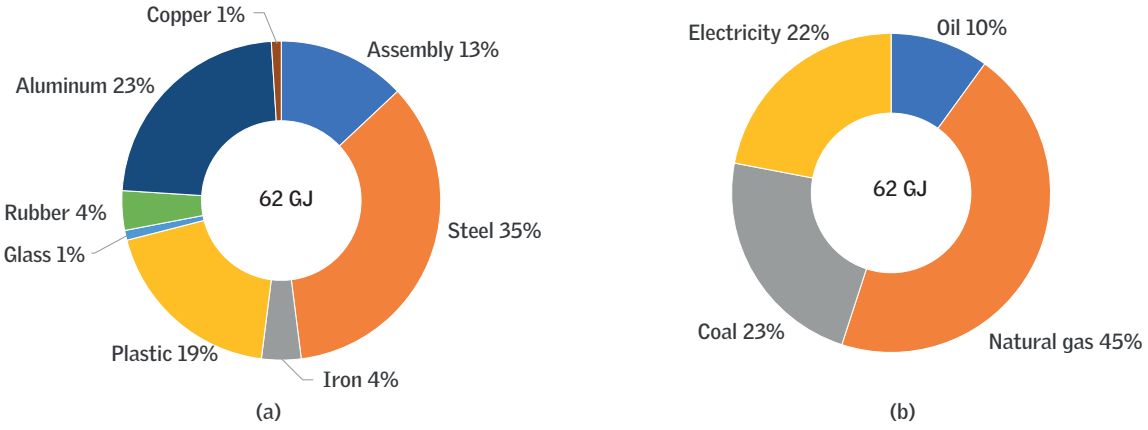
To reach the full potential of automotive decarbonisation—and achieve the zero-carbon car—industry players need to address material emissions. Recycling of waste and easy returns for end-of-life vehicle disposal can incentivise responsible disposal. Sustainable manufacturing for production processes need to reduce waste and improve recyclability and reuse of materials. Production of vehicles takes considerable energy, water and resources, increasing the carbon footprint. This requires assessment of raw material source, transportation of products, waste in the supply chain, energy consumption for production and the renewable energy component.

Currently, the use of coal is highest in production of material. Mining and material production are responsible for the highest emissions. This requires a conscious roadmap for structural changes (see *Graph 12: Emissions by material and energy*). A McKinsey study expects that the growing market share of battery electric vehicles globally will expand the material emissions by about three times[27] of vehicles' lifecycle emissions in 2040.

Increasingly, companies are adopting policies to reduce material intensity in terms of increasing the component of recycled material from the waste and material substitution. McKinsey has estimated that the automotive industry can decrease material emissions by 32 per cent while decreasing costs. Further reduction is possible with green electricity.

McKinsey estimates that about 60 per cent of the cost-positive decarbonisation approaches involve aluminium and plastics.

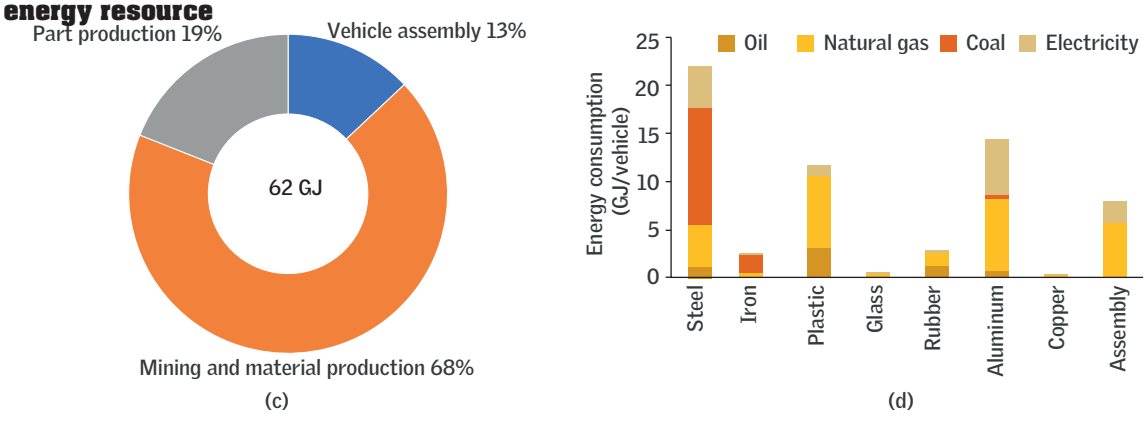
Graph 12: Emissions by material and energy



Source: Energy Consumption Analysis for Vehicle Production through a Material Flow Approach, MDPI

By productive phase energy resource

By material and



Source: Energy Consumption Analysis for Vehicle Production through a Material Flow Approach, MDPI

More expansive use of recycled aluminium, new smelting technologies, and green electricity can reduce emissions from aluminium production by about 73 per cent from current levels while also reducing production costs. Similarly, recycled materials such as polypropylene or polyethylene, especially for plastics in parts of vehicles that are not generally visible, can produce savings and cut emissions from plastic production by 34 per cent. Scaling nylon recycling technologies could further decrease total plastics emissions by up to 92 per cent. This includes carbon credits earned from averted oil extraction.

Several companies have adopted recycling policies for collection and recycling of end-of-life parts, working with dealers and distributors of parts. Eco-design efforts are being made for dismantling and recycling for final disposal or for backward flow of cars and their parts. They have improved dismantling and recycling of vehicles in response to the emerging legislation in Japan and Europe for end-of-life vehicles (ELVs). The aim is to achieve near-zero landfill waste at the production plants by recycling the entire volume of fly ash from the incineration furnaces as raw material for the cement industry. What is needed is an evaluation of the methods for recycling the small quantities of difficult-to-process waste which are being sent to landfills.

Aluminium and steel are fully recyclable. Recycling aluminium saves 95 per cent of the energy used in primary production. Today, in Europe, more than 90 per cent of the aluminium included in a car is actually recycled when the car has reached its end-of-life.[28] The scrap generated during the production process is also fully recycled and can be used over and over again for new car parts or other aluminium components without any loss of properties.

However, not every decarbonising process is within the control of the automaker. For instance, about 79 per cent of emissions from aluminium production comes from the smelting process. In addition, many of the technologies that could help decarbonise the automotive sector are not yet available at scale and would require massive upfront investments. Automakers' approach to decarbonising materials depends on their ambition and their customer's willingness to pay. Hydrogen-based steelmaking in particular is already technically feasible. However, widespread adoption is dependent on costs, supply chains and regulatory changes that support this transition.[29]

Clean power and vehicle production: A study, conducted for the European think tank Fuel Institute, found that with ICE vehicles, 73 per cent of the emissions is from vehicle operation, whereas

with an EV, 72 per cent of the lifecycle emissions originate from the fuel burnt to generate electricity. However, it is 27 per cent lower than that of an ICE vehicle. The study which included an ICE vehicle, a BEV and a PHEV concluded that the EV has 41 per cent[30] lesser emissions than an ICE vehicle in Europe.

About a third[31] of these CO_2 savings could be achieved by electrifying existing processes of material production, using renewable energy sources and expanding the use of new technologies that reduce process emissions, and by using recycled materials and recycling a larger share of the materials.[32]

An EV can reach its full green potential only when the power used to charge it is green, or which uses renewable sources, and the production process also uses green electricity. The power generation mix has to be adequately decarbonised to enable deep reductions in the emission load of mobility.

A study by the US-based Argonne National Laboratory (ANL) found that a typical EV in the US takes about a year in operation to reach "carbon parity" with a petrol vehicle, assuming the vehicle travels about 40 miles (64.37 km) every day. If the EV draws power from a coal-fired grid, the catch-up period stretches to more than five years. If the grid is powered by carbon-free electricity from renewable sources, the catch-up period is about six months.

The ICCT study shows that among electric two-wheelers, motorcycles have 33–45 per cent lower lifecycle emissions, while scooters have 38–50 per cent lower emissions compared to their petrol counterparts. By 2030, these vehicles could account for emissions lower than 45–66 per cent and 50–70 per cent, respectively.

Phase-out of internal combustion engines: There has been considerable traction in the global market with regard to setting targets for ICE vehicle phase-out. Cities and countries have set

timelines; automakers have declared voluntary targets. Currently, these policies are primarily targeting light-duty vehicles or cars.

The *World Energy Outlook 2022* has identified members—countries or states—of the International Zero Emissions Vehicle Alliance legislation that have a target or stated ambition in place to phase out sales of ICE light-duty vehicles, including passenger cars and light trucks (see *Table 1: Countries with targets to phase out ICE vehicles*).

In addition, voluntary announcements have been made by passenger carmakers to completely phase out ICE vehicles—largely in the European Union, the European Free Trade Association countries, and the UK. In Europe, Jaguar promises to sell 100 per cent electric vehicles by 2025, Alfa Romeo by 2027, Opel by 2028; and Bentley, Cadillac, Fiat, Mini, Rolls Royce and Volvo by 2030. Honda will do the same in China by 2030 and Audi by 2033. General Motors, Lexus, Hyundai, Volkswagen and Toyota plan to meet the target by 2035 in Europe.[33]

This foreshadows disruption in the global market that will impact all vehicle-producing countries, including developing countries such as India.

Long-range transport: In addition to urban commuting, long-range transport, which includes long-distance roadways,

Table 1: Countries with targets to phase out ICE vehicles

Target date	Country	Category of vehicles
2025	Norway	LDVs
2030	Austria, Slovenia, Washington (USA) Denmark, Iceland, Ireland, Netherlands, Singapore (passenger cars)	LDVs
2035	European Union, Cape Verde, Canada, Chile, United Kingdom, California, Massachusetts and New York (USA)	LDVs
2050	Costa Rica, New Zealand, Connecticut, Maryland, New Jersey, Oregon, Rhode Island, Vermont (USA)	Passenger cars

Source: International Energy Agency, World Energy Outlook 2022

railways, aviation and waterways, have a significant impact on carbon emissions from the transportation sector. IEA estimated in 2020 that shifting from trucks to freight rail leads to about 72 per cent lower energy use per tonne-kilometre and from aviation to high-speed rail can enable 93 per cent lower energy use per passenger-kilometre. Even for longer urban trips, using urban rail instead of private cars leads to 91 per cent lower final energy use per passenger-kilometre. Moreover, if additional measures are initiated to improve energy efficiency, clean and renewable electricity and space-efficient transport systems used, supported by fiscal strategy, carbon-reduction gains can be maximised.

As per *ITF Transport Outlook 2021*, at the regional travel where the options are only road and rail transport, non-urban passenger transport is responsible for 34 per cent of all transport emissions and 60 per cent of passenger transport CO_2 emissions. By 2050, the share of non-urban transport will double. Globally too, rail accounted for 30 per cent of the global surface transport in 2015.

Road-based freight transport: Among all the transport segments, taming emissions from freight is the toughest and hardest to abate. Globally, as *ITF Transport Outlook 2021* estimates, long-range freight by all modes currently accounts for about 42 per cent of total transport emissions and will be responsible for 44 per cent of emissions by 2050. Road freight is 15 per cent of total freight activity but emits 44 per cent of the sector´s CO_2. Surface freight emissions in developed economies have higher carbon intensity and per capita levels.

Urban freight transport, on the other hand, is about 3 per cent of the total freight activities but is very carbon-intensive. It is estimated that urban delivery trips account for roughly the same emissions as global maritime shipping (that is 70 per cent of all freight activity), with around 20 per cent of all freight emissions. Urban freight will further accelerate under the influence of e-commerce. Due to this, urban freight activity is expected to grow in tonne-kilometres faster than non-urban trucking.

Road freight will continue to remain a challenge in the future. Rail and inland waterways are the least carbon-intensive.

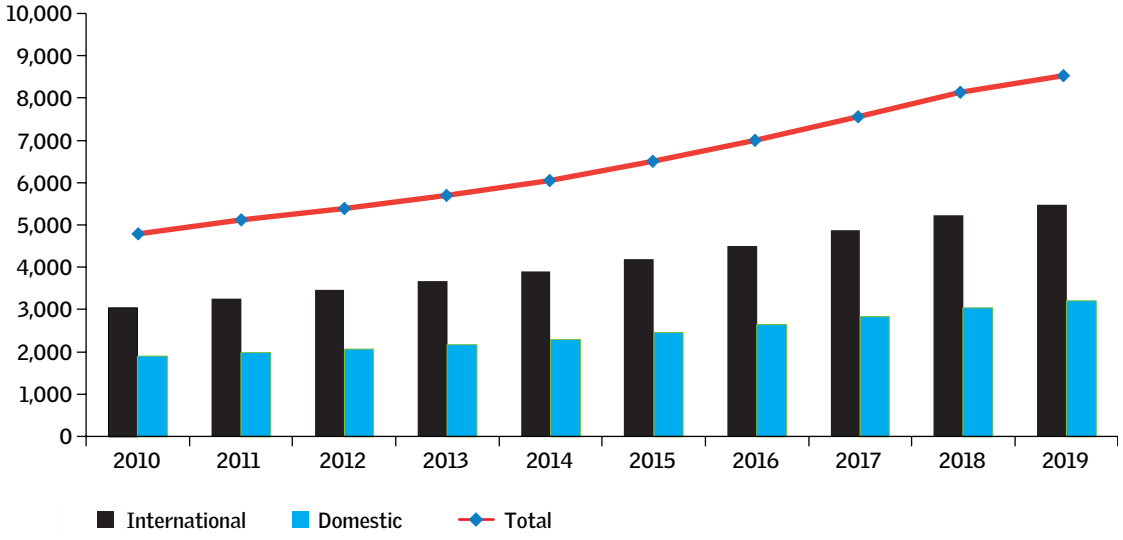
Railways and aviation: Rail is considered the most energy-efficient mode of long distance transport. According to the *World Energy Outlook 2022*, oil meets half of its energy requirements and most of it is used by freight rail. Modal transfer from roadways to rail and from short-haul flights to rail can provide substantial gains. But there is a limit to which the infrastructure can develop as opposed to more flexible operations of long-haul road freight and transport. Energy transition from coal and diesel to renewable electricity will also be critical.

Globally, growth in air travel—the most carbon-intensive transport—has been explosive. Before the pandemic, airline passenger traffic increased at a compound annual growth rate of about 6.5 per cent in 2010–19 (6 per cent for domestic, 6.8 per cent for international), according to data from ICAO (2020). Its share will increase significantly, especially more for the intercity segment by 2050, growing by almost 210 per cent compared to 2015. It is also evident that only 11 per cent of the world's population travelled by air in 2018, and only around 4 per cent took longer distance international flights. Thus only 1 per cent of the global population is responsible for more than half of total aviation-related emissions[34] (see *Graph 13: Global evolution of world air passenger traffic, 2010–9*).

It is not easy to achieve modal shift from aviation to other modes at a scale as both railways and roadways can substitute air travel only on high demand and limited shorter haul routes. However, road transport may remain popular on a wider scale due to the flexibility that it offers.

The *ITF Transport Outlook 2021* expects aviation to witness the largest relative growth by 2050, increasing by a factor of 3.5 compared to 2015 during post-pandemic recovery. Aviation can reach 2019 levels by 2023.

Graph 13: Global evolution of world air passenger traffic, 2010–19
International and domestic flights (in billion passenger-kilometre)



Source: ICAO (2020[3]), Annual Report of the Council 2019, https://www.icao.int/annual-report-2019/Documents/ARC_2019_Air%20Transport%20Statistics.pdf

Solutions for taming emissions from aviation are limited. The options are using low-carbon alternative fuels and improving fuel efficiency. Electrifying aviation is still not possible. Alternative fuels include hydrogen, ammonia and synthetic fuels, but these technologies have not matured yet. Currently, improving energy efficiency is the key strategy to reduce emissions. This will also have to be supported by carbon pricing and ticket taxes, but there is a limit to the extent this can be leveraged given the cost impacts on travel.

NEXT STEPS: ACCELERATING LOW-CARBON TRANSPORTATION SOLUTIONS

More ambitious transport decarbonisation policies are needed to reduce transport CO_2 emissions to limit global temperature rise to 1.5˚C. *ITF Transport Outlook 2021* states that even if countries meet all targets of their initial NDCs, the planet would far exceed the 1.5°C and even the 2°C global warming threshold.

Many NDCs list CO_2 reduction ambitions specifically for transport,

but few include clear measures to reach them. While 81 per cent of NDCs recognise transport as relevant, only 10 per cent have stated transport-specific mitigation targets. All transport-related NDCs will require additional commitment to reduce 600 million tonne of CO_2 by 2030. A lot more ambitious, effective and targeted strategies are needed at scale and speed.

The solutions need to be understood in the context of the imperatives of the Global North and South to chart future pathways. The challenge is to align action at hyper-local, regional, national and international scales in all sub-sectors and across all regions.

The developing South needs transformative action to reinvent its public transport, paratransit, and active transportation systems to protect and augment its higher share of sustainable modes. This can contribute strongly towards global climate goals.

Even though the developing South will see substantial increase in transportation demand and emissions, the transportation system in the developed North that has already locked in enormous carbon in its car-centric infrastructure will also need aggressive measures. It may be noted that in 2050, USA and Canada will still generate 2.3 times the per capita travel demand of Sub-Saharan Africa, and the OECD Pacific region 1.9 times. Thus, the rich world cannot escape the aggressive mobility strategy to curb emissions from urban mobility and focus only on technology pathways.

The technology leapfrog in the developing South will have to be enabled across all regions, more so in the poorer South, to make the transition towards zero-emission vehicles on clean electricity and side-step ICE vehicles.

Both regions will need strategic interventions to address emissions from the freight sectors and long-range transport, which will continue to grow with economic growth but has limited solutions.

INTRODUCTION

THE ACTION AGENDA

- Prepare a **global strategy and regional roadmap** on clean fuels and technology to control real-world emissions; implement stringent fuel economy regulations for fuel savings and an ambitious electrification programme; and prepare a global fleet renewable strategy by preventing dumping of used vehicles in the poorer South.
- Put in place **time-bound targets** to improve the modal share of public transport, walking, cycling and shared mobility in all regions. This needs to be measurable and verifiable.
- Expand the **infrastructure** needed for walking and cycling and network development to induce change.
- Enforce **vehicle-restraint measures** and demand-management measures to curb personal vehicle usage. Remove hidden subsidies for personal vehicles through a variety of measures such as differentiated taxation, congestion and emissions pricing, parking caps and pricing for demand management. Institute low-emission zones to promote walking, cycling and zero-emission vehicles.
- Adopt and mandate **compact city design** and form-based code to reduce travel distances and contain urban sprawl.
- Implement **transit-oriented development** with planned densification, mixed use and mixed income development to improve access to public transport for the maximum number of city dwellers.
- Induce a **modal shift in freight transport** from roadways to railways along with truck electrification and green freight programmes.
- In **aviation**, ensure improvement in fuel efficiency, retirement of older fleet, and clean fuels.
- Adopt innovative **fiscal instrument and polluter-pays principles** for the transportation sector.
- Design a **mechanism for climate finance** that works for transportation strategies.
- Implement a **public communication strategy** to influence policies and politics to build support around transportation and mobility solutions.

INDIA CAN LEAPFROG

To leverage its strength India will require its own time-bound roadmap for stringent action in all sub-sectors of transportation to meet the goals of India's long-term low-carbon development strategy.

India needs to implement a stringent roadmap for Bharat Stage VII emissions regulations and more stringent energy consumption target for the internal combustion engines while meeting the zero-emissions target in all vehicle segments.

States need to implement time-bound and locally appropriate targets to improve the modal share of public transport, walking, cycling and shared mobility in all classes of cities. Indian states need state-level mandates to strength bus transport services with IT-based monitoring and passenger information systems. Urban transport policies need to integrate and mandate the requirement of infrastructure for walking, cycling and safe access and network development for functional use. Enforcement of vehicle-restraint measures and demand-management measures are urgently needed to curb personal vehicle usage.

There is need for a mandate of compact city design and form-based code and transit-oriented development programme for planned densification, mixed use and mixed income development to improve access to public transport for the maximum number of city dwellers. Financial instruments to mobilise resources to fund transportation strategies need to be adopted.

For long-range transport it is necessary to achieve the targeted modal share of 45 per cent for railways by 2030 and much more ambitious target beyond. Reform e-retail and e-commerce for efficient deployment. In aviation, improvement in fuel efficiency, retirement of older fleet, and clean fuels need to be ensured. Dedicated state-level funding is needed to accelerate the transition. Institutional arrangements and mandate for the implementation of sectoral plans need to be defined.

INTRODUCTION

Building strong public support for the hard decisions to move away from car-centric infrastructure development is critical to change the politics and to build support for difficult solutions in this hard-to-abate sector.

1

OVERVIEW OF INDIA'S TRANSPORT-SECTOR EMISSIONS

OVERVIEW OF INDIA'S TRANSPORT-SECTOR EMISSIONS

India's Long-Term Low-Carbon Emission Development Strategy (LT-LEDS) was submitted to the United Nations Framework Convention on Climate Change in the 27th Conference of Parties in Sharm el-Sheikh in Egypt.[1] It has taken transport on board and indicated ongoing action and plans for the future.

While emphasising integrated, efficient and inclusive low-carbon transport systems, the document highlights current policies and programmes that are expected to contribute towards its attainment. It aims to develop an integrated, efficient, inclusive low-carbon transport system. It states that transport contributes about 10 per cent of the GDP directly and indirectly. As per Ministry of Environment and Forests and Climate Change (MOEFCC) estimates, the transport sector contributes about 12.1 per cent of India's energy-related CO_2 emissions and 9.7 per cent of the country's total greenhouse gas emissions. This share is lower than the emissions from the industry and energy sectors. But rapid increase in transportation demand can skew this curve in the coming decades as the industry and energy sectors begin to stabilise and improve their emissions.

LT-LEDS states that the emissions from the road transportation sector are fossil-fuel driven, and the road-transport sector accounts for about 87 per cent of passenger traffic and 60 per cent of freight-traffic movement. Sales of internal combustion engine vehicles have more than doubled the fuel consumption and related GHG emissions from the transport sector. During 2000–19, the two-wheeler and car segments, driven by rapid urbanization, have grown at a CAGR of ~10 per cent. This trend is expected to continue as urban population is projected to increase from about 370 million in 2011 to 600 million by 2030.

The document has asked for significant expansion of low-carbon options across transportation modes for passenger and freight mobility. This includes improved fuel efficiency, phased transition to cleaner fuels, modal shift towards public and less polluting modes of transport, electrification across multiple

modes, demand-side management, and traffic management and intelligent transport systems. It has highlighted current policies and targets that include leapfrogging directly to Bharat Stage VI emissions from Bharat Stage IV levels; vehicle scrappage policy; comprehensive package for electric vehicles, including domestic manufacturing in auto parts and batteries, investments in charging infrastructure and demand aggregation; and making Indian Railways net-zero by 2030 to cut 60 million tonne of CO_2.

It has highlighted the key elements of a long-term low-carbon growth strategy. This includes reducing fuel demand and GHG emissions through improved fuel efficiency through raised standards, optimised networks, improved technologies and fleet modernisation; phased adoption of cleaner fuels, including hydrogen; modal shift towards public and less polluting modes of transport to integrate transport with urban planning; multi-modal connectivity; enhanced railway capacity; electrification across multiple modes supported by programmes, policies and measures for domestic manufacturing of electric vehicles and batteries; and electrification of railways.

According to this strategy, addressing both passenger and freight transport will be important. The road freight sector will see the National Master Plan for Multi-modal Connectivity—PM Gati Shakti; integrated and optimised freight networks through programmes such as Gati Shakti, transit-oriented development, Bharatmala, Sagarmala, and dedicated rail freight corridors. The National Logistic Policy aspires to reduce cost of logistics in India to be comparable to global benchmarks by 2030.

It lays out the regulatory framework for including current policies and targets that include the National Urban Policy Framework, the Town and Country Planning Act and state planning regulations, local area plans, sustainable public transport including sustainable mobility through the National Mission on Electric Mobility and Battery Storage, National Mission on Sustainable Habitat and Atal Mission for Rejuvenation and Urban Transformation (AMRUT).

OVERVIEW OF INDIA'S TRANSPORT-SECTOR EMISSIONS

India's long-term carbon-development strategy has laid out the key elements of the long-term pathways for all modes of transportation—urban as well long-range transport for passenger and freight (see *Box: India's long-term carbon-development strategy: Proposed elements for transportation sector*). Even though the roadmap has included all the right strategies and policies to decarbonise transport and induce modal shift, the bigger question is related to the impediments holding back upscaled transition.

This transformation will have to be enabled. The long-term pathway document underscores that the transition to a low-carbon development pathway will entail costs due to the deployment of new technologies, development of new infrastructure and other transaction costs. The overall financial needs for the entire trajectory will be in the range of trillions of dollars by 2050. This requires a well-defined roadmap for each sub-sector and a domestic fiscal strategy that will restructure the current funding programmes according to the sustainable mobility principles and identify the gaps for supportive international finance. This will have to be attained as the country grows and urbanizes.

India mirrors the challenges and opportunities of the developing world and can provide the template for transformative change.

This is challenging as road transport has remained the dominant source of emissions. According to the Third Biennial Update Report to the United Nations Framework Convention on Climate Change (UNFCCC) by the Ministry of Environment, Forest and Climate Change (MoEFCC) in 2021, among the transport sub-sectors, road transport contributes approximately 90 per cent of all transport emissions in India, followed by civil aviation (6 per cent), railways (3 per cent) and domestic water-borne navigation (1 per cent).[2] This requires ambitious targets and early interventions to reduce road-sector emissions and prevent escalation from the hard-to-abate aviation sector.

INDIA'S LONG-TERM CARBON DEVELOPMENT STRATEGY: PROPOSED ELEMENTS FOR TRANSPORTATION SECTOR

Induce mode shift: This includes crafting of appropriate policies to induce a modal shift and expanding the use of less polluting modes with the order of preference to rail over road over airways. It also included avoiding higher per-capita emissions by encouraging public transport, and leveraging portfolio of urban transport policies and schemes, including the National Urban Transport Policy 2006, Smart Cities Mission, Atal Mission for Rejuvenation and Urban Transformation (AMRUT), Green Urban Mobility Scheme (GUTS), and National Transit Oriented Development Policy.

Vehicle fleet electrification: Strategies include the Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME India) scheme (Stage I and II) and the National Mission on Transformative Mobility and Battery Storage, Production Linked Incentive (PLI) scheme for Advanced Chemistry Cell (ACC) Battery Storage and advanced automotive technology and Draft National Energy Storage Mission. IT also includes publication of the revised consolidated guidelines and standards for charging infrastructure, 2022. Implementation of vehicle-grid integration options, increasing decarbonisation of the grid and establishment of off-grid renewable hybrid charging/swapping stations for batteries, policies related to the management of EV-related waste, circular economy principles for the EV sector and re-skilling the workforce for manufacture and operation of new technologies and related infrastructure are also included.

Improving fuel efficiency fuel efficiency regulation to reduce oil import costs and enhance energy security.

Green hydrogen as a long-term alternative: This will be contingent on the availability of low-cost finance. It includes green hydrogen to fuel maritime transport with connectivity between ports and hydrogen-producing facilities.

Electrification across multiple modes: By 2050, both the rail and road transport will be encouraged to achieve high rates of electrification. Electrification of railways will be over 80 per cent of the broad gauge network already electrified till March 2022. Electric transportation will also become less carbon-intensive in the medium and long term.

Alternate fuels for surface transportation programme: This includes usage of ethanol, compressed natural gas (CNG), biodiesel and liquefied natural gas (LNG) as short-term fuel alternatives and exemption of electric, ethanol and methanol vehicles from requiring permits to carry passengers/ goods.

Induce mode shift to railways: The National Rail Plan 2030 targets increase modal share of the railways in freight to 45 per cent. Indian Railways plans to become net-zero by 2030, leading to 60 million tonne of annual mitigation of CO_2, a 100 per cent electrified broad-gauge network, and transition to head-on generation. The Gati Shakti National Master Plan provides for a GIS-based digital platform to bring together 25 Central ministries and/or departments and all states and Union territories for integrated planning and coordinated implementation of infrastructure projects. Dedicated freight corridors are planned by the railways. National High-Speed Rail Corporation Ltd. to finance, construct and maintain high speed rail corridors are to

OVERVIEW OF INDIA'S TRANSPORT-SECTOR EMISSIONS

be set up. The National Logistics Policy is to provide for adoption of efficient, economical and environmentally sustainable modal mix. The Sagarmala Programme will enhance the performance of country's logistics sector and target port modernisation, port connectivity, port-led industrialisation and coastal community development.

Aviation: Civil aviation constituted 6 per cent of the total transport emissions in India in 2016. Currently, the options for low (or zero) carbon airplanes are extremely limited. They include radical new aircraft designs (e.g., the "blended wing" concept) that could improve fuel efficiency by 25 per cent compared to the most efficient planes today. But flexible usage of airspace, single engine taxing, continuous descent approach, airport carbon accreditation programmes in the aviation sector, carbon offsetting and reduction scheme in INTERNATIONAL AVIATION are some of the solutions.

Green ports initiative and shipping: This includes green shipping and IT-enabled management of ports in the maritime sector.

As seen in the global context, there is a need for a roadmap for a massive shift to low-emitting modes of transport, including public transport, walking and cycling, along with electrification of nearly all transportation modes and restructuring of long-range transport to align with 1.5°C pathway. This will require more active policies that include regulations, standards, public infrastructure and taxes and subsidies to accelerate the big transition.

This makes it necessary to understand what it takes to build solutions at scale and with speed. Over the last decade, several policies have evolved, addressing both urban and non-urban long-range transportation, which can have a bearing on the transport-sector trajectory. But, as noted, globally the strategies are not yet scalable to build ambition for the transition to net-zero.

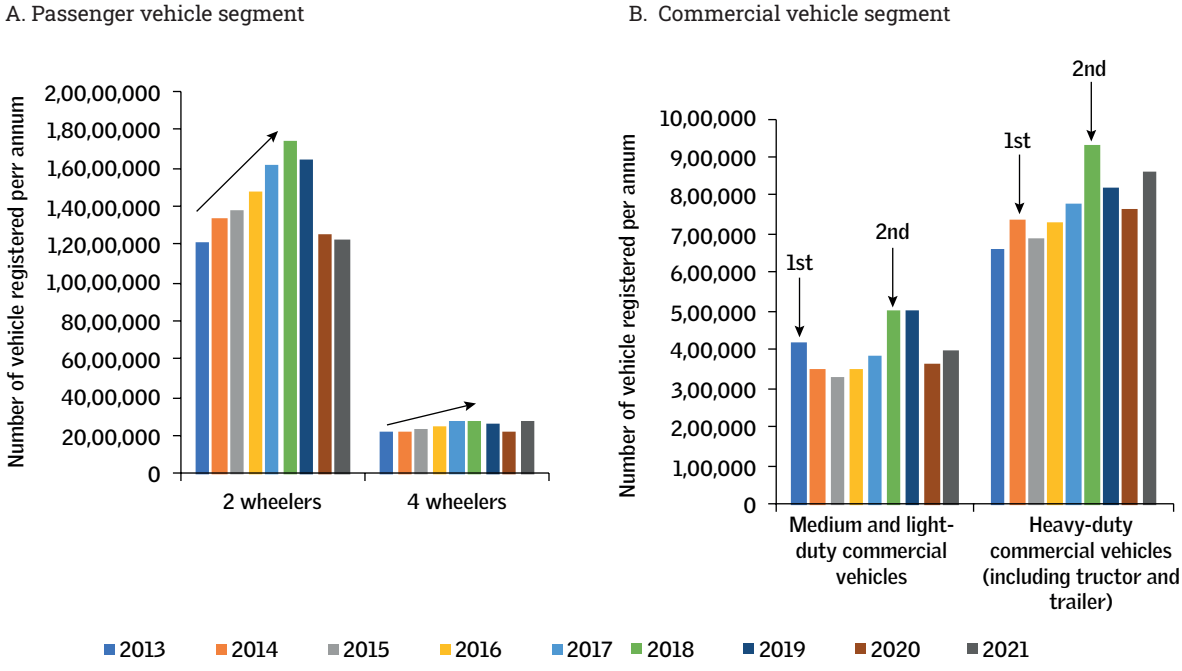
This report therefore outlines the challenges and opportunities in each sub-sector of transport, including road transport and urban commuting and long-range transport of roadways, railways and aviation for freight and passenger transport. This considers the imperatives of clean, zero emissions and fuel-efficient vehicle technologies and transportation and urban mobility strategies for the big solutions.

EXPLOSIVE MOTORISATION

Clean and low-carbon transportation strategies need to take shape against the backdrop of the rapid and explosive motorisation. In the past decade (2011–21), the number of registered motor vehicles in India has doubled from 1.4 to 2.8 billion in 2021.[3] In 2013–18, the annual registration of both two- and four-wheeler segments has increased by 44 per cent and 26 per cent respectively by hitting new records for five consecutive years. Commercial vehicles are also growing steadily though the growth curve is more cyclical in nature—in which every four to five years annual vehicle sales are reaching a new high (see *Graph 14: Annual growth of different vehicle segment*).

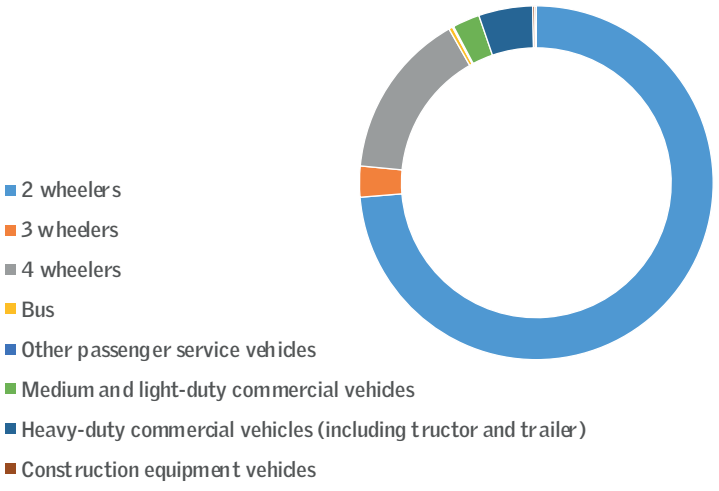
IEA's *India Energy Outlook 2021* report states that a total of 300 million vehicles of all types will be added to India's fleet between now and 2040.[4] This has been largely induced by massive growth in personal vehicle ownership, both two- and four-wheelers

Graph 14: Annual growth of different vehicle segments



Source: VAHAN dashboard

Graph 15: Registered vehicle composition in India (in July 2022)



Source: VAHAN dashboard

that are almost 89 per cent of total vehicle stock (see *Graph 15: Registered vehicle composition in India*). But typically, the fleet is dominated by two-wheelers. With smaller engines the carbon footprint of individual units is small but as they are numerous their impact on pollution and emissions is substantial. Growing dependence on these vehicles for mobility also undermines expansion and usage of public transport.

Steady shift towards bigger engines: In the passenger four-wheeler segment, India is losing the small-car advantage as the SUV population is growing rapidly. Bigger engines lock in massive energy and carbon. It has grown nearly six times during 2010–21, from 0.2 million units to 1.3 million units. These vehicles with bigger engines are energy guzzlers.

IEA has cautioned that while advances in vehicle technology improved the rate of fuel consumption of all new vehicles during 2010–19, a large share of these fuel savings are offset by increased vehicle weight and power. The share of technical improvements that have been nullified by greater vehicle size and power range from 40 per cent in USA, China and Europe to 17 per cent in India.

Therefore, future growth in vehicle characteristics should be kept in mind in the planning stage so that stringent norms and tax measures act as disincentives.

The rise of SUV sales in India is consistent with the global trend. As per IEA estimates of 2019, even globally, nearly half of all cars sold in the US in 2018 were SUVs, and worldwide the share of new SUVs has doubled compared to a decade ago.

ENERGY IMPACTS OF TRANSPORT IN INDIA

As road transport is the dominant mode for transport and mobility, its share in energy consumption is also higher than other modes. Diesel and gasoline are the primary fuel for transportation in India. These fuels together meet almost 91 per cent of the total energy used by transport modes. In recent years, both the Centre and states have taken various steps to diversify the energy mix in transport, including CNG, bio-fuel and electricity.

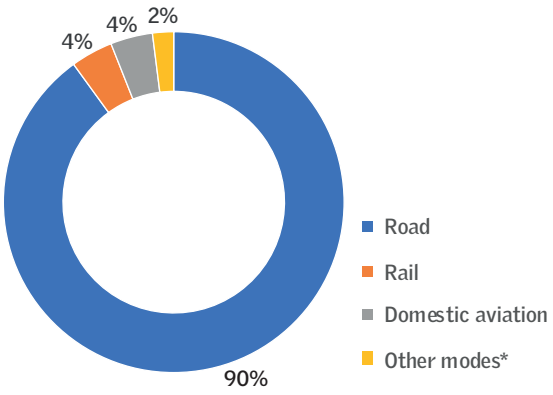
IEA's stated policy scenario, however, projects a doubling of the demand for oil for road transport by 2040, largely due to addition of 170 million passenger cars and 25 million trucks to the vehicle stock during 2019–40[5] (see *Graph 16: Energy consumption for transport by mode and fuel [2017]* and *Graph 17: India—Final energy use of transport by sub-sector and road transport by fuel in the stated policies scenario [2010–40]*).

IEA's *India Energy Outlook 2021* states that against the backdrop of the total of 300 million vehicles being added to India's fleet between now and 2040,[6] the demand for oil is expected to increase by almost 4 million barrels per day (mbd) to reach 8.7 mbd in 2040, the largest increase for any country. Over half of the growth will be fuelled by diesel-based freight transport. An additional 25 million trucks are expected to be on India's roads by 2040 as road freight activity triples. If a combined strategy of fuel efficiency, electrification of vehicle fleet, and fuel switching is implemented, the growth in oil demand can be limited to less

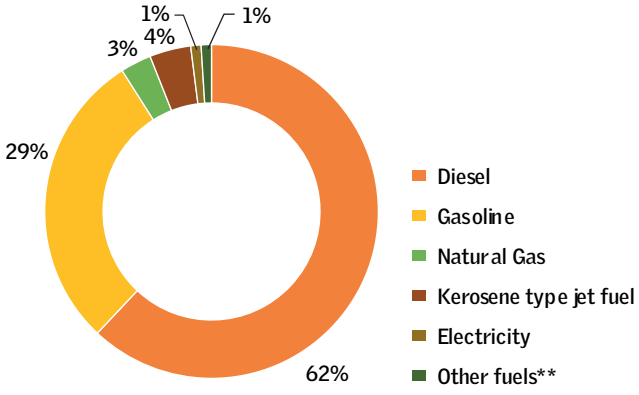
OVERVIEW OF INDIA'S TRANSPORT-SECTOR EMISSIONS

Graph 16: Energy consumption for transport by mode and fuel (2017)

A. Energy consumption for transport by modes



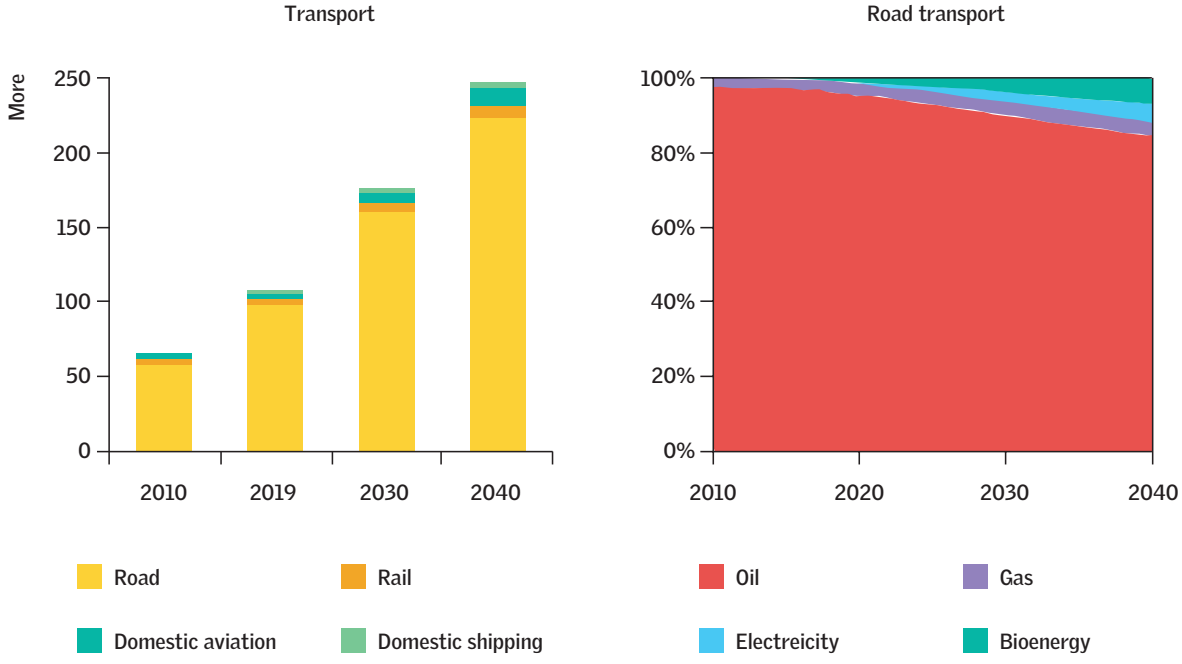
B. Energy consumption for transport by fuel



*Other modes of transport include domestic navigation and gas pipeline transport
**Other fuels include biofuels (bio-gasoline and biodiesel), fuel oil and liquefied petroleum gases

Source: IEA

Graph 17: India—Final energy use of transport by sub-sector and road transport by fuel in the stated policies scenario (2010–40)



Source: IEA 2021, Air Quality and Climate Policy Integration in India

than 1 mbd.[7] Improvement in fuel efficiency is central to this priority package to tame energy guzzling.

The energy demand for road transport is projected to more than double over the next two decades, based on today's policy settings.[8] India is set for a huge expansion in transportation infrastructure—from highways, railways and metro lines to airports and ports.[9]

MOBILITY AND DEMAND FOR TRANSPORTATION IN INDIA

Transport-sector emissions and carbon intensity is directly linked with travel and commuting patterns. With its growing economy, India has rapidly expanded its highways, railways, metros, airports and ports over the past three decades to support the ever-increasing demand of moving people and goods. These have led to fivefold increase in both energy use and emission from transport over the last three decades.[10] Indian cities are growing bigger—according to the United Nations, India will add around 200 million urban population by 2035.[11]

A study carried out by the United Nations Environment Programme (UNEP) in 2015 observed a strong positive correlation between per capita mobility and income level in Indian cities.[12] With cities becoming bigger and stronger in terms of size and economy, trip lengths and trip rates are also increasing, resulting in much higher demand for transport. The same study reported increase in India's passenger transport demand from 289 to 6,966 billion passenger kilometre (billion pkm) between 1970 and 2010,[13] with a compound annual growth rate (CAGR) of 8.28 per cent per annum, which was faster than the economic growth of that period. This demand is not going to settle soon; instead, it is expected to increase to 31,872 billion pkm by 2050, which is almost 4.6 times higher than the 2010 level.[14]

The International Transport Forum (ITF) Transport Outlook 2021 on India shows that passenger transport activity in India

more than tripled in 2000–20, reaching over 6 trillion passenger kilometres (pkm) despite the impact of Covid-19 pandemic in 2020. Passenger cars, however, accounted for below 20 per cent of all passenger transport activity in 2020.[15] But levels of car ownership have almost doubled in the past ten years. In 2020, buses accounted for roughly 20 per cent of all pkm. Formal city bus systems are limited to a few large Indian cities but these are losing ridership and revenue. The pandemic has further worsened this.[16] Census 2011 shows that walking and cycling formed 45 per cent of all work trips in India.

A 2015 UNEP study for India warned that the passenger kilometre for the country is expected to more than triple by 2050.[17] Trip length and rate that have huge bearing on emissions, and will also increase as city size and income increase. Without adequate public and paratransit, private transport will overtake public transport mode share by 2040.

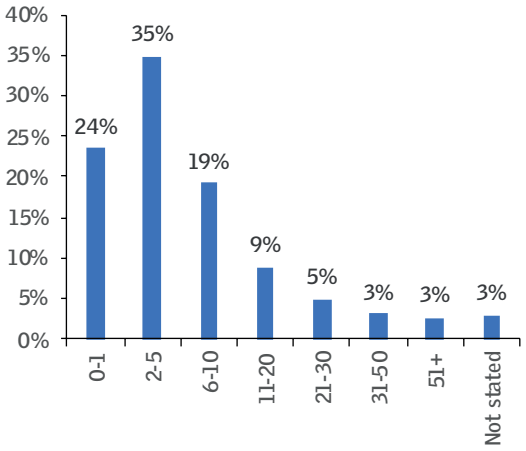
Yet India, like the other developing countries, has a better opportunity in high density and mixed-use urban forms.

Freight and long-range transport: This battle cannot be fought without addressing emissions from freight, non-road transport, railways, aviation and marine sources. The ITF 2021 estimates shows that big trucks that are energy guzzlers and high emitters hog over 80 per cent of total road freight traffic.

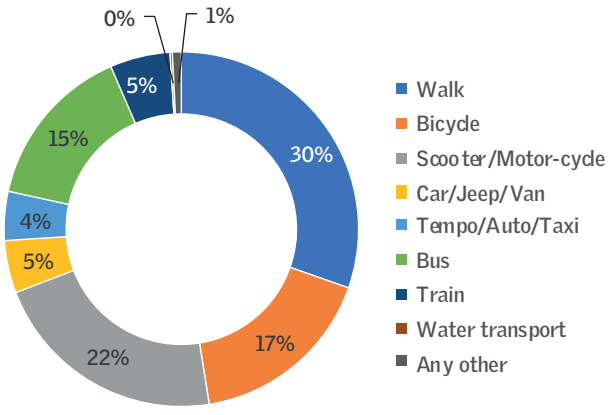
The share of rail-based freight is lower than that of road-based freight. Maritime trade as total international maritime transport activity to and from India is 2.5–3 trillion tonne-kilometre (tkm) per year (2015–20). This exceeds the volume of inland transport activity, which is around 2 trillion tkm for this period.[18] The aviation sector has also started to grow. Global experience shows that as emissions from road transport begin to decline, aviation and marine begin to overwhelm.

Graph 18: Mobility pattern in India (urban working population)

A. Trip length for work trip in urban India



B. Mode share for work trips in urban India

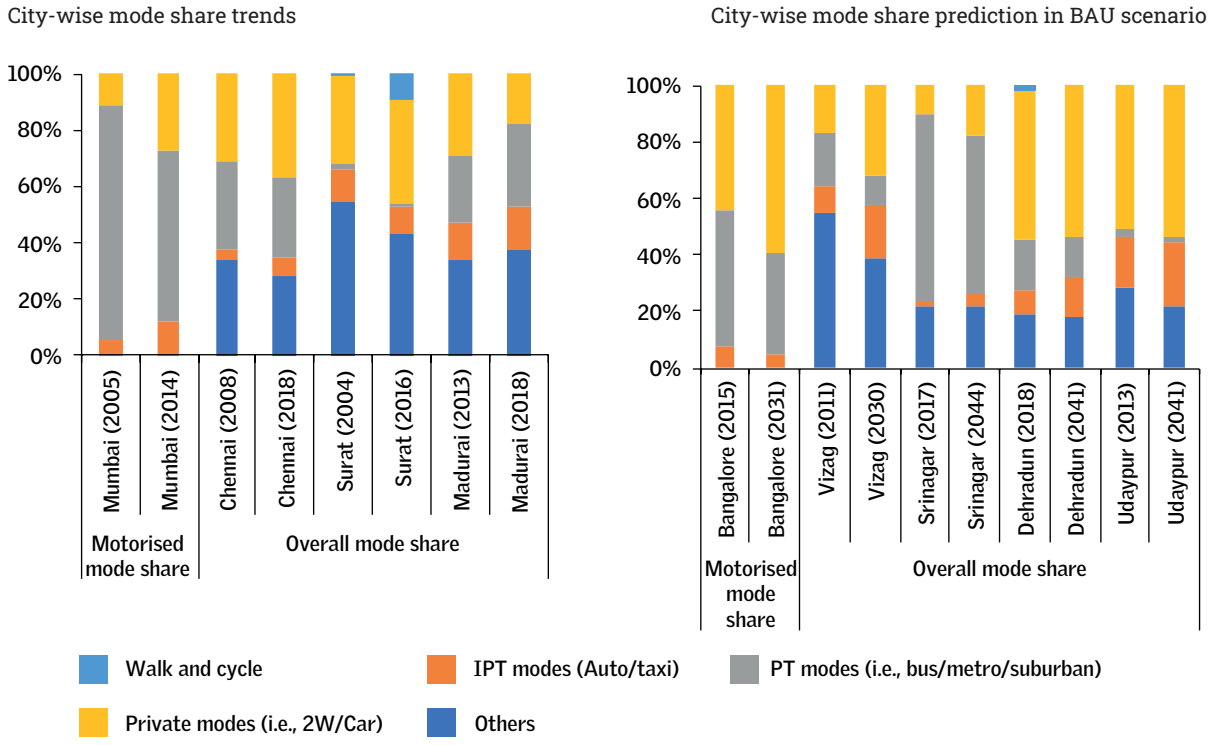


Source: Census 2011

Modal share—majority walk, cycle and use public transport: Despite rapid motorisation, the majority of Indians still walk, cycle or use public transport. Census 2011 (the most elaborate document available till date to represent national-level statistics) shows that almost 58 per cent work-related trips in urban India have average travel distances of 5 km for their work. Almost 71 per cent of the work trips are by walking, cycling, intermediate public transport (auto, taxi and public transport modes), bus, train etc. (see *Graph 18: Mobility pattern in India (urban working population*).

Currently, there is no established official practice in India to carry out regular assessment of modal share, trip length and distances, which have strong bearing on emissions and are also critical inputs for transport planning. Such information is available from one-time city mobility plans, which were carried out largely in 2010–18 in various Indian cities. But not all cities have prepared their mobility plans. Also, most of these plans were prepared during the early part of the last decade and therefore do not have updated information. Very few cities have prepared updated plans to indicate the change over time.

Graph 19: Mode share in urban India



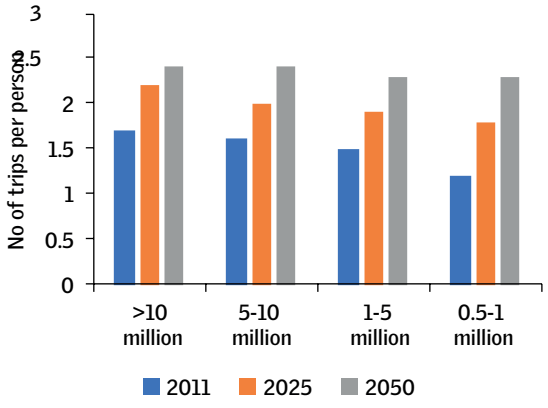
Source: CMP and other transportation studies of respective cities

As these are the only comprehensive documents that provide an indicative baseline for the cities, the Centre for Science and Environment carried out an analysis of these reports, especially of cities that have two subsequent plans during the decade. The analysis indicates the changing trend. It shows increasing modal share of private vehicles and declining share of sustainable modes. Furthermore, comparing a city's mode share of the base year with the business-as-usual scenario reflects similar trends (see *Graph 19: Mode share in India*).

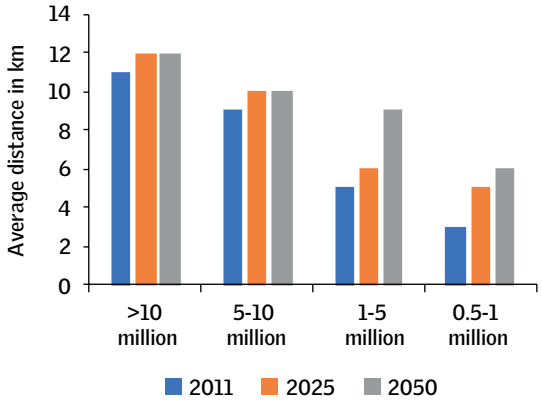
Increasing trip distances: As cities grow bigger—both in terms of economy and scale—and sprawl, mobility pattern also change rapidly. Increase in trip rate and trip length create additional strain on the city's mobility systems. As per the UNEP 2015 study, both trip rate and length are expected to increase irrespective of the city sizes[19] (see *Graph 20: Projected trip rate and trip length in Indian cities*).

Graph 20: Projected trip rate and trip length in Indian cities

A. Projected trip rate in Indian cities



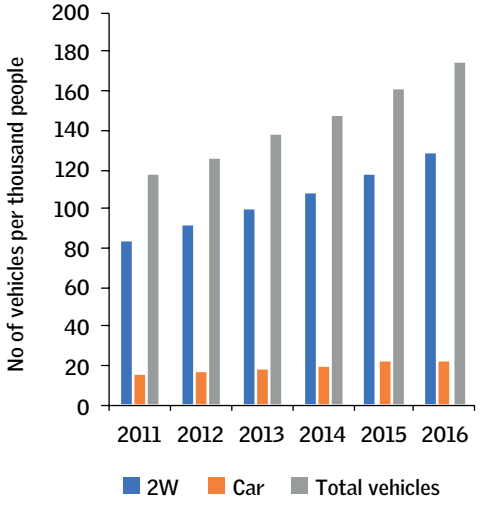
B. Projected trip length in Indian cities



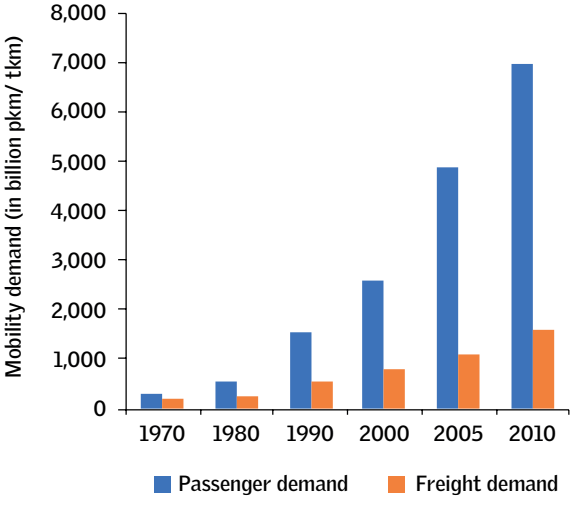
Source: UNEP

Graph 21: Growing demand for mobility and private transportation

A. Growing private vehicle ownership in India



B. Growing mobility demand in India



Source: Road Transport year book and UNEP report

Increased number of trips and long-distance trips without adequate public transport systems is fuelling demand for private modes. As a result, in 2011–16, two-wheeler and car numbers increased from 84 to 128 and 16 to 23 vehicles per thousand people, respectively (see *Graph 21: Growing demand for mobility and private transportation).*

OVERVIEW OF INDIA'S TRANSPORT-SECTOR EMISSIONS

As of now, high usage of public transport, walking and cycling and low vehicle ownership are a reflection of low income levels. In fact, a large part of the urban majority cannot even afford public transport. Also, the traditional compact and accessible city forms have helped to keep travel distances short in most cities and towns of India.

This baseline may get seriously jeopardised if active policies are not pursued to build and modernise public transport, expand walking and cycling infrastructure and pursue transit-oriented development in cities with multi-modal systems, along with vehicle-restraint measures to limit automobile dependence. There is considerable lag and latency in the underdeveloped infrastructure and systems for transportation that make progress slow.

The mobility strategy will have to be strongly combined with transformative improvement in vehicle technology, fuel economy regulations and ambitious electrification of fleet to reduce carbon emissions. Along with urban transportation systems, urgent action is needed to reduce as well as clean up road-based freight transport while actively pursuing policy to expand railways for both freight and passenger traffic.

This requires deeper analysis and stocktaking of each of these strategies to identify the roadmap and enabling mechanism.

2

VEHICLE TECHNOLOGY PATHWAYS

VEHICLE TECHNOLOGY PATHWAYS

Future motorisation will have to be linked with clean, efficient and zero-emissions technologies to meet the ambitious net zero and global temperature stabilisation goal.

India has leapfrogged directly from Bharat Stage IV (BS-IV) emissions standards to Bharat Stage VI (BSVI) emissions standards to reduce the toxic emissions and protect public health. This has led to substantial improvement in emissions-control systems, especially in diesel vehicles. As a next step, from 2023 onwards India will implement the real-world driving emissions regulations to bridge the gap between the certified emissions levels and real-world emissions performance on the road.

While India is now gearing up for both real-world driving emissions regulations and in-service compliance regulations as well as the next revision of the emissions standards to implement BSVII emissions standards most likely during 2027–28, equally strong focus is needed to tighten the fuel economy regulations for all segments of vehicles with internal combustion engines to reduce the energy and carbon impacts of motorisation.

Simultaneously, India requires ambitious targets for fleet electrification to accelerate zero tailpipe emissions.

India, among the major vehicle-producing countries in the world, has demonstrated the leapfrog principle that needs to define the developing country trajectory. It has narrowed the lag in emission standards in three years to align with Europe and is also accelerating the process to meet the BSVII standards within a shorter timeframe. But this strategy has to be more comprehensive so tightening the emission standards will also maximise fuel efficiency gains. This will require equally strident and stringent fuel economy norms to reduce the energy and carbon impacts of motorisation and also create conditions for rapid electrification.

FUEL ECONOMY STANDARDS TO REDUCE ENERGY AND CARBON IMPACTS

Fuel-efficiency standards for vehicles directly influence mileage and carbon emissions per litre of fuel burnt per kilometre. This is expected to reduce oil demand and emissions of heat-trapping gases, and protect consumers from rising oil prices, strengthen energy security, and drive electrification of the vehicle fleet.

So far, India has implemented fuel efficiency standards only for passenger cars. The standards for commercial vehicles—light, medium and heavy as well as two-wheelers and three-wheelers—are not in place yet. It is also not yet clear how soon the standards for passenger cars will be tightened for the subsequent stages and the standards for other vehicle segments implemented.

These standards are crafted by the Bureau of Energy Efficiency (BEE) under the Energy Conservation Act, 2001 administered by the Ministry of Power (MoP). The standards are also notified under the Central Motor Vehicles Act, 1988, and its Rules by the Ministry of Road Transport and Highways (MoRTH) for implementation. The process of setting and implementing these standards in India is relatively new.

PASSENGER CARS

The first-ever fuel-efficiency standards for passenger cars in India, termed corporate average fuel consumption standards (CAFCS), were implemented in 2017–18. Stage 2 standards are scheduled for implementation in 2022–23. A gazette notification (of April 23, 2015) outlines these standards. BEE estimates that these standards can lead to a reduction of 22.97 million tonne in fuel consumption by 2025.

To compute the actual fuel consumption of every vehicle model that runs on petrol, diesel and Compressed Natural Gas (CNG), CO_2 emissions in g/km are affirmed through tests during type-approval certification of vehicles. The actual fuel consumption of electric models is also measured in terms of kWh per 100 km.

Thereafter, the respective "petrol equivalent fuel consumption values" of a particular vehicle model is calculated for diesel, liquefied petroleum gas (LPG), CNG and electric vehicles based on the conversion factors notified in the regulations. Thus, actual fuel consumption of vehicles is derived from CO_2 emissions (g/km) tested at the time of vehicle certification.[1]

The design and implementation of these standards are very different from the BS-VI mass emissions standards for toxic emissions which have been implemented as a "per vehicle standard", meaning that they require all models of vehicles to pass the certification test to meet the assigned values for pollutants to be sold in the market. Certification based on this testing by a vehicle-testing agency such as the Automotive Research of India (ARAI) is the basis of compliance and sale in the market.

The CAFCS for cars is set in terms of petrol-equivalent litre per 100 km, based on the weight of the vehicle model. Weight influences fuel consumption of vehicles—small cars use less fuel than bigger cars and SUVs. However, compliance with the standard is worked out differently. Compliance is not based on per vehicle measurement at the time of certification. Compliance is monitored at the corporate fleet-level. This means for each manufacturer, the average fuel consumption (in terms of petrol equivalent litre per 100 km) is computed and weighted against the sales of each make and model during the fiscal year.

The compliance is assessed annually for each car-maker based on the sale of each and every make and model and certified CO_2 emissions value provided by a vehicle certification agency such as Automotive Research Association of India (ARAI) and the average emissions levels are weighted against sales. Then weighted average of the sales of all manufacturers are taken together to compute industry-wide compliance. At the end of each year, the status of industry-wide compliance is established and reported. It is calculated based on a formula given in the

notification that requires specific parameters like CO_2 per fuel efficiency-level and kerb weight of the vehicle (weight of the vehicle that takes into account the weight of all the standard equipment fitted on the vehicle and consumable items while measuring the weight of the vehicle).

This compliance mechanism is based on self-reported data on certified emissions levels and sales data of each model and make of vehicles for the fiscal year that is submitted by all manufacturers every year to MoRTH. Therefore, transparency and accountability in the reporting systems is critical for effective implementation. This will have to be ensured in future.

Different manufacturers produce widely different cars—a mix of small and big, petrol, diesel, CNG and electric cars—and individual fleet-wide targets vary accordingly (that is represented in a mathematical slope that has been notified as a regulation). But irrespective of this variation, the industry-wide collective average has to stay within the regulatory limit.

An assessment of Stage 1 standards of 2017–18 shows that all car companies have not just met but exceeded the lax requirement of fuel efficiency. According to an evaluation by IEA, the average fuel consumption of new light-duty vehicles sold in 2018 was roughly 9 per cent above the target for that year. Thus, the industry has comfortably achieved its target. Moreover, at the current level of fleet-wide fuel efficiency or CO_2 emissions intensity, only a small improvement is needed to meet the Stage 2 standard in 2022–23, especially after the weight adjustment.

As mentioned, CAFC standards are intimately linked to the average weight of cars. For instance, the Stage 1 standard of 5.49 litre per 100 km or 129.8 CO_2 g/ km was linked with the average car weight of 1,037 kg. The Stage 2 standard limit, applicable from 2022, is 4.77 litre per 100 km, and linked with an average vehicle weight of 1,145 kg or 113 CO2 g/km.[2, 3] Already, by adjusting and lowering the average weight of cars, meeting the Stage

2 standards has become easier. The original notification had pegged the standard to average kerb weight of 1,145 kg for the Stage 2 target of 2022–23, and it was stated that the next stage can adopt either this or a lower weight as per the market trend at the time of adoption. With a reduction in the share of diesel vehicles in the fleet, the overall average weight of vehicles in India has decreased to below 1,100 kg. Accordingly, BEE has proposed to change the weight for Stage 2 standards to 1,087 kg to meet the same target.

Lowering of the weight to this extent does not change the norm value much but makes it somewhat easier for the industry to meet the standard. After this adjustment, the original target of 113 CO_2 g/km or 4.77 litre per 100 km remains unchanged. Thus, the industry has no additional ground to delay implementation of the 2022–23 CAFC standards.

Another recent International Council on Clean Transportation (ICCT) analysis shows fleet average CO_2 emissions for passenger cars in India for 2020–21 was 121.3 g/km. So with the same average weight going forward, the compliance target for FY 2022–23 will be 113.1 g/km. To bridge the gap of 6.8 per cent from 121.3 to 113.1 g/km in two years, the industry needs to reduce fuel consumption by approximately 3.5 per each year. ICCT points out that the actual real-world decrease can be much lower considering that manufacturers are likely to expand their use of super credits and flexibility mechanisms, which implies that targets are not very ambitious in the first place.[4]

Yet another approach of CAFC standards is the practice of allowing extra credit points to compute compliance with the standards. This is consistent with global practices to encourage innovation to go beyond the minimum requirements of the standards. These extra points incentivise the industry to adopt improved technologies and zero-emissions electric cars to go beyond the common minimum standards and push the innovation trajectory. This approach has been adopted because

there are several parameters of vehicles like weight and aerodynamics, and other innovative technological approaches that cannot be considered while testing emissions from the vehicles but these influence fuel efficiency and their adoption vary across the industry. To encourage eco-innovation, the CAFC regulations allow extra credit points to be earned by the car manufacturers for their annual calculation of compliance.

Currently, the CAFC standard has provided for super-credits for predefined technologies, which include battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs), and strong hybrid electric vehicles (HEVs), as well as for regenerative braking, start–stop systems, tyre pressure monitoring systems, and six-speed or more transmissions. If these credits are linked with high-end solutions, technology can improve faster, but if they are linked with small incremental technology approaches, it can be a wasted effort.

India has not only set unambitious targets that the industry can meet easily, but it has further weakened the targets by giving away super-credits or extra points for ineffectual technological approaches like six-speed transmission that normally all big and luxury cars use or tyre pressure monitoring that depends on a driver's behaviour. The biggest giveaway initially was the mild diesel hybrids that resulted in only nominal improvement; these were removed subsequently from the eligibility list. But weaker targets and super-credits for ineffectual technological approaches have impeded movement towards more substantial technology transformation like electrification.

This is a missed opportunity as global experience has shown that a well-designed super-credit system combined with stringent fuel efficiency norms can help speed up technology transformation and electrification of the fleet. This is the experience in Europe. Despite having heavier vehicles—compared to low-powered smaller cars of India—Europe has set CO_2 standards at 95 CO_2 g/km in 2020–21 as against 113 CO_2 g/km in India. The average

weight of the car fleet in Europe is about 1,400 kg—higher than in India. Even with heavier cars, Europe has set a target that is 20 per cent tighter than that of India. This has accelerated electrification of the fleet—an important decarbonisation strategy—in Europe, despite the pandemic-led economic downturn. Europe is pushing for aggressive targets—at present (2020–24) it is at 95 gCO_2/km, and the standards will be tightened to 80 CO_2/km by 2025, and 33 CO_2/km in 2030, and zero CO_2/km target is proposed to be implemented from 2035 as the EU is expected to phase out ICE light-duty vehicles.

India's current standards cannot drive electrification of the fleet: These standards can be met with the normal incremental effort of the industry to improve ICE vehicles. On the other hand, even the electrification of a small percentage of the fleet can help meet the standards, removing the incentive for any improvements in ICE fuel efficiency. This has been borne out by an International Council on Clean Transportation (ICCT) study which estimated that with only 1–2 per cent electrification of the fleet, major carmakers like Maruti and Tata can meet Stage 2 targets without any significant changes in the ICE technology. But tighter targets would have required higher levels of electrification.

While staying on track to meet Stage 2 standards, the process of tightening the next targets for 2026 and 2030 should be put in place and decided this year for notification to give a longer-term space to the industry. The targets need to be ambitious and a strategy to leverage them for electrification needs to be in place. Super-credits should be phased out after 2023, testing methods for certification should be improved to reduce the gap between lab-based emissions and on-road emissions and related fuel efficiency performance to ensure real world performance. The industry is also hoping to work out a carbon credit scheme but its design and valuation is critical for it to be effective.

Another lesson to be considered is that while tightening the norms, the testing method for vehicle certification in the

laboratory will also have to be made more stringent for delivery of real-world fuel efficiency performance. One of the most critical parameters is the driving cycle (that simulates on-road driving conditions through a cycle of acceleration, deceleration and idling) that is used for measuring emissions in the laboratory. The current cycle used in India is not as exacting. As the global good practice indicates, India needs to adopt the Worldwide Harmonized Light Vehicle Test Procedure (WLTP) based on the new driving cycles (Worldwide Harmonized Light-duty Vehicles Test Cycles or WLTC) as the standard laboratory test to measure fuel consumption and CO_2 emissions intensity of passenger cars. While this proposal is already on the anvil, it needs to be adopted not later than April 2023 when more reforms are expected to be rolled out on fuel economy as well as BS-VI standards.

Only a more rigorous test cycle for certification can help lower the gap between certified level of emissions and real-world performance. As India moves towards tighter fuel efficiency norms and electrification and labelling of cars, consumer demand for bridging this gap will become much stronger. Consumers will become more sensitive to on-road emissions and fuel efficiency performance of internal combustion engines as well as the range of driving per electricity charge for electric vehicles. It may be recalled that recently, the Delhi government had to delist and debar a popular e-car model Nexon from getting incentives under the electric vehicle programme because consumers had complained that they were not getting the range promised by the manufacturer (based on certified data). Both fuel efficiency regulations and electric vehicles programme need to mandate use of the WLTC cycle to address this concern over real-world performance.

HEAVY-DUTY VEHICLES

Even though India took the initiative to craft fuel consumption standards for heavy-duty vehicles in 2016–17, their implementation has been unclear. India first passed fuel consumption standards for diesel vehicles ≥ 12 tonne in 2017 in

two phases, with Phase 1 going into effect in April 1, 2018 and Phase 2 going into effect in April 1, 2021. In 2019, a notification amended the standards to include fuel consumption standards for diesel vehicles ≥ 3.5 tonne, starting in April 2020. In September 2020, months before Phase 2 standards were supposed to go into effect, the government removed Phase 2 standards altogether and extended the compliance deadline for Phase 1 standards to January 1, 2021. The Ministry of Road Transport and Highways (MoRTH) has issued a new notification in July 2022 with revised timeline for standards. According to this notification, vehicles with gross vehicle weight between "3.5 tonne and 12.0 tonnes" and vehicles with more than 12 tonne are required to meet the constant speed fuel consumption standard from April 2023.[5]

The earlier reason for deferments is industry opposition to the design of the standards. In contrast to the CAFC standards for passenger cars, the standards for heavy-duty vehicles were designed as "per-vehicle standard" in which each vehicle model is tested for certification and does not follow a corporate average level annually. The chassis and engines for heavy-duty vehicles are used for diverse application with a wide variety of body designs. These are often not tested as fully built vehicles.

The vehicle industry opposed this, stating that it does not leave the system flexibility to account for fleet-wide changes possible across the industry with a range of other innovations that also allow for a more diverse product portfolio. The industry wants to adopt more simulation-based models for reporting compliance, which draw upon test results from the certification process.

While it is possible to move towards corporate average standards, Stage 1 standards (that have already been crafted) need to be implemented quickly. The new format and test procedures can be adopted for the next round of revision. But in the interest of energy security and decreasing the carbon impacts, implementation of these standards must not be delayed any further as passenger cars are the biggest guzzlers.

The vehicle industry had demanded flexibility to account for fleet-wide changes possible across the industry with a range of other innovations that also allow for a more diverse product portfolio. Also, in the meantime, the BSVI emissions standards were implemented and the norms required further revision. These norms are now expected to be implemented from January 2022.

TWO-WHEELERS

Two-wheelers with small engines have the smallest energy and carbon footprints among all motorised vehicles. But they are also in need of fuel efficiency standards. Two-wheelers dominate the vehicle fleet and are so numerous that they use up nearly 60 per cent of all the petrol consumed in the country. This cannot be ignored. Traditionally, the two-wheeler fleet was dominated by small, low-powered engines but due to change in consumer choices, the trend is towards bigger engine capacity with more power and torque.

The Bureau of Energy Efficiency (BEE) started the discussion on fuel efficiency standards for two-wheelers. But this process has been discontinued. This needs to be revived as given the sheer numbers and steady ingress of bigger and high-powered vehicles, early interventions are needed to frame the standards within a specific timeline.

NEXT STEPS ON FUEL ECONOMY STANDARDS

For an effective decarbonisation strategy there is an urgent requirement to adopt fuel economy targets for all segments of vehicles and have a system of dynamic revisions of the targets.

Passenger cars: Tighten the standards for the 2026 and 2030 to give a clear direction and time to the industry to improve. Future changes in average kerb weight also need to be anticipated by the new standards. It is quite likely that the average vehicle fleet weight will increase in future as consumer preference is shifting towards SUVs and sedans, especially compact SUVs.

Tighten the testing parameters for vehicle certification: India needs to quickly replace its current driving cycle that is used for testing and measuring emissions from vehicles in the lab for certification. Currently, the Modified Indian Driving Cycle (MIDC), which is a modified version of the European NEDC test cycle, is used for testing cars in India. It is necessary to adopt the WLTP—based on the new WLTC—as a laboratory test to measure fuel consumption and CO_2 emissions from passenger cars, and other pollutant emissions in April 2023. Only a more rigorous test cycle for certification can help lower the gap between certified levels of emissions and real-world performance. As India moves towards tighter fuel efficiency norms and electrification and labelling of cars, consumer demand for bridging this gap will become stronger. Consumers will become more sensitive to on-road performance of IC engines as well as the driving range of electric vehicles.

Super-credits and flexibility mechanisms should be modified to make the industry more innovative: While tightening the requirements of super-credits to incentivise some technologies and electrification, there should also be a plan to phase out inconsequential technical approaches post 2023. Currently, as per assessments carried out by ICCT, manufacturers selling luxury or high-end vehicles, including BMW, Volvo, Mercedes and Jaguar, benefit more from the flexibility mechanisms. ICCT points out that 25.5 per cent of the 2019–20 passenger cars sold in India were equipped with six-speed or more transmissions.[6] It is important that CO_2 credits for this technology are not allowed any more. Giving such credits stymies innovation and new technology adoption. Super-credits should instead be oriented toward electrification.

Mandate public disclosure of super-credit flexibility mechanisms: While the industry has begun using super-credits to establish compliance with the standards, annual reports published by MoRTH on compliance of the industry do not provide detailed information on how technological

approaches have been adopted by different manufactures to earn super-credits. The official report needs to put this out for deeper understanding of the trends in technology adoption and innovation.

Penalty: The Energy Conservation (Amendment) Act, 2022 has introduced penalty for non-compliance. According to this bill, if the manufacturer of a vehicle fails to comply with fuel consumption norms, he shall also be liable to pay an additional penalty per unit of vehicles sold in the corresponding year, as follows:

i. Rs 25,000 per vehicle for non-compliance of norms up to 0.2 litre per 100 km; and

ii. Rs 50,000 per vehicle for non-compliance of norms above 0.2 litres per 100 km.

Carbon trading as an instrument for compliance: As part of the next round of regulations, the Bureau of Energy Efficiency (BEE) is exploring the possibility of developing a carbon credit system for the compliance mechanism. This means those who overachieve their target can trade their CO_2 credits with the laggards to help them meet the target. Even the National Automotive Policy, 2018 has recommended banking and trading of CO_2 credits by vehicle manufacturers.

It was stated that CO_2 credits awarded to a manufacturer for exceeding compliance requirements should be valid for two to three years. This will offer flexibility to manufacturers and avoid penalties for non-compliance. It was also stated that a public information system will be created to provide manufacturers model-level information on emissions and fuel consumption. Additionally, CO_2 credits or debits per manufacturer will be available to facilitate trade of credits between manufacturers.[7]

These measures can work as instruments of compliance if they are designed effectively. Moreover, trading should only be allowed after the standards have been tightened. The mathematics of the trading is important. First of all, actual trading should happen between companies based on real financial transactions and should not be moderated by a nodal agency for industry-wide compliance. The trading needs to happen between individual manufacturers. Market valuation of credit is most critical and the amount of credit purchased and pricing should be transparent. At this stage, the oil equivalent energy, which has been adopted under the Perform, Achieve, Trade (PAT) scheme of the Ministry of Power (MoP), should be taken as the benchmark and the value should not be below this.

Moreover, the trading should happen only in terms of absolute tonne of oil equivalent or tonne of CO_2 emissions and not in terms of g/km of CO_2 emissions. As the trading happens based on lifetime emissions of cars, the km of vehicle models can be hugely variable. For instance, diesel models will travel longer than petrol vehicles. Therefore, the quantum of emissions to be traded by different manufacturers will depend on the fuel mix of their portfolio.

Additionally, future trading must not be allowed. Trading should happen for one fiscal year and the credits should be carried over or banked for multiple years. For instance, the credit for the period 2017–22 should not be made available for compliance in 2021–22. If manufacturers begin to trade for compliance based on past credits, the system will be weakened. Proper rules will have to be fleshed out for credit transfer.

Data disclosure: For compliance reporting, application of super-credits and trading of credits robust data in the public domain is a necessary requirement. Corporate fuel average system cannot work if it is not known how credits are being decided and given; and details of make and models sold, and their emissions status are unavailable. The data has to be transparent.

To achieve transparency, complete disclosure of data to enable a proper assessment is needed. At present, MoRTH publishes the basic summary of corporate average performance and targets along with credits accrued in the form of a simple table mentioning names of the corporate manufacturers. This data matrix also requires a thorough technology assessment of change in the fleet, sales data and technological information of all carmakers needed for assessing compliance. Both annual fuel consumption reports and manufacturers' report with details on eco-innovation and super-credits need to be put out. Doing so will improve transparency and accountability in the system and will also help independent evaluation of compliance. India must follow global best practices in this regard.

Implement heavy-duty vehicles standards: The "per vehicle standards" that have already been developed must be implemented without any further delay. The heavy-duty segment consumes a major share of diesel, and contributes significantly to the transport sector's CO_2 emissions. India has to fast track implementation of the standards even though the industry is insisting on the corporate average fuel efficiency approach. While implementing the "per vehicle" standard now, the option of corporate average standards can be assessed for the next level of revision, which must also be expedited. Fuel economy measurement and rating approaches should be enforced at the earliest. Clearly there has been considerable uncertainty around the implementation of the Stage 1 standards for heavy-duty vehicles, which are major guzzlers of fuel. Their implementation is now expected in January 2022 after a delay of four years.

Assess and finalise alternative method of testing: The Bureau of Energy Efficiency (BEE) claims that the present test procedure for heavy vehicles is expensive and consumes time and energy. So they are proposing to develop a tool that can assess the fuel efficiency of a vehicle without the need for a physical test. The Government of India has created a technical committee and BEE has initiated the development of a computer-based

simulation tool (like the Vehicle Energy Consumption Calculation Tool [VECTO] in the EU) as per Indian conditions. It is claimed that the tool can help reduce the cost and time of forecasting of performance of vehicles. But the tool will have to be reviewed and assessed for efficacy. This segment is complex given the fact that the engine and chassis of heavy-duty vehicles are adapted for diverse applications and vehicle body types.

Frame and implement fuel efficiency standards for two-wheelers: Immediate steps need to be taken to set fuel efficiency standards for this segment. A system and process for setting of standards will have to be put in place for time-bound implementation. Even though these vehicles have the smallest carbon and energy footprints, given their sheer numbers and gradual migration to bigger and more powerful engines, the benefit of lower-powered vehicles on Indian roads may be soon eroded.

Consumer information: So far, there has not been much of a regulatory effort to inform consumers about the choices based on fuel-efficiency performance that is verified and graded. The current voluntary system that the vehicle industry follows in this regard is weak. A strong analysis of global good practices to understand how to improve consumer access to information to make informed choices and push the market towards stronger efficiency benchmark is needed. The role of regulations in taming operational fuel use is not well understood and needs attention. Several car manufacturers have made public mileages in km per litre for their car models. But there is no scientifically established labelling system to provide more structured information to consumers who can then understand the ranking of the models in terms of performance or compare them with peer models to make an informed decision. Consumers largely depend on informal and anecdotal data available from different sources.

Introduce fuel-efficiency labelling programme for vehicles: India needs to introduce a detailed and robust labelling programme for vehicles within a year and mandate that only the sale of cars and

two-wheeler models with labels will be allowed. Any vehicular labelling programme is bound to fail if it is not backed by a rigid framework for enforcement. Regulators must ensure credibility of labels, monitor whether manufacturers are complying with the labelling system for all their cars, and carry out extensive outreach programmes to enable consumers make green choices. The system should be dynamic. Vehicular labelling systems, once implemented, must be allowed sufficient time to seep into behavioural patterns of the consumers. For this, trust must be built for the consumer and this is possible only if consumers are familiar with labels and understand the information that a label provides. A familiar example from India is the Indian Standards Institute (ISI) mark for household appliances.

Introduce a transparent system of consumer information for fuel efficiency: A fuel economy guide could be released in English and other Indian languages. Consumers should get detailed information about emissions, fuel and monetary savings, comparison with peer brands and front runners, etc. This requires common portals to enable consumers to calculate potential cost savings on buying a particular vehicle based on usage and mileage. This would be in addition to the regular fuel efficiency values. The information must have clarity about the gap between certification values and real-world values to prevent confusion. Fuel consumption and emissions data must be integrated and highlighted in all promotional and advertising material of a vehicle model. The consumer must be able to verify the claims of auto-makers.

The global vehicle technology trajectory is evolving rapidly, driven by net-zero pathways. The major vehicle markets of Europe, USA and China, among others, are adopting green recovery approaches to recover from the pandemic-linked economic dislocation to drive low-carbon and zero-emissions pathways. They are co-joining strategies to set more stringent targets for fuel and carbon savings from internal combustion engines (ICE) while accelerating electrification of their vehicle

fleets. Nearly 20 countries have committed to phase out ICE vehicles completely in the time horizon of 2040–50.

India cannot ignore these sweeping changes in the global markets. It makes neither economic nor environmental sense to remain static.

3

TRANSITION TO ZERO EMISSIONS—ELECTRIFICATION OF VEHICLE FLEET

ZERO-EMISSIONS TRANSITION—ELECTRIFICATION OF VEHICLE FLEET

Electrification opens up new opportunities for India to not only meet its decarbonisation and clean air goals but also to lead the market and build industry for economic spin-offs. While zero-emission vehicles can help to meet the public health goal in cities, this is also the most efficient way to decarbonise the fleet. Carbon neutrality can be further maximised if linked with clean and renewable electricity.

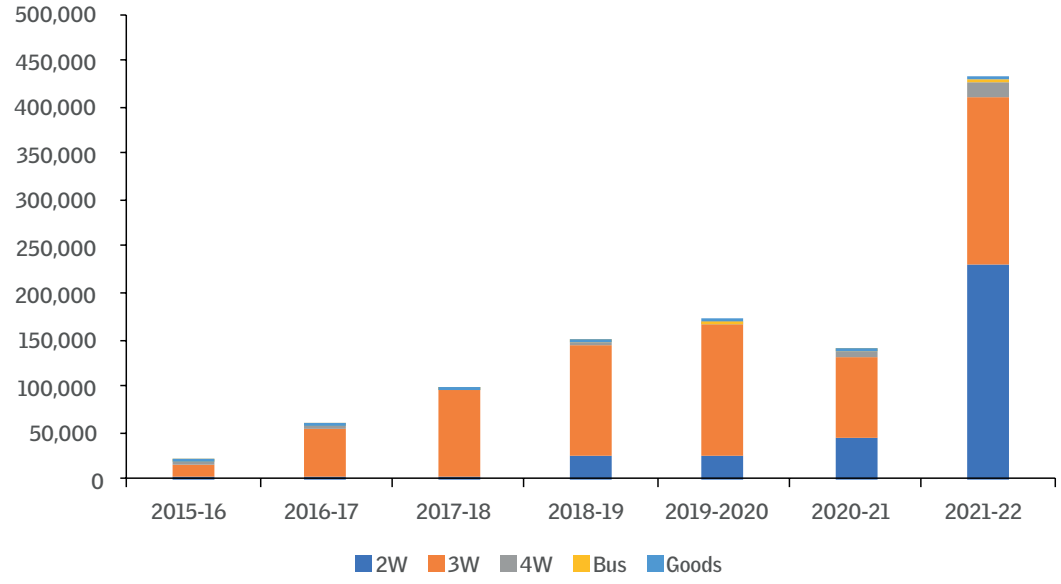
Fleet electrification is also an opportunity for developing countries, including major vehicle-producing countries like India, to sidestep the complex and expensive technology trajectory of ICE vehicles—which is lagging behind the global curve—to step jump to much cleaner trajectory. This is also an opportunity to build a new industry and an economy with employment spin-offs.

Though adoption of electric vehicles (EVs) is picking up, the numbers do not yet add up to meet a high level of ambition. The total EV stock is still around 1 per cent of all new vehicle sales in the country. In 2019, government think tank NITI Aayog stated its aim of electrifying 70 per cent of all new sales of commercial cars, 30 per cent of all private cars, 40 per cent of all buses, and 80 per cent of all two-wheelers and three-wheelers by 2030. But this is not yet backed by any regulatory mandate or long-term policy roadmap to bring more certainty in the market.

Predictably, and as noted in rest of developing world, the immediate and easier targets are the small vehicles of two- and three-wheelers, and small commercial vehicles and paratransit vehicles (see *Graph 22: Segment-wise electric on-road vehicle registration* and *Graph 23: Electric off-road vehicle registration*).

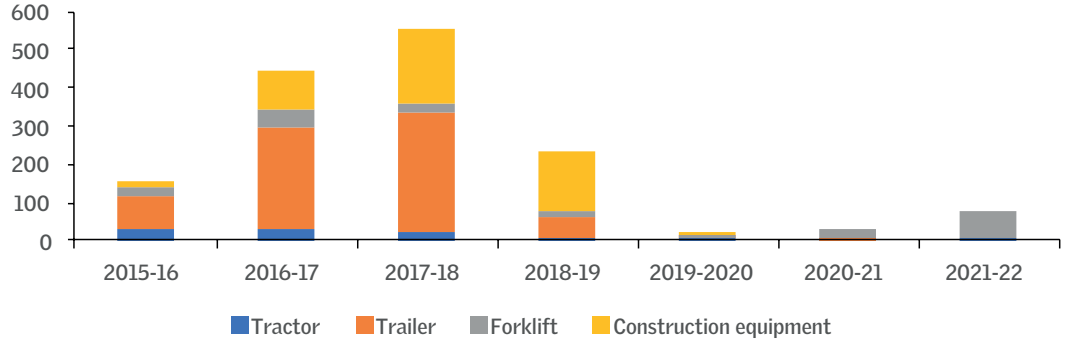
Need national and state-level regulatory targets for electrification: The NITI Aayog target can serve as a starting point for such an ambition. Once the target has been formally defined, it can become the foundation for a definitive roadmap. This can include a zero-emission vehicle production/sales mandate that

Graph 22: Segment-wise electric on-road vehicle registration (FY 2016–22)



Source: Computed based on VAHAN database

Graph 23: Electric off-road vehicle registration (2016–22)



Source: Computed based on VAHAN database

becomes effective on the basis of a state-defined credit system and an effective fuel efficiency standard that will provide a push for the production of zero-emission vehicles.

Currently, there is no national regulatory target for time-bound fleet electrification in India. The national incentive programme

called Faster Adoption and Manufacturing of Electric and Hybrid Vehicles (FAME) was originally designed to last until 2022 but due to the pandemic and underutilisation of the fund has been extended until 2024. But this only extends the current unfinished programme without adding to the ambition and target or indicating the next steps post FAME II. Thus, there is no longer-term visibility of the future strategy for the national electric vehicle programme and the associated incentive programme.

FAME incentives are expected to improve price parity with internal combustion engine (ICE) vehicles, stimulate demand and target large-scale fleet conversion (public transport, delivery fleet, ride hailing, etc.). As of March 2022, FAME II has registered about 19.3 per cent of the planned fleet target, with total sales of 300,987 vehicles—162,201 two-wheelers, 125,359 three-wheelers and 12,489 cars. Since FAME targets were not met, the scheme was extended till 2024, with an amendment that increased the electric two-wheeler (E2W) subsidy to Rs 15,000/kWh.

To achieve even 30 per cent zero-emission vehicle (ZEV) sales by 2030 will require significantly larger effort and discipline to define and implement milestones according to a definite timeline.

Several state governments have announced ambitious electrification targets in their EV policies, which broadly set plans for a period of five years. While one group of states (Andhra Pradesh, Kerala and Uttar Pradesh) have set absolute goals of 10 lakh EVs by 2030, others (Meghalaya, Goa, Haryana, Delhi, Odisha, Assam, Punjab and Maharashtra) have set targets within a range of 10–30 per cent EV penetration in the market. Chandigarh and Bihar are the outliers with goals set at 80 per cent by 2026 and 100 per cent by 2030 respectively, while Karnataka aims to effectively convert all fleets in the state to electric by 2030. West Bengal has set a target of 25 per cent electrification of new vehicles by 2024 and 50 per cent by 2026. If planned with binding targets, this can accelerate change.

Time-bound regulatory targets are needed to drive and guide electrification and for holistic ecosystem development for high growth. That will be possible only if the policies are further refined and implemented fully and effectively. As seen globally, governments are not only setting time-bound targets for fleet electrification but also setting timelines to phase out ICE vehicle sales.

NEED VEHICLE-SEGMENT-WISE TARGETS

High growth from a very small base will require vehicle segment-wise growth rate to pick up quickly. According to a CSE projection, to be 30@30—i.e. achieving 30 per cent EV penetration by 2030—the average overall annual growth rate will have to be maintained at a minimum of 46 per cent of the current market share from now to 2030. However, the opportunities vary across vehicle segments. Smaller vehicles that need small batteries, such as two- and three-wheelers, can make faster transition. The incentive support for buses can catalyse this market more effectively. But electrification of cars and bigger commercial fleet and trucks is still slow and will require a strategy of charging infrastructure and incentive support, both fiscal and non-fiscal, to attain scale and the objective of decarbonisation.

Four-wheelers will have to be part of the game plan to build local industry and battery production. This will require more strategic incentives for a wider genre of vehicle segments for demand and scale. The FAME II incentive which is two and three-wheeler focused, can create a demand only for small battery cells. But the 30@30 target will require more vehicle segments and a much larger battery capacity. The International Council on Clean Transportation (ICCT) has estimated that by 2030 India will need an annual addition of 246.9 GWh and a cumulative addition of 824.7 GWh.[1] The four-wheeler segment will have to be part of this transition as the 1.5°C stabilisation target will be less tolerant of ICE vehicles.

ZERO EMISSIONS TRANSITION—ELECTRIFICATION OF VEHICLE FLEET

ADOPT SUPPLY MANDATE FOR VEHICLE INDUSTRY

A time-bound regulatory target for fleet electrification will also require to be backed by the zero-emission vehicle (ZEV) mandate. This requires manufacturers to sell a minimum specified number of ZEVs as a share of their overall sales in the market. This ensures wider availability of the electric vehicles product range, incentivises original equipment manufacturers (OEMs) to access financial resources for technology innovation and product diversification and also increases consumer confidence to drive the EV demand.

As the ZEV mandate has implications for OEM businesses, which require phased preparedness for ZEV manufacturing to replace ICE vehicles, the Centre for Science and Environment (CSE) carried out a perception survey to understand the industry perspective. The response varies across vehicle segments.[2] According to the majority of two- and three-wheeler OEMs, the industry may see a growth of up to 40 per cent per annum over the next five years. But about 40 per cent of the EV only OEMs believe that it can even be 50 per cent. Demand-driven measures can bring down the EV cost in two-wheeler and three-wheeler segments sooner, and with total cost of ownership (TCO) parity already achieved price parity can be reached soon.

Four-wheeler manufacturers in the car segment on the other hand believe that the industry is unlikely to see a growth of more than 5 per cent per annum over the next five years. Less than 10 per cent believe that close to 10 per cent EV penetration is possible. They believe that price parity is unlikely to be achieved in the car segment in the short run. They attribute this to high upfront cost, public hesitation due to inadequate public charging, low battery range, and low level of innovation and limited models, which are the key inhibitors.

The majority of e-bus OEMs believe that the industry is likely to see a growth of up to 30 per cent per annum over the next five years. But they strongly believe that this segment will require

continued support and inclusion of private bus operators as their consumer base.

While the ZEV mandate is being supported by the two- and three-wheeler segment, car and bus OEMs take a conditional view that they can work only with stronger and extended financial incentives for both consumers and industry.

For industry, this minimum intended scenario for a phased-in mandate for 2025–30, which can be derived from the OEM consultation, is a 25 per cent target for two-wheelers, 50 per cent for three-wheelers, 5 per cent for four-wheelers and 15 per cent buses by 2030. The targets can be smaller in 2025 and ramped up until 2030.

It is, however, also possible to create a more optimistic scenario for the mandate from what the OEMs have said about the potential EV penetration in different vehicle segments over the next few years—it is possible to drive a more optimistic ZEV target scenario that aims for 50 per cent EV penetration for two-wheelers, 70 per cent for three-wheelers, 25 per cent for four-wheelers, and 25 per cent for buses. If implemented, this can add up to achieve at least 47 per cent EV penetration across these categories by 2030. This is still much less than the intended vehicle electrification target set by NITI Aayog, which aims for a combined EV market penetration of about 76 per cent.

ADOPT ZEV CREDIT-TRADING SYSTEM TO SUPPORT THE MANDATE

The ZEV credit trading system will allow automakers to sell in a particular state only if they have either a manufacturing unit or a supply network in the state. This could be combined with a zero-emission credit-trading system based on quarterly output that could incentivise manufacturers to not only build EVs to win ZEV and emission credits, but also look forward to a fresh revenue stream from banking and trading over compliance credits.

A ZEV credit trading mechanism can be a powerful tool. It can even bring in manufacturers that do not produce EVs into the fold; they can purchase excess ZEV credits from a competitor, and plan for production in the long run. The policy template, therefore, has to be a combination of targets and mandate- and incentive-based strategies. India has already experienced the impact of low targets with fuel efficiency. It leaves no incentive for companies to outdo it. Avoiding low targets could boost the process and help accomplish goals towards decarbonisation.

STRENGTHEN FOCUS ON PUBLIC TRANSPORT AND COMMERCIAL TRANSPORT

Unlike developed countries, which have prioritised electrification of car fleet in the initial stages and then expanded to other segments, India's electric vehicle programme has prioritised the public transport strategy and high-mileage commercial vehicles. In the personal vehicle segment, two-wheelers, which are numerous and use up nearly 60 per cent of petrol, have been strategically prioritised. The current FAME incentive scheme, with a corpus of Rs 10,000 crore, which has been designed to support about 15.6 lakh vehicles, targets 10 lakh two-wheelers, 5 lakh three-wheelers, 55,000 passenger cars and 7,000 electric buses. This can help to decarbonise a sizeable share of travel trips on mass modes. Support for cars is small.

A segment-wise split of FAME II incentives allocated to electric vehicles till 2022 shows 35 per cent of the subsidy package was to be spent on electric buses, followed by 25 per cent on electric three-wheelers, including e-rickshaws, and 20 per cent on electric two-wheelers. Thus electric two-wheelers (E2W) and electric three-wheelers (E3W) account for more than half of the FAME subsidy package. Charging infrastructure and four-wheelers come fourth and fifth in the pecking order.

LOCALISING MANUFACTURING

Electric mobility is also about industrial policy and maximising economic gains and employment opportunities. Being a

major vehicle-producing country, India needs to leverage this opportunity to build the industrial base to localise manufacturing of batteries, battery management systems, power train and components.

The Central government has announced the Production-Linked Incentives (PLI) scheme as part of the economic recovery package during the pandemic to support gigascale advanced cell manufacturing of up to 50 GWh. PLIs of Rs 18,000 crore have been earmarked for manufacturers to set up production units of at least 5 GWh. The PLI scheme provides incentives of 2–12 per cent of incremental sales revenue and 4–7 per cent of incremental exports revenue. This is linked to the National Mission on Transformative Mobility and Battery Storage, 2019 to promote local manufacturing of cells, modules and battery packs. The government has set up a system for monitoring localisation of parts in electric vehicles to ensure compliance with the minimum local value addition criteria to avail FAME subsidies.

However, for the PLI strategy to be successful, the EV market has to grow big enough to create demand for batteries. As mentioned earlier, the FAME II focus on two- and three-wheelers can create a demand for small battery cells. But the estimated new annual addition of 246.9 GWh and cumulative addition of 824.7 GWh in 2030,[3] as estimated by ICCT, will require aggressive electrification of all segments to create a matching demand. India needs an industrial policy.

This requires well-defined strategies for battery production and raw material sourcing, battery assembly and management, among others. Issues related to battery raw material security need to be addressed as access to mined materials for batteries is a challenge to localisation of battery cells in India. There are additional concerns around vulnerability to geopolitical complexities and uncertainties in the global supply of material and minerals and battery technology. Securing supply chain for cobalt, lithium, nickel, and graphite will be a challenge as the

geopolitics and price volatility add to the uncertainty. The sector will require infusion of capital to achieve scale in battery cell manufacturing and battery pack assembly. Policies should be able to promote locally appropriate and diverse battery chemistry to reduce reliance on a limited set of raw materials.

However, electric vehicle policies of the state governments, including Tamil Nadu, Telangana, Punjab and Odisha among others, have included plans for promoting EV manufacturing. They have provided incentives for the industry as well as support for skilling and reskilling for job creation.

STATE-LEVEL POLICY AND BOTTOM-UP PRESSURE

There is considerable opportunity in the bottom-up pressure from state-level EV policies that are expected to define the terms of change at the ground level. Nearly 21 state governments have framed and notified or have drafted electric vehicle policies to define the scope of intervention at the state level. Significant leveraging is possible if these policies are designed with clear targets, enabling mechanisms and compliance strategies.

State policies can be effective catalysts, as is evident in the early changes in the state markets that have taken the lead to implement EV policies. Delhi and Maharashtra have witnessed steep improvements in EV sales following the implementations of demand incentives and setting of targets in commercial segments. The market share of EVs in Delhi increased from 3 per cent to 12.5 per cent after the introduction of EV policy in the first quarter of 2022, according to the VAHAN database of the Ministry of Road Transport and Highways (MoRTH). Though this is largely driven by the auto-rickshaw segment, this growth is evident in other vehicle segments as well. Similarly, Maharashtra registered 60 per cent of its total EV stock after notification of the EV policy.

With many states, there is wide variance in the scope and design of programmes. As states decide on the scope and adoption of a combination of instruments and approaches according to local

priorities and imperatives, they have considerable opportunity to harmonize approaches in several sub-segments of policies—including target setting, incentive structure, fiscal and non-fiscal instruments, charging infrastructure design, industrial plan for investment and jobs, battery ecosystem, and recycling and appropriate regulations—to integrate the market for scale. If some of the gaps are addressed, this can create an effective level playing field for the industry and the consumers.

States have an opportunity to offer an ecosystem that can trigger ground-level transformation. They can play an important role in addressing last-mile bottlenecks in EV adoption and setting up of an EV manufacturing ecosystem. For instance, Delhi has drafted an aggregator policy mandates transition to an all-electric fleet for cab companies, food delivery firms and e-commerce entities by April 1, 2030 and proposes a fine of Rs 50,000 per vehicle if a company fails to make the transition. The policy covers new three- and four-wheelers on boarded by cab aggregators with timelines for compliance—10 per cent for E3W and 15 per cent for E4W in the first six months of the notification of the policy and 100 per cent within four years of the scheme notification.

This bottom-up pressure can create consumer demand and value for the end user for quicker adoption. Similarly, infrastructure support for EV manufacturing to build supply chains and retain value within the state can create new employment opportunities while curbing vehicular emissions.

The gaps in current strategies can be strengthened for time-bound implementation, scale and speed of action. This requires a deeper understanding in terms of the scope of action and harmonised action for integrated markets.

A CSE review of the EV policy documents of state governments compared the key architecture and elements of the policies to understand their effectiveness. Within the federal structure, state policies are expected to be uniquely designed according to local

imperatives. This is reflected in the wide variety of targets set for the programmes, in different kinds of incentive structures, in varying combinations of instruments for demand creation and EV adoption, in diverse approaches to promote EV manufacturing and job creation, and in assorted funding strategies for market transformation.

However, the fragmented nature of diverse policy structures in different states need to be harmonised for easier access to industry. The response of the traditional original equipment manufacturers (OEMs) who are well entrenched in the ICE manufacturing industry has begun to pick up pace. Start-ups and non-conventional players are moving more aggressively with innovative business models. A similar trend is playing out in the bus sector. The charging infrastructure is also catalysing new investment and private business. Though the start-up economy might find it harder to push the pathways when interest of the ICE industry is still overpowering.

In this context, it is necessary to understand the course correction needed to build strong ambition for the transition.

NEED VEHICLE SEGMENT-WISE APPROACH

Electric two-wheelers: NITI Aayog aims for 80 per cent electrification of electric two-wheelers. These vehicles achieved price parity after the increased support with the FAME II amendment. Initially, the FAME I scheme had allowed cheaper, low-speed and low-range scooters with lead acid batteries to invade the market. But this was corrected under the FAME II scheme, which laid out a performance criteria that required a minimum range of 80 km per charge and minimum top speed of 40 kmph while defining energy efficiency, minimum acceleration and higher number of charging cycles. It also disallowed lead acid battery-powered scooters.

FAME II has lowered upfront costs and improved price parity to

build demand. According to a CSE analysis, with the enhanced FAME II subsidy the upfront cost reduced by an average of 35 per cent. In fact, if the FAME II incentives and incentives under the Delhi government policy are combined, it shaves off an average of 57 per cent from the on-road price of the vehicle models in Delhi, achieving significantly competitive prices in comparison to popular petrol two-wheeler models. This segment is likely to reach the tipping point for scale much quicker if strategies are refined and supported. Already, sales are picking up to counter the high petrol prices.

But this alone is not enough to accelerate the market to meet NITI Aayog's ambitious target. Concerns about the safety of electric two-wheelers has become prominent as vehicle fires have raised questions about safety standards in place and compliance with those standards in the manufacture, testing and qualification of batteries as well as chargers.

Electric cars: Government subsidy is not oriented towards personal vehicles as it has prioritised electrification of high mileage public transport and commercial vehicles. Very limited subsidies are available in the personal car segment. Lack of support and slow growth have stymied this market. Despite that, industry is working on launching new models to leverage the high petrol prices and high durability of electric car batteries. Thirty-three models are expected to be launched in 2022–23. There are five sedans, 27 SUVs, four hatchbacks, one pickup truck and 1 coupe in the range of 200–700 km per charge. It is expected that as the battery economics improves, manufacturers will be able to pack even higher ranges into smaller batteries to increase consumer interest.

While FAME II subsidies are not available for personal cars, the Delhi electric vehicle policy allowed subsidy for e-cars for a limited number of units. Waiver of road and registration tax is added to this. When all of these incentives at the state level are combined, upfront price of the vehicle models reduced by an

average of 19 per cent, though several models continued to be slightly higher priced than their petrol counterparts.
It is also important to note that to achieve 30@30 or stronger targets, cars will have to be part of the agenda. An ICCT estimate shows that of the total cumulative battery capacity needed in 2030 to support this target, the share of passenger cars will have to be at least 31 per cent. More ecosystem support, tax waivers, non-fiscal preferential incentives, reliable charging network and facilities, and initial support for a targeted fleet can help to build the e-car market. Consumers will also require stronger ecosystem support.

However, e-cars for commercial application are eligible for FAME II incentives. Incentives and tax exemptions for commercial car segment allow 32 per cent reduction in the upfront price of the vehicle, though several models continue to be higher priced than their petrol counterparts in some variants even after incentives. While direct fiscal incentives can be a powerful tool to make vehicle acquisition affordable and enhance attractiveness for the consumer, the key to scale will clearly be a combination of OEM price, government support, product diversity, and charging infrastructure.

Electric buses: The clear thrust of FAME II on electrification of public transport buses is an appropriate strategy to decarbonise urban commuting, especially given the fact that the majority in India use public transport. The demand aggregation model prescribed by the amended FAME II to expand e-bus sales will likely reach its target of selling 7,000 buses that were sanctioned under FAME II scheme. That number, however, is far too small if the government plans to electrify urban commuting. For larger success, the electrification of buses has to be combined with the larger bus augmentation plan of India, which will not only help to decarbonise the segment but also achieve economies of scale. According to a report published by the Department of Heavy Industries, India could emerge as the second-largest e-bus market by 2030 if four out of 10 buses sold are electric.

To achieve those numbers, the government needs to script a much more ambitious transition plan for bus electrification. To decarbonise public transport in the country by 2030, the system needs at least 100,000 electric buses plying on the roads by then. At the moment, real change on the ground is still small, even though it is closer to the target of 7,000. While FAME I could get less than 500 buses registered, FAME II so far has seen tendering of 5,450 buses. In the meantime, state government policies have emerged in Andhra Pradesh, Kerala, Tamil Nadu and Telangana for targeted e-bus deployment supported by tax incentives, subsidy or special tariff on electricity.

The upfront capital investment required for e-buses is more than double that of the ICE buses—battery and charging infrastructure add to the cost. Generally, capital expenditure (CapEx) needed for ICE is 20 per cent of its overall cost. But in the case of e-bus, it is almost 45–50 per cent. The total cost of operation (TCO) for operating one e-bus, even after subsidy, is almost equal to its ICE counterpart.

Though FAME II tried to address several limitations of FAME I, including coverage, promotion of cleaner technology, setting up clear deployment targets along with dedicated fund allocation, etc., there is still a lot of space for improvement.

One challenge of the FAME II strategy for buses is that it got spread too thin across states, which diluted its impact. From that perspective, the new amendment in June 2021 seeking a strategy of aggregating demand for e-buses (and three-wheelers) for deployment in cities is a step forward. Accordingly, Energy Efficiency Services Limited (EESL) has begun aggregating demand for deployment in the nine mega-cities of Mumbai, Delhi, Bangalore, Hyderabad, Ahmedabad, Chennai, Kolkata, Surat and Pune. This will help to create a few EV growth centres and demand aggregation can reduce cost and present a learning curve to other cities. This will be supported by expansion in EV charging infrastructure.

The e-buses thus aggregated are mandated by FAME II to run on a Gross Cost Contract (GCC) model. This requires OEMs or designated operators to provide the buses and also operate and maintain them on behalf of State Road Transport Undertakings (STUs). The buses have to be operated on a payment per kilometre basis that will help de-risk STUs. E-bus deployment under GCC model requires holistic planning of the system including identification of bus routes, depot infrastructure, quality of power supply, and tariff, as these have a considerable impact on the cost of the project. This has begun to positively impact upfront costs while improving the efficiency of services. E-bus procurement has made the tender process more service oriented as STUs now prefer to specify their service needs instead of only specifying the details of the vehicles. This is an important strategy that needs to be strengthened.

However, there is a view emerging that this mandate of the GCC model is forcing some public transit agencies to adopt a completely new bus operating model that may require substantial changes even in their organisation structure to manage it. The bigger STUs with their own infrastructure and human resource in place may not find it practical to operate a small e-bus fleet on the GCC model and the rest on their own. Further, there are very few operators in India that can be inducted under the GCC model. As many big STUs in India have the organisational strength to manage their services, an open FAME incentive structure may provide more flexibility to the STUs to choose the appropriate operational model for themselves.

The operational model should be made flexible so that more capable STUs with better ecosystem support can organise their operations as per their need and local planning and strength. Incentives should be more flexibly provided based on technical and financial viability of the projects. The fact that this needs to be addressed is evident in the slow and repeated tendering process in several states. This has further slowed down e-bus procurement.

The FAME II subsidy should also be designed to create more options for a combination of charging technologies. Currently, e-buses with only conduction charging facilities dominate the market. FAME II incentives should also promote charging options for DC Pantograph charging or battery swapping or any other approach. It is possible to adopt battery lease model (in which responsibility of the battery and setting up charging infrastructure is given to a private partner) to reduce the high upfront cost.

FAME II incentives also need to acknowledge that e-bus deployment requires detailed planning before deployment and city-level comprehensive fleet planning for routes and charging. City-level e-bus deployment plans are needed to provide for e-bus-oriented transit infrastructure, including depots, terminals, bus stops, etc. The state should also proactively assists the power sector to improve grid capacity by providing subsidy benefits.

The e-bus industry has also witnessed balancing of traditional OEMs and new entrants. Until 2020–21, about 74 per cent of the total e-bus supply order has been received by new market players such as Olectra-BYD, PMI-Foton and JBM-Solaris. But traditional bus OEMs such as Tata Motors and Ashok Leyland, who together dominate the ICE bus market at 81 per cent, only form 26 per cent in the e-bus market. However, Tata Motors is the second highest seller of e-buses. It is also necessary to have a strategy to reach out to private bus operators.

Electric three-wheelers: The ambition set for the electric three-wheeler segment is higher than that for two-wheelers at 80 per cent by 2030. This low volume, high frequency and short-haul transport system for last-mile connectivity makes it an attractive option for quicker electrification.

ZERO EMISSIONS TRANSITION—ELECTRIFICATION OF VEHICLE FLEET

Manufacturing of lithium-ion E3W models conforming to safety norms have started even though e-rickshaw models continue to operate in the unorganised sector. Major issues faced by E3W companies range from relatively limited access to capital, perceptions about range and access to charging. Banks are reluctant to lend to start-ups engaged in EV manufacturing due to lack of awareness about EV technology and its associated risks. Moreover, the practice of daily rentals for E3W operations creates additional challenges for repayment of loans. The government addressed issues in the segment with increased subsidy under FAME II, which depressed the total cost of ownership parity.

Special challenges in the three-wheeler market arise from the daily leasing model the segment works with. This makes financing and monthly repayment a challenge. The requirement for a public charging network is significant. Out of the 23 most commonly sold E3W models in India, 17—i.e. 74 per cent of the models—have a range equal to or greater than 100 km. However, only 30 per cent can run 120 km or more on a full charge. The top speed of only 9 per cent models exceeds the 25 kmph mark. As part of an intermediate public transport strategy in cities, a targeted mandate for fleet electrification as designed by Delhi can be useful for expanding adoption.

Electric cargo vehicles: Goods carriers are suitable candidates for targeted electrification because of their high usage levels that offer high potential to reach price parity.

In this segment, customers look for vehicles with high-payload capacity, lower total cost of ownership, and the ability to operate in ambient temperature and road conditions.

To be able to deliver high payloads, commercial use requires uninterrupted running times, or, larger range in addition to public charging facilities to ensure minimal downtime. The minimal availability of public charging stations continues to deter the

adoption of electric vehicles despite the advantages of lower operating costs.

The low cost of ownership and operating costs of the electric cargo vehicles make it an attractive option for inter and intra-city cargo applications. A commercial electric vehicle operates on one-sixth of the running cost of a petrol- or diesel-fuelled vehicle, though with higher acquisition costs. A TCO comparison for electric and diesel vehicles suggests that electric vehicles are more favourable than diesel above 30–35 km of daily use. Since most commercial cars have an average daily use of 200 plus kilometres, electric cars offer a better cost option.

Product development and mandate for targeted electrification is important for this sector.

Strategic focus on fleet aggregators and last-mile feeders: Among the high utilisation segments, this is a target segment for quick electrification with ambitious targets. These include market segments such as ride-hailing, urban freight/deliveries, and employee transport, which are marked by larger efficiencies in comparison to the traditional taxi industry as they can more appropriately predict, capture and optimise rides. Players mainly work with two differentiating factors—price and waiting time—to win competitive advantage. All of them use cars, e-bikes and three-wheelers in varying degrees. Uber, Ola and Rapido dominate this market, with increased focus on low-cost last-mile connectivity.

Increasingly, the focus is shifting towards scalable models for large-scale deployment to create concentrated demand for EVs. Evidence shows that high asset utilization allows the fleet operators to recover the cost of buying, operating and maintaining the vehicle much sooner, making electric mobility a profitable prospect. The total cost of ownership of the vehicle forms the basis for establishing the financial viability of such fleet operated projects.

ZERO EMISSIONS TRANSITION— ELECTRIFICATION OF VEHICLE FLEET

Multinational companies such as Amazon and Ikea have set global targets to move to electric vehicle deliveries. The Delhi government has partnered with Flipkart, Amazon, Zomato, Blue Dart Express, and 26 other companies to start using electric vehicles for deliveries under a project called Deliver Electric Delhi. But this sector faces challenges in terms of limited EV options for heavier delivery vehicles, permit concerns related to cross-sector usage of the same vehicle, and licensing system of two-wheelers.

This segment will require more nuanced approach at the deployment level in cities. Further incentives are possible in terms of differential fares between e-ride services versus ICE-vehicle-based services. Incentives can also be linked with e-kilometres based on odometer reading. Many countries have used parking as a strong tool to speed up electrification among fleet operators. For example, reserved parking spaces specifically designated for fleet operators, preferential parking permits, preferential parking rates, priority queuing and even allowing limited parking of EVs without obstructing safety or traffic in restricted areas where parking is not usually allowed. Fleet aggregators and last-mile feeders also has special needs to have access to overnight charging, home-based and neighbourhood-scale roadside charging with discount, support and preferential electricity rates.

Another strategy gaining ground is electrification of feeder services linked to metro systems. Delhi metro plans to electrify its last-mile connectivity. The facility is now available at 29 stations, with an operational fleet of over 1,000 e-rickshaws. For mass electrification to become a reality, what is required is a clearly articulated change model that can drive multi-directional growth and achieve extraordinary scale that matches India's ambitions.

DISINCENTIVES FOR INTERNAL COMBUSTION ENGINES

This has proved to be an effective method to catalyse demand for electric vehicles across several electrified markets. Instruments

such as tax measures, pricing policy, non-fiscal measures, or specific segment oriented phase-out plans to improve competitive position and opportunities for the EVs can offer potential gains. Several cities in India are restricting the number or places of usage for three wheelers or are phasing out old vehicles to control local air pollution. These measures can be linked with replacement of these vehicles with electric vehicles with incentives. Popular in Nordic and Scandinavian countries and elsewhere in Europe as well as in China, such a programme can be offer game-changing results in India. However, the market will need to offer adequate models, viable financing options and charging infrastructure for such a scheme to take off in India.

TIGHTEN FUEL EFFICIENCY REGULATIONS FOR FLEET ELECTRIFICATION

As noted, a strong fuel efficiency benchmark can accelerate electrification of the vehicle fleet. India has not only set weak targets that the industry can meet easily, but it has further weakened the targets by giving away super-credits or extra points for ineffectual technological approaches such as six-speed transmission that normally all big and luxury cars use or tyre pressure monitoring that depends on the driver's behaviour. Initially, even mild diesel hybrids were allowed super-credits, which were removed subsequently from the eligibility list. But weaker targets and super-credits for ineffectual technology approaches do not help speed up electrification. Tighten the fuel economy standards for passenger cars and reform the super-credit system to incentivise electric vehicle. Standards for buses and other heavy duty vehicles need to be strengthened and two- and three-wheelers brought within the ambit of the standards.

CHARGING INFRASTRUCTURE

Several arms of the government have begun to enable the charging infrastructure. The Ministry of Power has now delicensed electricity consumption for charging and swapping a battery in a vehicle. The Ministry of Housing and Urban Affairs (MoHUA) has revised the Model Building Byelaws in

2019 to provide for electric vehicle only parking areas within the premises of various building types. Building premises can now have an additional power load equivalent to power required for all charging infrastructure within. Though charging infrastructure is incentivised under both the FAME schemes, with direct incentives and tax support, charging networks are taking shape only now, and in a small way.

Immediate steps are needed to address the investment deficit in charging infrastructure. The cost of charging equipment, land and grid connectivity requires initial capital. Access to capital continues to be a challenge with banks as well as non-banking financial companies. Inflow of investment and financing of charging businesses, especially for the small players, remains a challenge and will require special attention.

Design of the charging grid with slow- and fast-charging components and urban planning layout for the charging stations need attention.

It is time to develop robust EV charging standards. Some of the battery fires in electric two-wheelers are reported to have been on account of the use of unsuitable charging equipment. Indian manufacturers use the Bharat DC 001 and AC 001 connectors, which are based on the Chinese GB/T connector standard. Since Bharat AC and DC chargers cannot charge all types of vehicles, new charging standards are required. The Bureau of Indian Standards (BIS) and Department of Science and Technology (DST) are currently working on indigenous charging standards for India.

DEVELOP VIABLE FINANCING FOR EVs

EV financing continues to be a critical issue. High financing cost and uncertainty around the small market, unclear long-term targets and uncertainties around the performance and resale value of EVs have failed to build confidence in the financing

sector. This has led to the problem of high interest and insurance rates, low loan-to-value ratio, and limited financing options for retail customers. This results in unsecured borrowing from the unorganised sector at even higher rates.

Different vehicle segments have different challenges and the economics for each use pattern will be different. Two- and three-wheeler fleet operators need high daily vehicle usage to justify their business model viability to financial institutions. This in turn needs a robust charging infrastructure network to support operations and better model availability in the market. And since these two aspects are lacking in the Indian market currently, operators find it difficult to access financing.

State policies offer some support with interest subvention on loans for buying electric vehicles. The Delhi Finance Corporation (DFC) and its empanelled Scheduled Banks and NBFCs are developing a scheme on interest rate subvention. The Kerala Finance Corporation (KFC) has created a programme to provide low-cost loans for EVs in the state. But a lot more is needed.

A 2021 NITI Aayog report recommends that the RBI include priority-sector lending mandates for EVs to increase finance available for them. The Central government or multilateral organisations can capitalize risk-sharing facilities to provide longer-tenure and lower-risk financing. Lowering of interest rate for EV buyers can be mandated to lower the cost of financing for end-users. More states should come up with interest rate subvention in their respective state EV policies.

Ensuring product guarantees for the long term on products in the market can mean that more OEMs can partner with financing bodies due to assured vehicle performance and increased resale values. OEMs can also offer maintenance and repair services free of cost for specific time periods after the purchase. Risk-sharing mechanisms such as the one being created by the World Bank

can cover loan repayment risks for financial institutions, making them more proactive towards EV loan products.

NEED ROBUST BATTERY ECOSYSTEM

Building a battery ecosystem to support an ambitious electrification target presents a challenge and requires well-defined strategies addressing each aspect of the ecosystem, including battery production and raw material sourcing, and battery assembly and management, among others.

A large part of the uncertainty for manufacturers rises from issues related to battery raw material security as access to mined materials for batteries has emerged as one of the biggest challenges to localisation of battery cells in India and the industry continues to be dependent on imports. India can build a strong battery recycling ecosystem to leverage urban mining output as feedstock for fresh batteries.

Build systems for battery recycling and recovery of battery material: India's Battery Waste Management Rules 2022 aims at achieving these targets. It makes producers and importers accountable for recycling. The producers can meet their extended producer responsibility (EPR) obligation through the EPR certificates generated on a centralised portal managed by the Central Pollution Control Board (CPCB). This will be based on the parameters such as the weight of battery processed, percentage fulfillment of material-recovery targets for a specified year and geographical source of the battery. The new Battery Waste Rules are outcome-based and can be measurable. It defines mandatory targets for collection and recycling within a compliance time-frame. Non-compliance will be penalised with an environment compensation charge.

It is evident that an electric two-wheeler manufacturer has to meet a mandatory collection target of 70 per cent of batteries placed in the market in 2022–23 and has a seven-year

compliance time frame starting 2026–27. For electric three-wheeler manufacturers, the meter starts earlier in 2021–22, according to their introduction into the market, and their compliance cycle starts in 2024–25. Electric four-wheelers have a longer compliance cycle at 14 years.

However, the rules miss out on a huge opportunity to enable sustainability standards that have the potential to make India a benchmark for the global battery industry.

The Rules mandate labels with information on the use of heavy metals—including cadmium, mercury and lead—but misses out on the mention of lithium chemistries that could enable efficient and effective recycling. Different battery materials require different kinds of treatment at the recycling stage.

The new Rules also miss out on using labels as an opportunity to reflect a battery's carbon footprint, a practice that would make their environmental impact more transparent, especially if it covers the entire life of the battery as well as the percentage of recycled battery materials such as cobalt, lithium and nickel. The deployment of such a practice could have multi-pronged benefits.

Using carbon footprint as a parameter for producer responsibility could trigger research and development activities upstream with lower footprint materials, possibly sourced from within the country. It could also ensure identification and avoidance of a supply chain with human rights abuse history. About 15 per cent of cobalt sourced from Congo comes from artisanal mines that often use underage labour.

The Rules also do not mention the use of recycling-friendly battery design and manufacturing. The design objective should not be just guided by extraction of resources, which will offer cost benefits, but also lead to efficient and effective recycling process.

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If larger sustainability standards were built into battery waste management, the potential for strengthening rules for design, production and disposal of batteries in India could improve. It will be more holistic in practice and govern the entire product life cycle, from the design phase to end-of-life.

4

TRANSFORMING URBAN MOBILITY

TRANSFORMING URBAN MOBILITY

As in other developing countries, urban India has an advantage and opportunity in high share of walking, cycling and public transport trips. Even though lower income levels and poverty are responsible for large captive use of these systems, compact urban forms also keep travel distances short to make cities more accessible. With well-designed policies and investment plans, India can prevent car-centric growth path to protect and augment the usage of sustainable modes.

While cities in developed countries require active policies and investments in infrastructure to bring people back from cars to public transport, Indian cities need to retain people where they are. Indian cities have the opportunity to prevent massive lock-in of carbon and energy intensity in the transportation infrastructure, as is noted in most parts of the rich world.

Yet, in reality, the new growth in cities is neglecting the advantage of the baseline and infrastructure is becoming more vehicle-oriented. Despite the advantage of its baseline for walking, cycling and public transport use, infrastructure development and systems have not matched even the current demand. This requires an early action.

UNDERMINING THE STRENGTH

There is a massive shortfall in the public transport systems and services in Indian cities. Even though nearly all global cities are struggling to scale up public transport infrastructure, Indian cities have a huge deficit and shortfall compared to some of the global front-runners. Bus fleet and mass transit networks are extremely inadequate to meet the requirements of the population in most Indian cities (see *Table 2: Comparison of public transport supply across cities*).

Against this it is therefore necessary to understand what is holding back scaling up of locally appropriate public transport systems.

Table 2: Comparison of public transport supply across cities

City	Metropolitan area	Area (km^2)	Bus	MRT network	Bus fleet (per lakh of population)	MRT km (per lakh population)
	Population persons ('000)		Fleet size	Km		
Global cities						
London	8,302	1,572	7,500	402	90	4.84
Singapore	5,312	716	4,212	167	79	3.14
Tokyo	13,277	2,189	1,462	305	11	2.30
Hong Kong	7,184	1104	5,743	178	80	2.48
Beijing	20,186	16,411	21,628	554	107	2.74
Shanghai	23,475	6,341	16,235	588	69	2.50
Seoul	10,442	605	7,512	327	72	3.13
Indian cities						
Delhi	19,000	1,483	6,672	350	35	1.84
Mumbai	20,000	603.4	3,410	31	17	0.15
Kolkata	14,900	206.08	1,337	38	9	0.26
Bengaluru	13,193	741	6,677	56	51	0.43
Hyderabad	6,810	625	3,521	67	52	0.98
Ahmedabad	5,578	505	870	7	16	0.12
Kanpur	4,581	403	340	9	7	0.20
Jaipur	4,107	467	250	12	6	0.29
Pune	3,990	516	2,300	12	58	0.30
Lucknow	2,903	631	132	23	5	0.79
Nagpur	2,406	227.36	487	27	20	1.11
Chennai	7,088	1189	3,454	55	49	0.77
Trivandrum	958	214	318	-	33	0.00
Guwahati	957	216	303	-	32	0.00
Mysore	921	155	458	-	50	0.00
Kochi	677	94.88	200	26	30	3.78

Sources: Collated by CSE from official websites, secondary information from respective offices, and news reports (in this order of priority) (last accessed in January 2022)

As far as public transport buses are concerned, it is estimated that currently there are 35,000–40,000 operational buses in urban India, but the requirement is at least 115,000–120,000 buses. There is a huge shortfall of 75,000-80,000 buses. Also the systems needed to improve the overall service level of buses is also very inadequate.

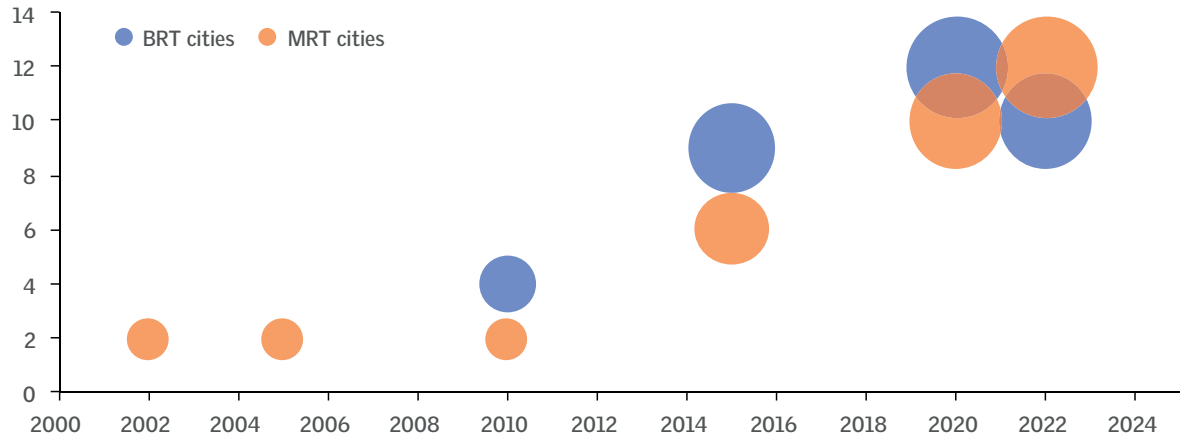
Moreover, bus-based rapid transit systems that can augment passenger throughput substantially through dedicated corridors is extremely limited. As of 2022, only 10 cities had operational bus rapid transit system (BRT) systems, with full-fledged or partial network, in the country. But the total operational BRT network in the entire country adds up to approximately 800 km. All these systems have remained quite stagnant with only marginal increase in kilometres. In fact, just the two cities of Ahmedabad and Surat make up nearly 50 per cent of the total BRT network length.

Even what was built has not been sustained and expanded. The mass transit systems originated in the Jawaharlal Nehru National Urban Renewable Mission (JNNURM) in 2005 when 11 cities—including Delhi, Vijayawada, Vishakhapatnam, Ahmedabad, Rajkot, Surat, Bhopal, Indore, Pune, Jaipur and Kolkata—qualified to build the BRT system. Of these, eight cities could develop the BRT but only six could sustain an operational BRT system as of 2022. Some of these BRT systems could be sustained. The Delhi BRT was dismantled post 2015, and Vijayawada and Vishakhapatnam had built routes but were not functional. Amritsar, Raipur, Hubli-Dharwar subsequently built BRTS systems.

As of 2022, six more cities—including systems that include Mumbai, Bhubaneswar, Chennai, Coimbatore, Hyderabad, Madurai and Tiruchirapalli—have planned BRT systems. Delhi is also planning to revive the plan (see *Graph 24: Status of mass transit in Indian cities*).

Choices between BRT and metro rail systems need to be determined by the local context of the cities. Metro rail can be viable only on high demand corridors of a few big cities. As of 2022, 12 cities in India have metro rail systems. The total metro rail network in the country adds up to about 706.7 km. Under the Jawaharlal Nehru National Urban Renewal Mission (JNNURM), eight cities had built and expanded the metro rapid rail transit system.

Graph 24: Status of mass transit in Indian cities



Source: CSE analysis

Kolkata was first to build the metro rail system in 1984, with a single network of about 21 km, which was expanded subsequently. The Ahmedabad–Gandhinagar metro ceased operations during the pandemic in 2020. The Kanpur and Pune Mass Rapid Transit System (MRTS) have started operation in 2021 and 2022 respectively. The preparedness to roll out locally appropriate public transport infrastructure is very limited.

BUS SECTOR: NEEDS MASSIVE SCALING UP

Buses are the prime movers in large- and medium-sized cities. Buses allow greater flexibility of operations with wider geographical coverage and accessibility, cost-effective travel and space efficiency. Bus routing can easily and flexibly meet the requirements of different population groups across all neighbourhoods. They can also cover areas with lower population density and travel demand. A bus occupies twice the space taken by a car but carries 40 times the number of passengers. Buses allow for enormous pollution and oil savings, but there is an enormous deficit in bus numbers and service in Indian cities.

According to the National Sample Survey Organization (NSSO) 2016, buses are the most preferred mode of mass transport in both rural and urban India. The majority of households (i.e. 66 per cent

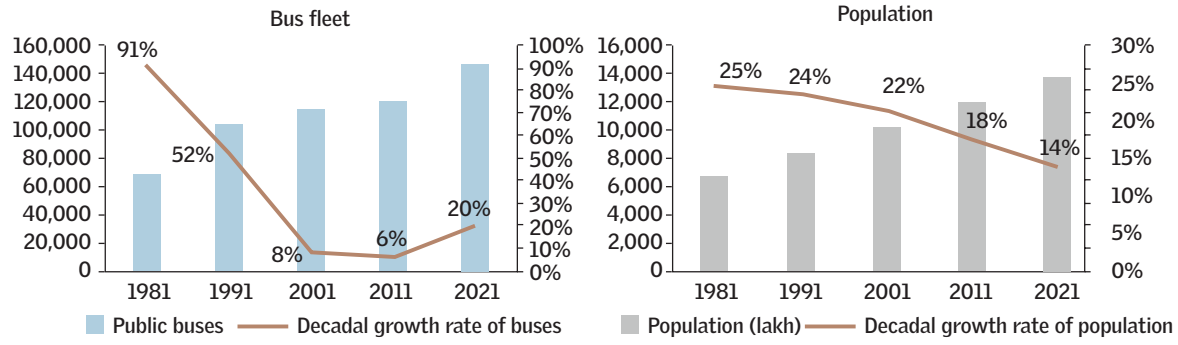
in rural and 62 per cent in urban households) spend the most on buses compared to other modes.[1] According to the *Road Transport Year Book 2018–19*, India had around 1.47 million buses in 2019, of which 0.14 million (nearly 10 per cent) were public buses,[2] and the rest privately operated. In 2017, public buses carried around 69 million commuters on a daily basis,[3] which is three times the passengers carried by Indian Railways (i.e. 23 million passenger per day).[4]

Not enough buses: The number of buses in India is still very low—only one bus per thousand population compared to Latin American countries like Mexico and Brazil (three buses and five buses per thousand population respectively), where buses are considered to be the main mode of transport.[5] As of the end of 2021, 70 urban centres in India—i.e. just 30 per cent of the total urban centres with more than 200,000 population (according to Census 2011)—have their own bus services that are eligible to operate buses.

As of 2016, there were well over 47 state transport undertakings (STUs) in India holding 1.43 lakh buses of different types. Almost half of these STUs are State Transport Corporations, about 12 are private enterprises, nine are government departments and seven are municipal undertakings. In addition, there are a number of Municipal Corporations or local special purpose vehicles (SPVs). As per the Central Institute of Road Transport (CIRT), in March 2010 India had 1.22 lakh buses for a population of 121 crore, i.e. one bus for every 9,890 people. In 2017, India had 1.47 lakh buses for a population of 138 crore, i.e. one bus per 9,366 people. While the numbers are limited fleet is also ageing.

According to a 2016 CIRT report, public buses carried 6.85 crore passengers per day, which is about three times the number of passengers transported by the Indian Railways every day (2.3 crore passengers). However, if both public and private buses and the data available from the Bus and Car Operators Confederation of India (BOCI) are considered, 37 crore passengers travel daily in

Graph 25: Decadal growth of bus fleet and population in India



Source: Census 2011, CIRT report 2017

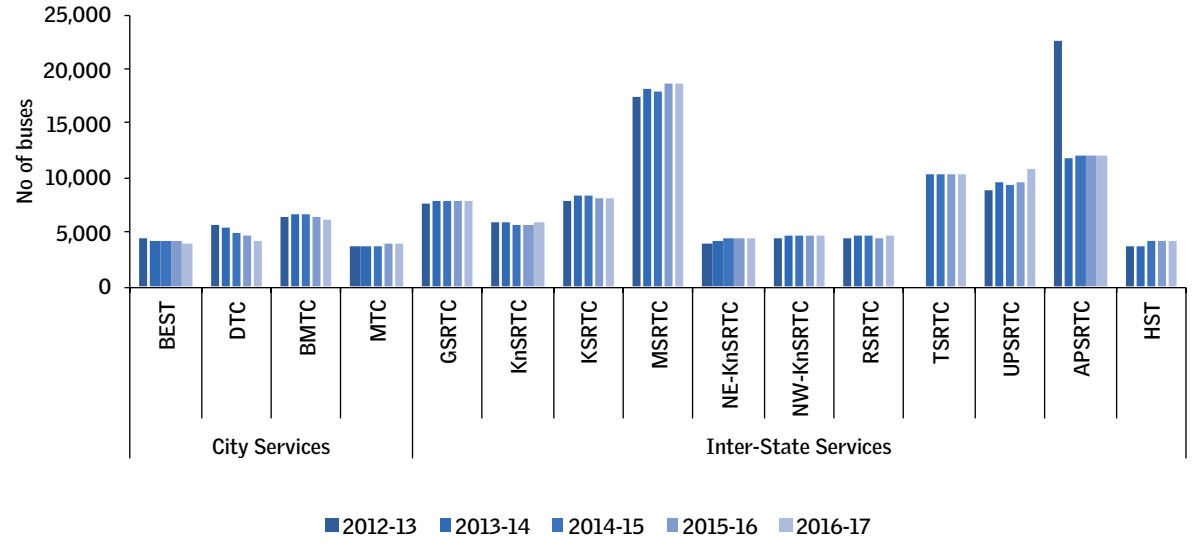
approximately 17 lakh buses, which is almost 16 times that of the passenger volume carried by the Indian railways (see *Graph 25: Decadal growth of bus fleet and population in India*).

Declining fleet size and ridership: Despite the growing travel demand, bus ridership is plummeting. A detailed assessment of 15 major STUs in India (i.e. BEST Undertaking, Delhi Transport Corporation, Bengaluru Metropolitan Transport Corporation (BMTC), Metro Transport Corporation (Chennai), Gujarat State Road Transport Corporation (SRTC), Kerala SRTC, Karnataka SRTC, Maharashtra SRTC, North Eastern Karnataka SRTC, North Western Karnataka SRTC, Rajasthan SRTC, Telangana SRTC, Uttar Pradesh SRTC, Andhra Pradesh SRTC and Haryana State Transport) shows that the majority of STUs has experienced either decline or stagnation in their fleet numbers between 2012–13 and 2016–17. It's important to note that these 15 STUs cover more than 70 per cent of total public bus fleet in India (see *Graph 26: Declining trend of buses in STUs*).

As a direct result of declining or stagnating bus fleet, ridership has also declined (see *Graph 27: Declining trend of ridership in STUs*).

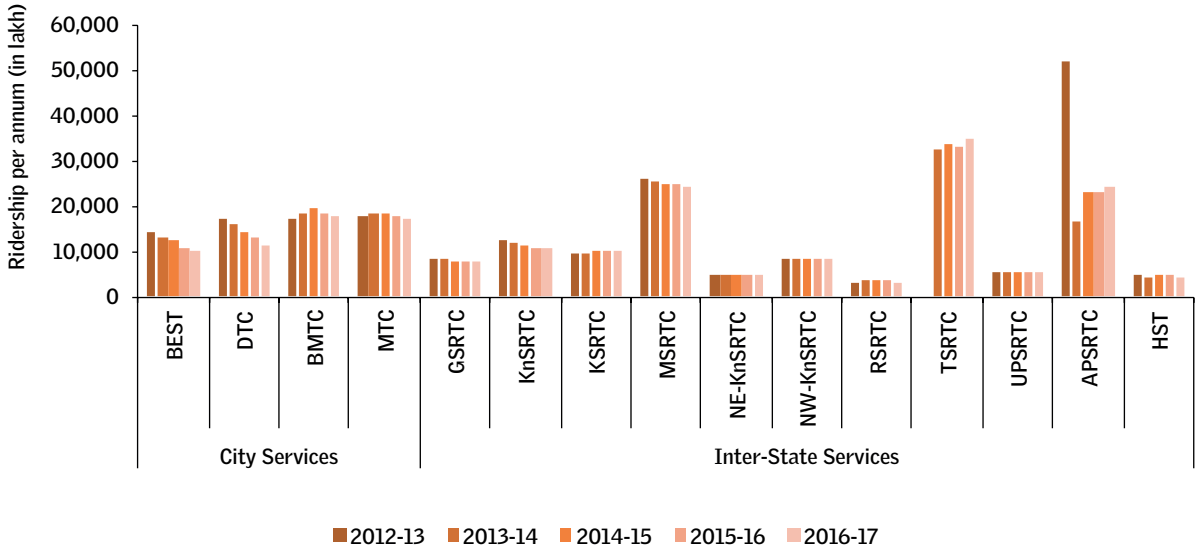
A similar assessment conducted by CSE of major cities—including Delhi, Mumbai, Kolkata, Bengaluru, Hyderabad, Chennai, Kochi,

Graph 26: Declining trend of buses in STUs



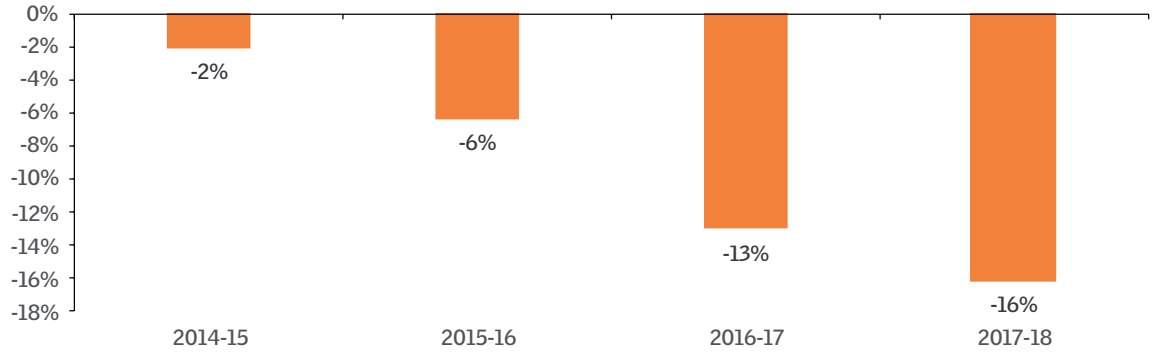
Source: CSE estimates based on data from MoRTH

Graph 27: Declining trend of ridership in STUs



Source: CSE estimates based on data from MoRTH

Graph 28: Percentage change in combined ridership of major cities in India



Source: RTI filed by CSE

Lucknow, Kanpur, Pune, Puducherry, Trivandrum, Guwahati, Mysore, Madurai, Vijayawada, Visakhapatnam and Faridabad—showed that between 2012–13 and 2017–18, these cities lost a combined total ridership of 41.2 lakh, i.e. an almost 16 per cent decline from their 2012–13 ridership level[6] (see *Graph 28: Percentage change in combined ridership of major cities in India*). Further, the bigger cities of Delhi, Mumbai, Chennai, Bengaluru and Hyderabad witnessed massive declines in tune of 13.6 lakh, 10.3 lakh, 7.9 lakh, 6.9 lakh and 2 lakh respectively.

Not just fleet size, service quality—particularly city services—is also degrading and becoming inefficient. According to the Ministry of Road Transport and Highways (MoRTH's) annual performance reports of Public Transit Authorities (PTAs), from 2011–12 to 2016–17 overall vehicle productivity of all the PTAs reduced from 329.1 km per bus per day to 306.84 km per bus per day. In big metropolitan cities like Mumbai and Delhi, bus productivity is close to 150 km per day (on average). In the same time period, fleet utilisation has also reduced from 90.4 to 89.7 per cent. In addition to the challenges within the bus sector, congestion is also leading to a decline in bus productivity in cities. Reduced productivity affects financial performance.

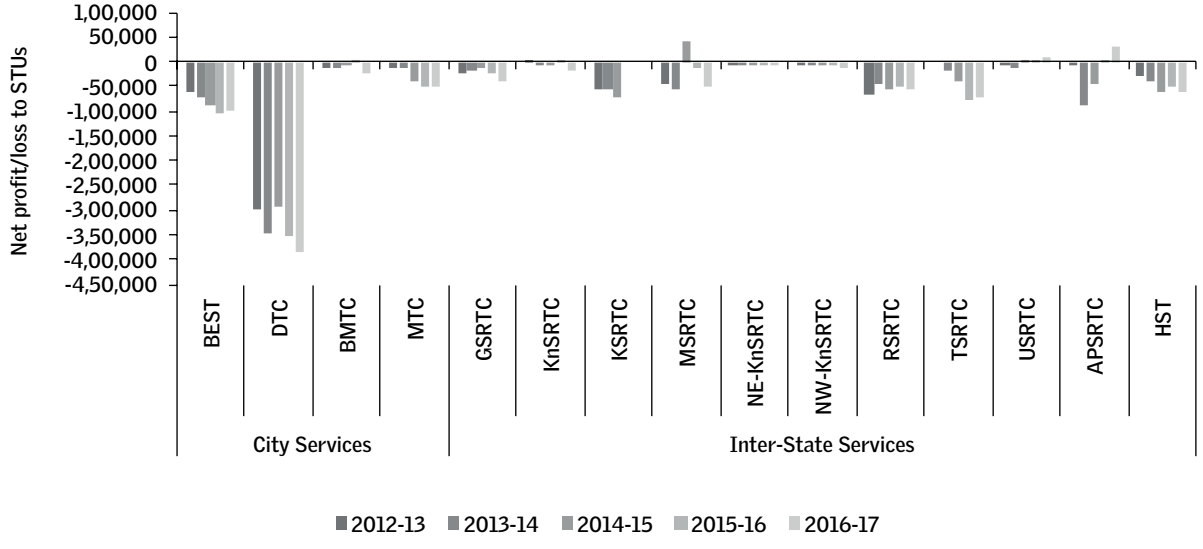
Increasing financial burden: The financial situation of STUs

is worsening (see *Graph 29: Increasing losses to STUs*). Between 2009–10 and 2016–17, the overall loss of all the STUs tripled from 4,737 crore to 13,956 crore.

According to a 2016–17 Central Institute of Road Transport (CIRT) report, state transport undertakings (STUs) are in general able to recover only 74 per cent of their operating cost.[7] The report also suggests that city-based PTAs are able to recover only 47 per cent.[8] This is aggravated by rising fuel and labour costs. In Delhi, over the past decade, diesel prices have increased by almost 49 per cent[9] and the minimum wages of skilled human power have increased by 1.6 times.[10] These are adding to the cost burden. From a more than 50 per cent market share in the early 1980s, the STU market share has fallen drastically to nearly 7 per cent in 2016. Under these circumstances, the support for the bus scheme becomes very important.

Constant increase in both fuel and manpower cost are putting PTAs under tremendous financial burden. For example, over the past five years, the price of diesel in Mumbai has increased by

Graph 29: Increasing losses to STUs



Source: MoRTH

almost 59 per cent (i.e. from Rs 59.04 as on August 1, 2017 to Rs 94.27 as on August 1, 2022)[11] and the minimum wage for skilled manpower (both bus driver and conductor come under this category) has increased by 1.2 times (i.e. from Rs 9,627 per month [in June 2017][12] to Rs 11,895 per month [in August 2021]).[13]

BUSES AND PANDEMIC DISRUPTION

During the full lockdown phase, bus services were disrupted and all the PTAs had to bear approximately 70 per cent of their operating cost while their earning was nearly zero. Even after the lockdown, for several months, their service efficiency was limited to 20–30 per cent of what it was previously. This impacted both ridership and revenue. The pandemic increased operating costs for all the operators due to more frequent cleaning and disinfections. According to an estimate provided by the Bus & Car Operators Confederation of India (BOCI), Rs 2.2 crore per annum is required for every 100 buses to meet the requirements of safety protocols. This has stymied investments in bus modernisation plans, augmentation of bus services and rebuilding of bus infrastructure. While traffic revenue plummeted, the requirements of viability gap funding increased by 69 per cent.

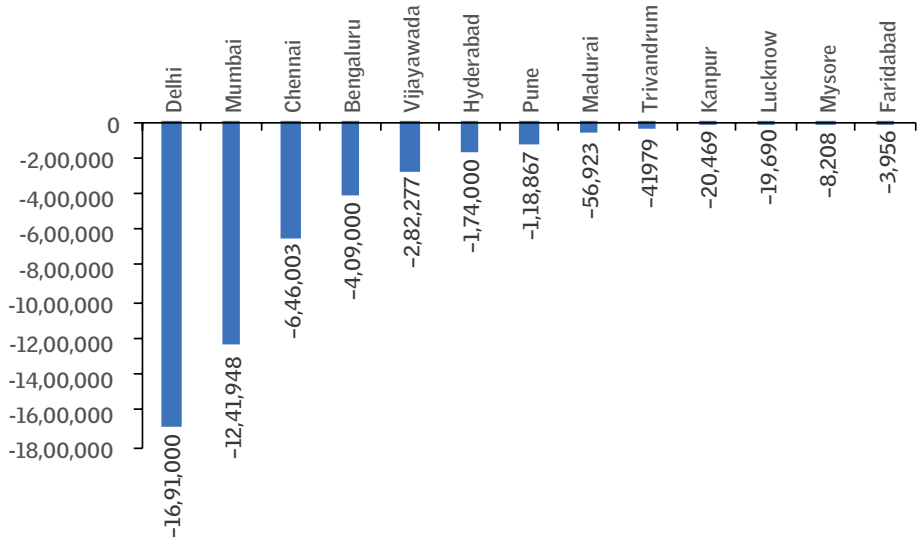
CITIES HAVE WITNESSED LOSS OF BUS RIDERSHIP

A CSE assessment showed that in 2013–18, even when travel demand grew in cities, 13 cities lost combined ridership of 40.8 lakh (see *Graph 30: Ridership loss in 2013–18*).

NEED TAX REFORMS FOR BUS TRANSPORT GROWTH

The paradigm to treat public transport as a commercial entity to impose taxes is one of the major reasons for the imbalance between assets and liabilities of SRTUs. As per the Seventh Schedule of the Constitution of India, taxes on passenger vehicles are levied by the Central and state governments for resource mobilisation, such as meeting the cost of road construction and its maintenance. The basis of computing tax varies from state to state. There is a multiplicity of taxes that also differs by mode.

Graph 30: Ridership loss in 2013–18



Source: RTI/ CSE, 2019

For the purpose of operating buses, SRTUs have to carry out certain activities such as creation, purchase and operation of properties. Several of these activities fall under the tax ambit of Central and state governments. Thus, SRTUs have to pay a total of 15 multiple taxes on immovable property (stamp duty and property tax), bus operation (excise duty, customs duty, gross sales tax [GST], entry tax/octroi, road tax, passenger tax, and advertisement tax) and bus purchase. The cumulative impact of all these taxes imposes an additional burden on the cost of operation of buses.[14] In addition to taxes, interests are applied to each cost component, including taxes. Once payments of these taxes get delayed, the interest increases proportionately, which further escalates the overall tax burden.

After the introduction of GST, VAT and octroi at the state level were abolished. But motor vehicle tax, which is an important source of state revenue, has continued. This is also skewed against buses and favours cars and two-wheelers. Cars pay a lifetime road tax once while buses pay road tax on a yearly or quarterly basis. A comparison between the annual road tax

burden on a bus versus car shows that buses pay more than cars. For example, in the case of Ahmedabad, Mumbai, Bengaluru and Pune, the taxation regime is so skewed against the bus system that the annual road tax paid by city buses is more than 20 times the maximum road tax paid by a car.

LOW-CARBON TRANSPORT NEEDS TO BE AFFORDABLE

There is no absolute threshold to define affordability of public transport, but globally it is accepted that not more than 10–15 per cent of household incomes should be spent on transport for it to be termed affordable. Alternatively, a cap of 10 per cent income spent on transportation by the poorest 20 per cent of the population is accepted as a benchmark of affordability. If the criteria of 15 per cent of income spent on transport is considered as the upper cap of affordability, then almost one-third (34 per cent) of Delhi's population stood excluded from basic non-air conditioned (AC) bus services in 2018. About 30 per cent of the population who earn Rs 12,500–42,000 per month are likely to spend 25 per cent of the total journey cost to get to the Metro station or to travel from the Metro station to the destination (after accounting for integrated journey costs and based on conservative estimates). This income group spends 9–14 per cent of their total income to use AC buses and/or Metro rail services, making these modes close to unaffordable for them.

For poor people, higher spending on transport leads to lower spending on housing, health and education, letting them spiral into greater poverty. Given the price sensitivity of Indian commuters—in both the low- and middle-income groups—there is need for locally appropriate systems and institutional and technological ecosystems to ensure affordable fares and subsidy delivery. It is also important to address the hidden subsidy that personal vehicles like cars and two-wheelers enjoy. Two-wheelers are the cheapest mode and travel by cars is also financially competitive with integrated journey costs by public transport. This rationalisation is critical to make public transport

work. Costs of operating improved public transport cannot be met through fare hikes alone because it will only catalyse a modal shift to private transport. Subsidies may be needed to meet the deficit to keep public transport affordable per se and vis-à-vis private modes. In India, this subsidy is typically provided to the operator, be it the Metro Corporation or State Transport Undertakings (STUs). However, this creates its own challenge as it does not incentivise improvement in the efficiency of the Metro or STU system as they know that they can fall back on the subsidy to cover their shortfalls.

NEED FUNDING STRATEGY FOR BUSES

The STUs principally face two funding challenges. Capital funding is required for purchase of new rolling stock, creation of bus stops, depots and terminals, and support services such as ITS. Operating expenses (OpEx) funding is required due to viability gap between cost of operations and revenues received. These challenges must form a basis for meeting any funding needs. Further, it must be remembered that most STUs have limited capacity to manage complex public–private partnerships (PPP) contracts.

The Union Budget of 2021–22 has provided for a new scheme that will be launched with the provision of Rs 18,000 crore to support augmentation of public bus transport services. The scheme aims to facilitate deployment of "*innovative PPP models to enable private sector players to finance, acquire, operate and maintain over 20,000 buses*". According to the Budget statement, the scheme will "*boost the automobile sector, provide fillip to economic growth, create employment opportunities for our youth and enhance ease of mobility for urban residents*". This is the only Centrally funded scheme for buses that is being planned. It needs to create the appropriate template for bus sector reform.

This scheme could give coverage to a larger number of cities. While augmenting the bus fleet, the scheme should also improve the service quality of buses and meet the service-level benchmark

for urban transport prepared by MoHUA. The bus sanction process may be designed to mandate detailed plans for urban transport to ensure proper coverage, ridership, fleet utilisation, infrastructure development, sustainability, affordability to commuters and constraints. They need monitoring systems based on key performance indicators. Currently, well-defined manufacturing standards and body-building code for different bus types are available in the country such as Automotive Indian Standards (AIS), Urban Bus Specifications II (UBS II) and Central Motor Vehicle Rules (CMVR). This requires standard guidelines for bus procurement.

The agencies need funding for both capital purchase of buses and infrastructure and also for meeting their operational viability gap. While subsidies should not cover inefficiencies, viability gaps are a reality. Almost all PTAs have expressed a preference for OpEx viability gap funding (VGF) for long sustenance of bus operations. Some states have explicitly recognised the need for VGF and have built this support through their schemes. For e.g. Gujarat's Chief Minister Urban Bus Service Scheme fund provides 50 per cent of the viability gap for every bus km—and capped at Rs 12.5 per km for diesel CNG buses and Rs 25 per km for electric buses—for 1 lakh-plus cities of the state.

Thus, the new bus scheme provides a choice to the applicant in terms of whether it would like to avail funding for CapEx or OpEx.

The scheme should also focus on standardisation of ITS specifications so as to have a smooth integration with backend system of STUs. The scheme may also provide support for integrated system operations such as One Journey, One Ticket. This will improve the efficiency and patronage of public transport operations. Both PTAs and sector experts believe that some additional funds can be provided for developing support infrastructure for operation and maintenance of these buses. The scheme may mention the list of mandatory support infrastructures like depot and additional infrastructures like

bus shelters, public information system (PIS) display boards, integrated ticketing system etc. for evaluation of proposals. Institutional reforms should be made a mandatory part of assistance. This may include an Urban Transport Fund (UTF), a fare policy, a Transit-Oriented Development (TOD) policy, a parking policy; an advertisement policy, and strategies for involving intermediate public transport in overall planning.

Bus transport requires performance parameters to set targets in terms of performance of planned implementation of the scheme, targeted augmentation of ridership, targeted improvement of fleet utilization, targeted increase in coverage and targeted reduction in viability gap in bus operations. Almost all the stakeholders have agreed that the funding should be linked with targeted performance parameters, so that PTAs or cities are responsible for desired outcomes. Performance parameters should focus more on developing a sustainable bus transport system instead of focussing only on revenue targets and ridership which often do not directly in hand of PTAs or operators. Instead, parameters should focus on inputs or service delivery. And all the parameters may reflect a broader theme but details of those parameters shall be city specific.

For overall development of an ecosystem of alternative sustainable means of finance for public transport authorities, the following is needed:

- Multi-year subsidy support for public transport linked to productivity improvements by the authorities;
- Scientific fare adjustment mechanisms adopted;
- Private vehicle proliferation through mode integration contained;
- Integrated demand aggregation to solve the last-mile problem used;
- Congestion charges along with rationalised parking policy introduced;
- Technology to improve fare collection efficiency used;
- Demand-side disincentives and taxation introduced;

- Taxes to reduce burden on public transport rationalised;
- Services for which there is a service provider market with strong guarantees outsourced;
- Public transport to viable models in order to ease its access to market funding linked;
- Upgrading to clean fuel technology should be accompanied by efforts to help financial health of public transport authorities; and
- Moving towards demand-side subsidies in the long run.

RIDERSHIP OF METRO RAIL SYSTEMS

Carbon intensity of commuting can be reduced only with easy and seamless transfers between different transport modes. About 14 cities have implemented metro systems (see *Table 3: Metro systems in India*). Most Mass Rapid Transit Systems (MRTSs) do not meet the projected ridership demand. Delhi, with one of the world's largest metro networks connecting peripheral and satellite cities, is also behind its target. The Ahmedabad–Gandhinagar metro has closed down post- pandemic. Other metro systems such as that of Kanpur Metro and Pune–Pimpri Metro are still new as they have started operations in December 2021 and January 2022 respectively. With very low ridership per km, the decarbonisation action gap widens further (see *Graph 31: Ridership in MRTS in comparison to its projected ridership*).

There is also a wide variation in ridership patterns. Kolkata carries 10,600 passenger per km of operation. Compact and high-density development have aided in higher ridership. Mumbai carries 9,800 passenger per km is Mumbai. Mumbai has an extensive local train network. Delhi and Bengaluru carry about 8,000 passengers per km. Jaipur, Nagpur, Kochi, Lucknow and Chennai Metros carry barely 1,700, 1,900, 2,500, 2,600 and 2,900 respectively (see *Graph 32: Ridership carried per km of operation*).

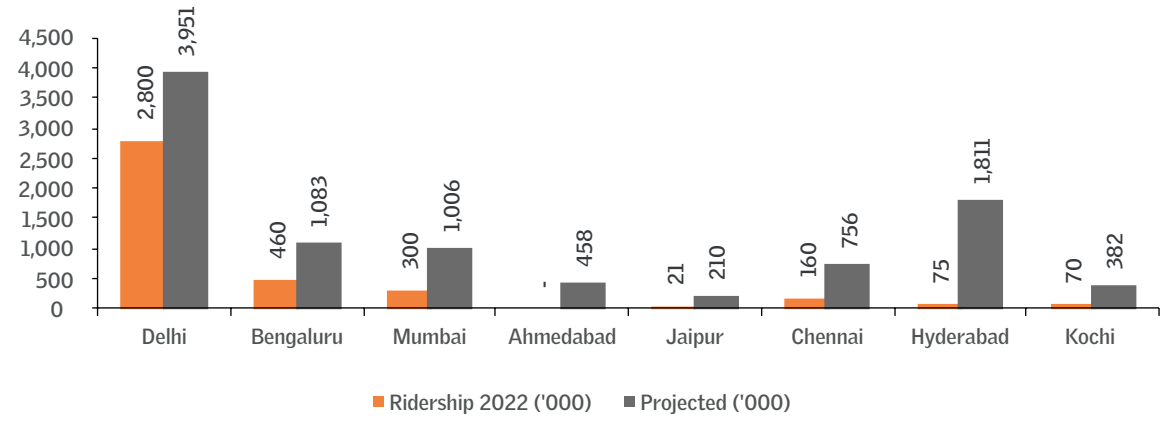
It takes Rs 222 crore to build a kilometre of network. Metro fares vary across cities. If a flat fare of Rs 30 for a metro ride is assumed given the level of ridership, it is possible to earn a revenue of Rs

Table 3: Metro systems in India

City	Started	Network length during launch (km)	Network length (km) 2022	Ridership (2022)
Delhi (includes Gurugram, Noida, Ghaziabad)	2002	8.35	350	2,800,000
Bangalore	2011	25.72	56.1	460,000
Kochi	2017	13.4	25.6	70,000
Mumbai, Greater Mumbai	2014	11.4	30.65	300,000
Nagpur	2019	15.6	26.6	51,670
Jaipur	2015	9.63	11.97	20,623
Chennai	2015	45	54.65	160,000
Hyderabad	2017	16	66.5	300,000
Lucknow	2017	8.5	22.87	60,000
Kolkata (taken in 2002)	1984	11	38.26	405,596
Ahmedabad, Gandhinagar	2019	6.5	6.5	-
Pune	2022	12	-	-
Kanpur	2021	8.98	8.98	-

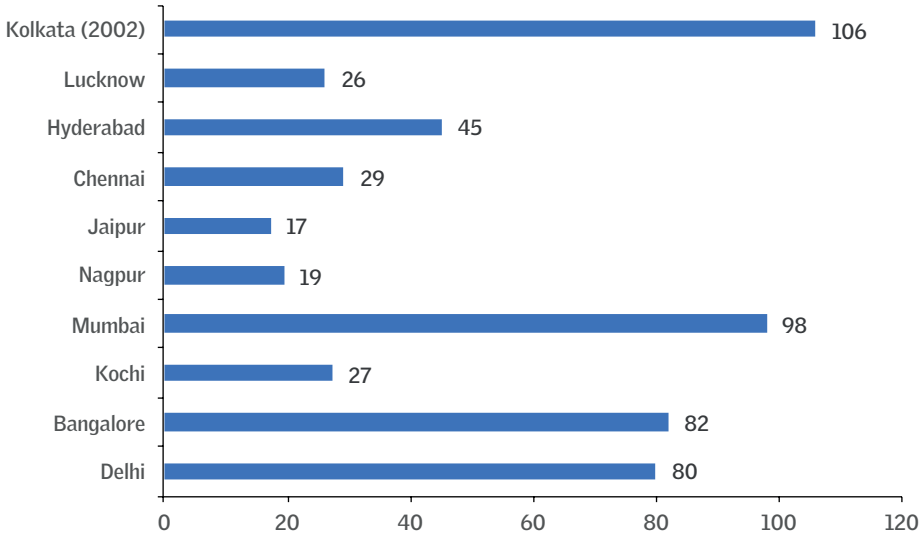
Sources: Respective websites, news reports (in the order of priority) (extracted June 2022)

Graph 31: Ridership in MRTS in comparison to its projected ridership



Sources: DPR, CMP, respective websites, news reports (in this order of priority) (extracted June 2022)

Graph 32: Ridership carried per km of operation (in '000s)



Sources: DPR, CMP, respective websites, news reports (in this order of priority), extracted in June 2022

1.8 crore per km, which is quite low in comparison to the cost of constructing a km of metro. There are variable cost of operation that occurs on a day-to-day basis and is captured in a monthly balance sheet. In this way, a metro will recover its expenses only in 100 years considering no further capital expenses are undertaken for its operation. But every asset undergoes depreciation and needs further investment from time to time.

Therefore, cities need a fiscal strategy to address this cost of operation. Ridership-carrying capacity must be optimised. Cities should work on improving urban land dynamics, improve accessibility to already build metro stations, improve last-mile connectivity and plan dense development over long corridors to capture adequate land value.

NEED MULTI-MODAL INTEGRATION

It is often not understood that for the public transport systems to work effectively, the service-level and coverage need to improve. The utilisation of the available systems can be optimised only if they are scaled up and physically integrated and fare integration policy adopted with the objective to keep the fares affordable.

Without such a strategy the utilisation of each system will remain sub-optimal.

Delhi has adopted a multi-modal integration policy that defines the design parameters for physical integration of different modes for easy transfer. This operates on the principles of bringing bus stops and pick-up and drop-off points of paratransit vehicles close to metro stations while car and two-wheeler parking are at a distance. It is also supported by public place-making and well-organised vending activities. The system design is expected to enhance last-mile connectivity.

To have accessible stations, Delhi Metro Rail Corporation (DMRC) has proposed multi-modal integration hubs (MMI) in the areas of 78 stations of phase I, II and II metro corridors. Of these, the design for 69 stations have been approved. Implementation is underway. Chhattarpur, the first metro station to have implemented MMI, has a dedicated pedestrian crossing, walking and cycling crossing, integrated public amenity areas, dedicated pick-up and drop-off locations and segregated traffic circulation plans around the metro station. This facilitates transfer to buses, autorickshaws and public bike sharing. Several cities with metro systems, including Bengaluru, Hyderabad, Mumbai, Lucknow etc., have begun to implement the MMI design for physical integration.

Cities with BRTs have also begun to adopt similar approaches. Ahmedabad and Surat have integrated BRTs with their city bus services through physical interchanges at select locations. The Pune Metro Rail Project has announced integration of the metro station with the bus service of Pune Mahanagar Parivahan Mahamandal Ltd.

However, in addition to physical integration of modes, this strategy also requires fare and operational integration for seamless transfers. In Surat, the common mobility card—or as it is locally called, the Surat Money Card—could be used for three

types of bus services offered by Surat Sitilink. The Delhi metro ONE card, which was once valid for use in DTC buses and cluster buses, was discontinued during the pandemic.
These initiatives need scaling up across all transit networks across the country for ease of journey and to make commuting trips carbon neutral.

BUILD COMPACT AND ACCESSIBLE CITIES

According to a 2015 World Bank study, satellite imagery for the 12 largest Indian cities shows that the proportion of built-up area outside a city's official boundaries exceeds that within its boundaries—it also exceeds the proportion of population for all 12 cities. Limited land availability, issues with land tenure and cost of land are pushing new growth to the urban periphery and beyond.

A CSE assessment of new housing development in the National Capital Region, Rajasthan, Punjab and Telangana shows sprawled development that is increasing average distances from the city centre as well as from essential services like education, health centres etc. This is increasing distances to services, journey time and number of trips to access services. As a result, transport cost is increasing, and use of walking and cycling to access services and job centres are declining. In some cases, transport cost has increased for the bottom 50 per cent of the population while spending on education and health has stagnated.

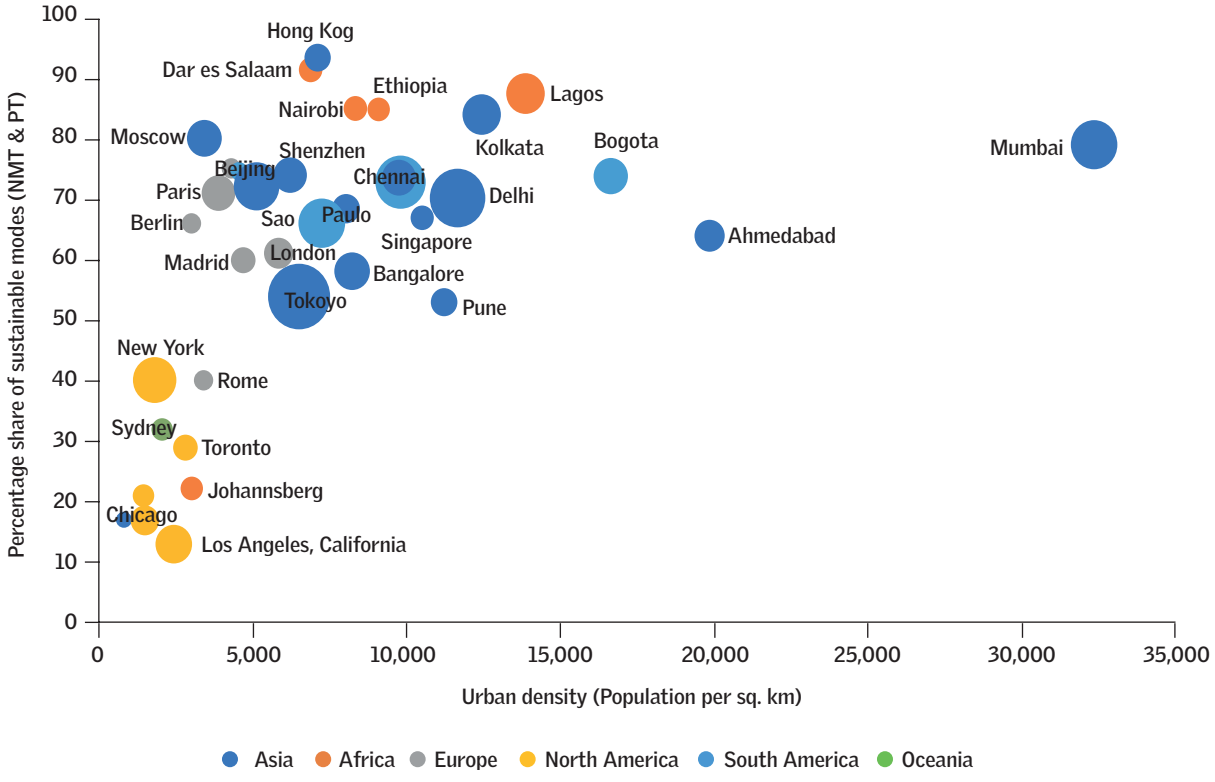
There is an enormous equity impact as the poorer population are most affected. It is evident that under the slum rehabilitation programme in Delhi, about 15 projects with 52,584 units have been constructed at the periphery. These housing units show about 8.76 per cent occupancy due to non-availability of required infrastructure and services. This has created the risk of losing livelihoods.

The value of building compact cities with well-distributed densities is well understood. But it is difficult to maintain.

Traditional urban core in Indian cities are compactly built with high accessible street densities that have helped to reduce trip distances. But the new development is sprawled and gated. Global experience shows that cities with high densities have higher share of sustainable modes of transport. Most developing cities, including Indian cities, Latin American and Chinese cities with higher densities, have higher share of walking, cycling and public transport. But developed cities in North America or Australia, with lower population densities, haver lower share of these sustainable modes (see *Graph 33: Relationship between density and use of sustainable transport*).

To address this issue, India has adopted the Transit Oriented Development (TOD) Policy to engineer development around

Graph 33: Relationship between density and use of sustainable transport



Source: Compiled by CSE from multiple sources

transit nodes in big cities in such a way that more people can live closer to the transit nodes and reduce dependence on personal vehicles. The TOD policy announced by the Ministry of Housing and Urban Affairs (MoHUA) has asked for high density, mixed land-use development in TOD zones with a radius of about 500–800 m around the transit nodes/mass rapid transit system (MRTS) stations with spacing of metro station at 1 km. This requires improvement in accessibility, walking and cycling, increase in ridership, compact walkable communities and meeting basic services within the zone. TOD development requires small block size, with finer and connected street network, optimised densities, mixed land-use, housing for economically weaker sections, multi-modal integration with last-mile connectivity, street-oriented buildings with active frontage, reduced and capped parking provisions, and at least 10–12 sq. m of open areas per person. This has also asked for value capture financing among others. The overall objective is to reduce private vehicle ownership, traffic and associated traffic demand, and prevent urban sprawl.

Aligned with the national policies, city governments are also taking on board or adopting state-level TOD policies. For instance, in Delhi, the Delhi Master Plan 2041 has integrated the TOD policy for intense mixed-use development within radius of 500–800 m around TOD nodes. It has also provided for regeneration schemes for mixed use, limited parking, built-to-edge active frontage, off-street public parking facility outside the Intense Development Area to serve as a "park-and-ride" facility, multi-modal integration, optimised density and diversification of uses and activities, enhanced mobility with fine network of pedestrian and NMT routes, and restricted and high-priced public parking with enhanced walkability and last-mile connectivity. The strategies in the TOD zones are expected to be guide by the public transport accessibility index.

In fact, nationally, several TOD projects have been announced or initiated. In Delhi, the Delhi Development Authority has identified

12 transit hubs to be developed as TOD Karkarduma. The Pune Municipal Corporation (PMC) has sanctioned 78 proposals for TOD zones (on metro line one and two) and five proposals on line three of the ongoing metro rail route. The Ghaziabad Development Authority has proposed TOD projects alongside the rapid rail transport and metro lines among others.

It may also be noted that MoHUA has also issued the National Habitat Standards to guide new development. According to this, at least 95 per cent of residences are to have daily needs retail, parks, primary schools and recreational areas within 400 m of walking distance. At least 85 per cent of all streets are to have mixed-use development. This needs small block sizes with high density permeable streets.

A recent notable development is the adoption of the form-based code by the Indian Railway Stations Development Corporation Limited (IRSDC). For all station area redevelopment, the precondition is to create a compact form to guide the layout with mandatory pedestrian passages through subplots that align with mid-block crossings. This prevents and eliminates walled superblocks with gates and allows accessible pedestrian networks. This has to be the guiding principle for new development to prevent locking in of carbon and energy intensity.

The idea of TOD has drawn the attention of the real estate developers as this concept of incentivising “high-density” development is attractive. But it is also clear that higher floor area ratio (FAR) does not automatically result in densification. Provision of large unit sizes defeats the purpose of densification. It is therefore necessary to link the FAR threshold with a minimum density requirement, mixed-use and mixed-income housing, along with employment and recreation options within walking and/or cycling distance. This is needed for optimal use of urban spaces and resource efficiency.

Even though the policies have evolved, integrating the right principles remains a challenge. As these key approaches to planning are ignored and neglected, any redevelopment or new development in cities stoke protest as people fear induced traffic and increased parking and congestion as new development is seen as a magnet for traffic. This has been noted in some of the key redevelopment projects in Kidwai Nagar and Nauroji Nagar in Delhi. Despite being in the TOD zones, these developments have emerged as gated communities. Yet TOD is supposed to mitigate traffic, congestion, and energy and carbon intensity by reducing the need for personal vehicles in the TOD zones.

Despite having these policies in place, almost all new developments are emerging as sprawled and gated with super blocks and walls around them, defeating the purpose of transit access. This is a lost opportunity, especially in TOD zones. Ground assessments in local colonies such as Gurugram and Gautam Buddh Nagar in the National Capital Region show how walls around housing colonies increase the nominal walking distances to local services and also metro stations to an induced motorable distance.

This also suggests that the building typologies also need to change in TOD zones. Some typologies that have emerged in cities such as Kolkata show how residential and commercial components have been integrated to mixed-use buildings with commercial, civic, retail and residential within the same blocks. Buildings have zero setbacks and active frontage, with retail facing the street. This keeps pedestrians and women safe.

Cities that have already begun deployment of diverse transportation systems have the opportunity to become more transit oriented with appropriate planning. Delhi illustrates this. Master Plans 2021 and 2014 have set a target of modal split of 80:20 in favour of public and shared transport. This needs a 1 per cent increase in the public mode trips every year and an equal reduction in private vehicular trips. But it is also stated that 60

GLOBAL TREND IN IMPROVING WALKABLE NEIGHBOURHOODS

The idea of 15-minute-walk neigbourhoods is now emerging as a global strategy. European and Chinese cities are propagating this. China's new round of Territory and Spatial Planning (TSP) adopted carbon-mitigation goals. China's Ministry of Natural Resources has adopted the Spatial Planning Guidance: Community Life Unit, which requires cities to build 15-minute (or five- to 10-minute) community life circles. Residents can access public service facilities within a 15-minute walk. Their Territory Spatial Planning Urban Design Guidelines provide for mixed-use, compact and people-oriented urban development. The Ministry of Housing and Urban–Rural Development has adopted the Urban Walking and Biking Transport System.

Even car-centric California has enacted the Sustainable Communities and Climate Protection Act (SB 375) since 2008. This requires each of California's 18 Metropolitan Planning Organizations (MPOs) to develop a regional strategy for reducing vehicle miles travelled to address climate change. They need to develop integrated land-use and transportation plans to focus development around transit. Cities that choose to comply with SB 375's regional plans receive a larger share of transportation funds as well as regulatory streamlining for projects.

This requires increased density in a station area, mixed land uses, current mix of land uses, community amenities in station areas, improved walkability, enhanced access to job centres and high-quality transit that combines housing and transportation, and improves the affordability index. SB 375 aims to reduce per capita emissions by about 7 per cent by 2020 and about 15 per cent by 2035. It hinges on the principle that increasing the number of people who live within the half-mile radius around stations can reduce per-household vehicle miles travelled by 30 per cent.

per cent of the urban area will be within 15-minute walking distance from the mass rapid transport system (MRTS) stations. The Unified Traffic and Transportation Infrastructure (Planning & Engineering) Centre (UTTIPEC) had estimated that after the full implementation of Delhi metro, about 80 per cent of Delhiites will be within 400 metre of some metro station. This is an immense opportunity to reorient urban planning to be able to increase the share of public transport usage and walking and cycling within the influence zones of the transit.

SCALING UP SAFE WALKING AND CYCLING ACCESS

Increasingly transport policies have underscored the importance of integrating walking, cycling and accessibility as the fundamental approach to low-carbon trajectory.

REINVENTING POST-PANDEMIC RECOVERY FOR SCALABLE OPTIONS

The pandemic disruption that devastated transport systems and disrupted mobility has also catalysed interest in this strategy for post-pandemic recovery. When, globally, public transport agencies faced economic setback due to hard lockdown phases, there was immediate interest in rebuilding walking and cycling infrastructure across developed- and developing-country cities. European cities implemented emergency plans to earmark and demarcate walking and cycling lanes overnight because public preference had shifted towards contact-free travel among all income classes. Cities began to develop infrastructure to support cycling and walking, e.g. bicycle lanes, expansion or repair of sidewalks, etc.

In global cities, including Melbourne, New York, Philadelphia, Chicago, Shenzhen, Edinburgh, Glasgow, Manchester and Wuhan, the city bike count increased by a range of 74–470 per cent. This led to increased use and sale of bicycle in the UK and in European countries and USA. Big investments were planned to create bike lanes in cities of Australia, California and France, among others. In fact, New York has adopted an ambitious plan to reconfigure road space for walking and cycling. London implemented streetscape programme leading to repurposing of traffic lanes and parking spaces for temporary bicycle lanes, pedestrianisation of school streets etc. Extensive cycling networks were mapped out and new car-free zones were identified. In fact, during the pandemic, London proposed an increase in congestion charge from UK £11.50 to UK £15.

Even cities in poorer countries have shown more strident interest in these measures. In Kampala, Uganda, pandemic restrictions on public transport promoted cycling. As Uganda has adopted the Non-motorised Transport Policy, it has paved the way for open street events, integrated walking and cycling corridors to promote contact-free and safe modes of transport.

Addis Ababa, Ethiopia, has adopted the Safe Cycling Programme, the pandemic catalysed further expansion of the bi-directional cycle corridor launched as part of Addis Ababa's Non-Motorised Transport (NMT) strategy and safe cycling programme.

It started with the National Action Plan for Climate Change in 2014 after which the National Mission on Sustainable Habitat were framed and sustainable habitat standards launched by the Ministry of Housing and Urban Affairs to address the issue of mitigating climate change. Subsequently, the Smart City Programme and AMRUT, among others, have taken on broad the principles of sustainable mobility.

These policies, and the national habitat standards, have taken on board the fact that walking is critical for the success of public transport as each public transport trip requires walk trips

for access. Walking can reduce vehicle use for short distance commuting. Walking is equitable as the urban poor are too poor to even afford a bus ride for daily commuting. Walking enhances urbanity, lifestyle and health and demands safe environment. Street design must facilitate pedestrians to remain at ground level with comfortable and safe access and minimum detours from the most direct path. All pedestrian facilities should be barrier free for universal access by all persons with reduced mobility, including those with hearing and visual impairments.

Walking and cycling are expected to be the most scalable solution to zero-emissions and the carbon-neutral transport trajectory globally. Yet, this is the most neglected strategy in overall transport policies. Even today, the majority of Indians walk, cycle and use public transport. According to Census 2011 data, an overwhelming 47 per cent of trips are walk and cycle trips in urban India. Yet this has not attracted requisite policy attention and budgetary support. This is reflected across the cities of developing countries of Asia and Africa. In cities of Africa, more than 80 per cent of daily commuting is by walking and public transport. Yet that has not attracted attention to build policies and investments around them.

Indian cities did not adopt specific strategies during the pandemic to promote these modes of transport. Only Kolkata reopened streets that were earlier closed to cycling during the pandemic. A Centre for Science and Environment (CSE) study during the pandemic in Delhi and NCR showed how the overall preference, especially in higher income groups, had shifted towards walking and cycling as well as use of public transport. It brought out that more are willing to shift to public transport if the systems can be modernised and expanded.

The pandemic also catalysed strategies to reduce the need for travel and reduce pressure on public transport systems in Indian cities. The strategies include work from home and reskilling of workers for digital working. There was preference for staggered

timing and roster-based attendance to reduce pressure on transit systems. Online retail has increased.

How can this crisis-induced change be taken forward as part of the post-pandemic green recovery and leverage economic recovery investments in road-building and urban renewal?

DIRECTION OF CHANGE IN INDIAN CITIES

Despite the odds, several initiatives in different cities are setting trends and generating key lessons for the way forward. Under different Central schemes, including the Smart City Programme and AMRUT, investments have flowed in targeted cities for transport and mobility. This has led to several projects on pedestrianisation and redevelopment of streets to be more people-friendly. Most of these schemes are related to designing and reclaiming road space for walking and cycling, pedestrianisation of earmarked corridors, closing traffic in selected stretches on specified days to let people experience the car-free spaces, and developing last-mile connectivity to improve access as part of the multi-modal integration plans.

These projects demonstrate the application of appropriate design specifications, integrated safe streets for people, complete street design standards, safe crossing designs and amenities for pedestrians and cyclists, visibility, lighting, shade, monitoring and more. These are further supported by bike-sharing systems for last-mile connectivity.

Moreover, the Place-Making Marathon, an initiative under the Smart Cities Mission of the Ministry of Housing and Urban Affairs (MoHUA), encourages cities to reimagine their public spaces and transform them within 75 hours. So far, 43 cities have worked to transform more than 85 public spaces.[15] These projects aims to create flagship walking initiatives in cities that focus on place-making and livability.[16] The Happy Streets initiative in Ahmedabad, for example, is a place-making activity that seeks to reclaim spaces for pedestrians and bicyclists. Khau

Gali, previously vulnerable to illegal encroachments, haphazard parking and traffic snarls, was rebranded as a Happy Street.

A Happy Street is a well-designed street with dedicated spaces for food outlets, paid parking facilities, accessible and quality public spaces for walking and cycling. The street is used mainly in the evening, when traffic is banned on this 325-metre stretch. The objective is to encourage social gatherings on a "must-visit" food street in the city.

There are significant lessons from these emerging good practices that need to be captured to inform the roadmap for scalable change. These programmes demonstrate good technical support for design and execution and ability to mobilise knowledge support and political and policy leadership within the departments to drive the programme. Street design guidelines, policies for non-motorised transport, better integration with larger transportation systems and policies in which requirements of walking and cycling have been bundled together, targeted funding support, improved buy-in from multiple departments and capacity building and local public awareness need to be adopted (see *Box: Walking and cycling initiatives in Indian cities: Lessons from good practices*).

Why these programmes are not scalable?

For an ambitious transport decarbonisation roadmap, it is important to understand the roadblocks to implementation. These barriers will have to be addressed to build the solution to scale.

Pedestrian and cycling infrastructure for improved accessibility is not prioritised for funding: Smart City programmes have focused on safe infrastructure and non-motorised transport as priority areas for the cities' competition. While it has catalysed several initiatives in different cities, these initiatives have not been scalable. An assessment of fund allocation under Smart Cities programme for 100 cities in 2018 showed only about 4 per cent of Rs 48,000 crore being allotted to non-motorised infrastructure.

WALKING AND CYCLING INITIATIVES IN INDIAN CITIES: LESSONS FROM GOOD PRACTICES

Several cities have implemented walking and cycling projects to improve accessibility, last-mile connectivity and multi-modal integration.

The Ministry of Housing and Urban Affairs (MoHUA) annually assesses and awards good practices on transport and mobility for its flagship programme Urban Mobility Initiative. The assessment captures on-ground changes in different cities of India. It indicates the direction of change even though the scale of change is still limited.

The following is a snapshot from some cities.

Delhi: Delhi was one of the first cities to adopt its own street design guidelines, and its master plan defined the accessibility requirements. The draft Master Plan 2041 prescribes that any road with width less than or equal to 18 metre and receives an hourly traffic of more than 8,000 pedestrian traffic per hour should be notified as a pedestrian-only zone. It has also proposed creation of active travel areas (ATAs) and walk plans, city-level active travel networks, and micro-mobility.

The initial 40 km of walking and cycling network was developed around games venues during the Commonwealth Games in 2010. Delhi has now notified the 2019 draft policy for enhancing walkability, which is awaiting approval.

In 2021, the Government of National Capital Territory of Delhi (GNCTD) announced a budget of Rs 5,000 crore to redesign 500 km along 162 PWD roads by 2023. The Delhi Development Authority (DDA) has also announced a 200-km dedicated corridor for pedestrian and cyclist by 2023. While PWD roads are mostly arterial and highways, DDA constructs the inner urban roads of Delhi.

In August 2021, the Delhi government announced beautification of 540 km of a 100-foot-wide road network to include redesigned footpaths, cycle tracks, plantation, lighting and drainage design. As of September 2021, seven of 150 stretches were proposed for beautification, with an outlay of Rs 500 crore. This was to be completed by 2023. Eight stretches are currently short-listed for implementation. In February 2022, the Delhi government announced that 1,300 km of PWD roads in Delhi will be pothole-free within a month. There is also a proposal to pedestrianise 21 commercial streets and another nine walk plans. These are at various stages of approval and sanction for implementation.

Some of the successful initiatives are pedestrianisation of Ajmal Khan Road and the main road of Shahjahanabad in Chandni Chowk. Initial surveys show positive feedback from the shopkeepers and shoppers in the areas. People have supported the public place-making and public amenities, barrier-free movement etc. The shopkeepers have observed increase in buyers' footfall, convenience of dealing with customers and reduction in theft from stores.

But longer-term operation and maintenance of the project is becoming increasingly difficult partly due to slackening of policy interest and local resistance. This is evident in Ajmal Khan Road. In 2020, vehicles were

allowed to ply again on these pedestrianised roads. In 2021, roll-back of pedestrianised roads was announced again.

As per a CSE assessment at 12 locations, the identified road stretches to be redeveloped show that they have considerable right of way, pedestrian footpaths, plantations and lights. These road stretches are not in areas with high footfall, and their utility hence remains low.

New Town, Kolkata: New Town has created 35 km of dedicated graded and at-grade cycle tracks, with proper segregations, adequate lighting and safe intersections. The tracks have earmarked cycle crossovers, cycle signages and signals, and CCTVs all along. It provides free parking for cycles. New Town has introduced public bicycle sharing, with a fleet of 100 e-bikes and 400 pedal bikes and 21 cycle-docking stations for e-bikes and pedal bikes. The satellite city has a supportive infrastructure, including mobile cycle repair clinics, cycle training camps and app-based public bicycle sharing system supported by 100 km of barrier-free pedestrian-friendly footpaths.

Chennai: About a 1.4-km stretch in Pondy Bazaar in Thyagaraya Nagar has been developed as a pedestrian plaza and designed for basic safety and convenience for pedestrians. It has addressed essential pedestrian amenities and caters to all road users. It has addressed all street services, including smart ducting for utilities such as storm-water drains, water supply and electrical cables to prevent frequent digging of roads. It has widened the footpath to up to 10 feet from the previous 2–3-foot width, with appropriate lighting, trees and planters, utility design, bicycle sharing, and facility for parking of non-motorised transport. This project has reclaimed space from carriageway for walking and cycling.

Bengaluru: Church Street First in Bengaluru is to be a pedestrianised street under the Clean Air Street Initiative by the Directorate of Urban Land Transport (DULT), government of Karnataka. The initiative started by closing vehicular traffic during the weekend from 10 a.m. to midnight in November–April 2021. An Indian Institute of Science (IISc) assessment shows that in three months footfall increased by 92 per cent, and during peak time by 117 per cent. There was appreciable improvement in visitor perception. The initiative also reduced air pollution exposure in that area.

Ahmedabad and Surat: Both Ahmedabad and Surat have extensive public bicycle-sharing (PBS) networks, with many PBS stations located along bus rapid transit system (BRTS) corridors or stations. The Amdabike Initiative has 500 stations, with approximately 1 lakh registered users. The system generates the highest ridership—amounting to approximately 1,500–2,000 bicycle users per day—in winters. Surat's PBS has 120 stations and a ridership of approximately 1,000 bicycle users per day in winter. Both cities have leveraged their respective BRT systems to build public bike sharing systems. Bike fleet operators are being encouraged to set these systems. Large bike-fleet operators are expected to have a fleet sizes of 1,000 bikes. Surat is orienting the deployment strategy to connect education, work and recreational centres in the central area.

Indore: In Indore, the Atal Indore City Transport Services Limited (AICTSL), the public transport special purpose vehicle (SPV), has a target of deploying 3,000 and more bicycles across the city. There are 100 docking stations, and a target of 300 and more docking stations. AICTSL, along with Municipal Corporation, has provided the space for docking stations and also maintains footpaths and cycle tracks. Space was provided at cycle tracks and footpaths for better access to users. The city has also learned from its past experiences

of these systems not being able to generate revenue. The focus has shifted towards increasing revenue from usage of bikes rather than advertisement space.

Srinagar: Srinagar Smart City Limited is developing pedestrian-friendly walkways and dedicated cycle tracks based on street upgradation projects, covering a length of 200 km and including different stretches of roads. This includes pedestrianisation of Polo View High Street, Lambert Lane, Goni Khan Market Street and Shalimar Canal. Public spaces such as Riverfront, Lal Chowk Precinct, Karan Nagar, Gole Market and Nishat Precinct are also being upgraded. This will also be supported by e-bike sharing. It is being executed by the Srinagar Smart City Limited.

Pimpri Chinchwad, Pune: Pimpri Chinchwad, in the northwestern city limits of Pune, has developed a walking and cycling infrastructure along 45 km of the BRTS corridor. It has a dedicated non-motorised transport (NMT) corridor. Under the Urban Streetscape Project, the Pimpri-Chinchwad Municipal Corporation (PCMC) has implemented 25 km of NMT infrastructure, with an aim to expand this to 60 km. It has been funded with Smart City and municipal funds. The city is developing a Harit Setu Master Plan to connect all green areas, important landmarks and land uses with a seamless walking and cycling network.

Gurugram, Haryana: Gurugram, 32 km southwest of New Delhi, is among the 11 awardees of the Smart Cities Mission initiative Streets4People Challenge to make city streets pedestrian-friendly. The Gurugram Metropolitan Development Authority has created the 10 km dedicated cycle track along Netaji Subhash Marg connecting HUDA City Centre to Subhash Chowk. This 10-km-long, 5-m-wide cycle track has been built converting the service lane on either side of Netaji Subhash Marg.

Jabalpur Smart City: A non-motorised corridor is being developed along a 9.57-km stretch of the Omti Nala. It combines uplift with a proper footpath and cycling plan. The sewerage and storm water drains are being revamped. This has been developed as part of the smart city projects.

Hyderabad: Hyderabad is combining a non-motorised corridor with solar power generation. This is being planned along Nanakramguda to Telangana State Police Academy (TSPA) and Narsingi to Kollur along the service road of Outer Ring Road, covering about 23 km of cycle track.

Ranchi: Public bicycle sharing was launched in 2019, with 600 bicycle and 60 docking stations in major locations covering an area of about 11.5 sq. km. It is planned for wide-area coverage to ensure rich connectivity for colonies, coaching institutes, colleges, parks, offices, employment zones and major locations.

Ujjain: Ujjain targeted 25 PBS hubs with more than 5 km of existing cycle tracks. It plans to redevelop a 2.1-km stretch as a complete street with a 4.5-m-wide cycle track, 7.5-m-wide e-rickshaw lane, 1.7-m-wide tree lane, 6-m-wide pedestrian lane, and 4-m-wide sitting lane with landscape pockets. This will be developed as a public plaza.

Even when Clean Air Action Plans for 132 cities under the National Clean Air programme mandated preparation and implementation of zonal plans for developing walking and cycling networks, safe streets and more, these requirements

were not internalised in departments' planning and spending of municipalities and municipal corporations. Although more than Rs 6,000 crore has been allocated by the 15th Finance Commission for the implementation of the multi-sector Clean Air Action Plans to 42 urban local bodies and urban agglomerations, there is barely evidence of this fund being used to improve walkability and accessibility. This is despite the fact that the Central Pollution Control Board requires all cities to report progress—that includes several indicators related to walking and cycling infrastructure—every quarter on the implementation of Clean Air Action Plans.

Most projects are conceived as pilots without a roadmap for mainstreaming it with the state infrastructure policy: These measures are not treated as a priority for annual spending by the concerned departments. The departments have no roadmap for continued operation and support either. This is most evident in the public bike sharing systems created in different cities. Often, after the initial investment in the infrastructure and fleet, the system falls into disuse and bicycles are stacked with no clear ownership of the project.

Even with a mandate the components related to walking, cycling and last-mile connectivity are neglected in the project development: According to the Metro Policy, 2017, every proposal for metro rail should necessarily include proposals for feeder systems that help to enlarge the catchment area of each metro station at least to 5 km. Last-mile connectivity through pedestrian pathways and non-motorised transport infrastructure, and induction of facilities for paratransit modes are essential requirements for availing Central assistance for the proposed metro rail projects. State governments are also required to commit provisioning of feeder systems for the metro rail proposed for availing Central financing assistance. But in reality these are not developed as ancillary development is seen as increasing the cost of projects. Also, multiple land ownership patterns around station areas complicate execution of these projects.

Municipalities and other road-owning agencies often complain of increased cost associated with proper development of walking and cycling infrastructure according to the all road users and people-friendly guidelines. Qualitative improvement of infrastructure is seen as adding to the costs in relation to the level of impact. For example, Ahmedabad's Happy Street cost Rs 8.5 crore to build a stretch of 325 metre,[17] which is three times more expensive than a two-lane road with paved shoulders[18] (Rs 6–8 crore per kilometre). It is not clear why this cost escalation on account of people-friendly roads is seen as an obstacle when more capital-intensive underpasses, overpasses etc. find greater support.

Inadequate skills and technical knowledge for implementing complete streets and pedestrianisation projects: While the road sections are designed in accordance with multiple Indian Road Congress (IRC) codes and design manuals, the network development for walking and cycling is rarely taken into account. Planning for network scalability is done on an ad hoc (or as required) basis, rather than with a vision, planning and targets to meet the needs of all road users. These requirements are not built into the detailed project report (DPR) and in the terms and conditions of the concessionaires and contractors. As a result, the market for such skills remains limited. Departments have not paid attention to building the requisite skills.

Multiplicity of agencies for road development and urban planning impede comprehensive street and area planning: There are multiple authorities for road planning, designing and maintenance and area development. Walking and cycling projects are therefore executed in a fragmented manner. More often than not, the Urban Development Authorities plan and approve projects, and state Public Works Departments (PWDs) construct within their jurisdiction.

But the responsibility of maintaining the infrastructure is often with the urban local bodies with little or minimal fund allocation. For instance, roads in Delhi are held by nine agencies that

includes four municipal corporations, the National Highway Authority, Delhi State Industrial & Infrastructure Development Corporation Ltd (DSIIDC), Irrigation and Flood Control (I&FC) Department, and Delhi Development Authority (DDA). Therefore any design improvement will require action on the part of the multiple authorities in an aligned manner. This impedes all street development and multi-modal integration projects as the land of the project areas can be owned by the metro rail, municipal corporations and PWD. Fixing responsibility for implementation of aligned design becomes a problem.

Pedestrianisation plans need effective management, monitoring and restraint measures: Pedestrian plans need supportive measures for operation and maintenance of the targeted zones and enforcement of restraint measures to eliminate motorised traffic. These programmes are designed with integrated restraint approaches; organised, restricted and paid parking; spaces for walking and cycling; rerouting of through traffic; soft traffic infrastructure change; tactical design; and parking tickets for residents and more.

Some of the established programmes such as pedestrianisation of Ajmal Khan Road and Kamla Nagar Market are already under stress as the street rules are violated and local shopkeepers resist change. In the absence of strong monitoring and enforcement, the systems fall apart. A recent review of the Ajmal Khan Road showed that intrusion of cars has begun.

Gurugram attempted to conduct pedestrian-only trials on a 600-m stretch of Sadar Bazar in March 2021. But this programme could not adopt vehicle-restraint measures or block access traffic. It had only deployed traffic police to advise not to ply vehicles. The vehicle-free trial was meant to last for a week but this faced opposition from the local shopkeepers. The Municipal Corporation Gurugram had to alter the plan. While restriction on four-wheelers has continued somewhat, entry or

exit of two-wheelers is not regulated. Unregulated parking and encroachments have continued.

Cities need mandate and funding support to implement adequate measures to scale up dedicated pedestrianised areas, streets or pockets for impact and low emissions zones. Municipalities will have to be made accountable and penalized for such violation and deviation from the plan. Cities and towns need to create a comprehensive list of high footfall areas and streets for planned pedestrianisation, to restrict movement of vehicles and increase connectivity with electric vehicles. This is needed to create low-emission zones in the city.

Without a city-wide mobility strategy bicycle-sharing systems are used suboptimally: Under various programmes, including the Jawaharlal Nehru National Urban Renewal Mission (JNNURM) and Smart City programmes, about 20 cities have launched cycle-sharing schemes. CSE's ground assessment in Delhi, Noida, Ahmedabad, Surat, Bhubaneshwar Bhopal, Gwalior, Pune and Pimpri-Chinchwad show suboptimal use of these systems. Pune has one of the most extensive networks of cycling lanes adding up to 834 km along with dedicated NMT crossing, designed PBS docking stations and designated space for on-street parking. However, as of 2022, many docks stand empty, broken or removed. Not many cyclists are seen in these lanes.

In Delhi, Dwarka has one of the better systems planned with 5,500 state-of-the-art bicycles along with 100 km of cycling tracks along metro stations and residential blocks. The first phase aimed for 2,500 cycles and 300 stands, followed by the second phase to have 3,000 or more cycles. In 2016, a bicycle-sharing policy was notified. Dwarka has better infrastructure network with adequate right of way (ROW), service lanes, pedestrian footpaths, cycle lanes, signages and lighting. The usage is still negligible. Delhi has also witnessed a rise in the cycle rental business in the heart of city. There are Yulu bikes at metro stations and market areas,

including Connaught Place and Khan Market, Delhi University, Lodi Gardens, Satya Niketan, Green Park, Delhi Haat, Vasant Lok, Chittaranjan Park, Hauz Rani and INA Market.

Both Ahmedabad and Surat have extensive public bicycle sharing (PBS) networks. However, the cycling infrastructure needs further design improvement, especially more traffic calming and safe passage at intersections. While there are over 50 km of cycling tracks in both cities, intersections are still cause of concern. Thus, continuous design improvement to meet the concerns and safety of users will have to be addressed for an upscaled operation.

Walking and cycling projects as standalone beautification initiatives do not meet functional utility—build infrastructure where people are: It was observed in several cities upgraded walking and cycling lanes are not in high footfall areas and are used mostly for leisure and recreation. In fact, redeveloped roads in Delhi are not in high footfall areas and are not well utilised. The 10-km cycling track along Netaji Subhash Chandra Bose Marg was launched in October 2020 by the Gurugram Metropolitan Development Authority (GMDA) and Municipal Corporation of Gurugram (MCG).[19] But the cycle track is underutilised, with an average of less than five bicyclists using the track in 15 minutes. Non-motorised transportation (NMT) projects need to be designed for utilitarian (work, market, etc.) trips.

Access to transit needs more qualitative improvement in access to NMT infrastructure: In line with the Indian Road Congress (IRC) codes, IRC 124-2017,[20] BRT corridors are designed to improve accessibility to BRT stations. The IRC code stresses that walking and cycling provide last-mile connectivity to BRT stations. Such requirements are integrated in BRT design. But sometimes this is done with no regard to the surrounding land use. Most BRT corridors are seen to contain footpaths and bicycle tracks, but they are rarely used by pedestrians and bicyclists. Locations where walking activity is higher do not have adequate facilities.

For example, in Ahmedabad, the Maninagar BRTS is a terminal station with access to the nearby railway station and the BRT station draws commuters from the rail station. But Maninagar has no specific footpaths, cycle tracks or public bicycle-sharing (PBS) systems. Commuters at this location find access from the railway station difficult. The nearby foot-over bridge is not favoured, which forces people to use the busy road (without footpaths) to reach the BRTS station.
It has also been noticed that spaces under flyovers are either converted into citizen parks or for PBS systems. But these newly formalised public spaces are rarely used by common citizens. One of the famous place-making projects is the space underneath the Shaheed Veer Bhagat Singh Flyover at Parle Point in Surat, Gujarat, which has now been converted into a PBS station alongside a recreational space. The survey count shows that three bicycle users visit in two hours. The location of the PBS station is not appropriate for utilitarian trips.

Poor accessibility of neighbourhoods impede progress: In most cities, unplanned low-income areas have limited access to affordable and efficient public transport services. Planned and richer areas are better connected, but are still not up to the mark. If all settlements—planned and unplanned—are not equally well connected with public transport services and are not made accessible, the capital will fail to implement fully its sustainable, low-emission forms of travel (such as walking, cycling or public transport). This requires immediate improvement in neighbourhood scale accessibility to bus and metro services and minimisation of interchanges.

CSE carried out a ground-level assessment of infrastructure for accessibility in 16 settlements in south Delhi, including neighbourhoods of varying economic status. Predictably, the planned settlements and higher income neighbourhoods performed better on most criteria compared to unplanned settlements dominated by the poor. But even planned colonies fell short of the benchmark for accessibility as provided in guidelines

and standards and are deficient in public transport-oriented design. This incites dependence on personal vehicles in these neighbourhoods.

Unplanned colonies are greatly burdened with legacy problems as they have grown incrementally and without any planning support. They are already densely built, with massively constrained infrastructure. There is barely any space left to manoeuvre as all vacant and open spaces have ceased to exist. Comparison of locational advantages and disadvantages of settlements shows that planned settlements are 2.8 times better placed than unplanned settlements. Planned areas have on average 1.6 times more road space and 1.4 times more open qualitative spaces.

On the criteria of "interface between settlement and the city", planned settlements are about 1.3 times better connected than low-income unplanned settlements. Again, within the low-income settlements, planned low-income settlements have a relatively better chance of being located strategically in relation to a major economic hub and important locations within a city. In unplanned low-income settlements, inter-modal transfer requirement increases the waiting time for a mode by 1.1–1.6 times. Most importantly, this increases the cost of the journey. In fact, the monthly cost of transport increases by 1.5–3.5 times.

On the criterion of "quality and affordability of access to public transport services", planned areas have 1.5 times better access to connecting and boarding points of public transport systems, such as metro stations and bus stops, than unplanned areas. Planned formal public transport networks are more accessible in planned settlements. Low-income unplanned colonies depend on informal and shared Intermediate Public Transport (IPT) like Grameen Sewa to access other systems and services. This adds to the cost as well as the hardships faced by these settlements as these systems do not necessarily penetrate deep due to infrastructure limitations. These modes also have huge route restrictions.

On the criterion of how people move and access services and amenities inside settlement clusters, most of the settlements do not have adequate amenities and services such as schools, markets, ATMs, convenience stores, pharmacies, etc. within the neighbourhood. As densely built unplanned settlements have limited land availability, and the quality of infrastructure does not comply with applicable design standards, people are forced to depend on mobility services to access several services beyond the neighbourhood. This increases (motorised) transportation requirements as the services are not within walkable distances. In fact, planned areas have 1.3 times better intra-neighbourhood accessibility than unplanned areas.

On the criterion of "status of accessibility infrastructure within neighbourhoods", all areas fall short of meeting the requirements of infrastructure for all street activities for safe access and connectivity. Unplanned areas are impacted more. Higher-income planned settlements have about 1.8 time more infrastructure than unplanned settlements. Streets of high-income areas are 1.7 times more walkable, IPT penetration in these areas is 1.9 times higher, and the sense of safety is 1.7 times higher.

It is therefore necessary to frame guidelines and mandates for improving streets and access infrastructure in both planned and unplanned low-income settlements. Settlement-wise and neighbourhood-wise plans for improving accessibility and connectivity along with city-wide deployment of integrated and affordable public transport services that deeply penetrate and connect neighbourhoods efficiently are needed. It is necessary to implement settlement-level plans to improve access and minimise modal interchanges to connect with city-wide public transport systems. Buses and metro services need to be easily accessible by walking and cycling and through feeders and intermediate public transport systems that penetrate deep inside neighbourhoods.

Housing programmes need to be integrated with transport connectivity and accessibility requirements. Data-driven action

for targeted improvement in all settlements and for tracking data on geospatial attributes of settlements and from surveys on layouts, built-up areas, availability of open spaces, street and circulation networks, encroachments, mobility patterns and level of public transport services need to be initiated. State governments and municipal corporations should be encouraged to create dedicated funds and institutional arrangement for local area improvements and infrastructure augmentation in settlements.

VEHICLE-RESTRAINT MEASURES

As part of the low-carbon trajectory, global cities are also increasingly adopting a series of restraint measures to reduce use of personal vehicles. A variety of instruments are in place, including parking policy as a demand-management measure, congestion and road pricing in targeted zones, and implementation of low-emission zones to regulate entry and exit of polluting vehicles and to promote walking and cycling. These strategies are broadly based on the polluter-pays and the user-pays principles to eliminate the hidden subsidy for personal automobility and also recover the cost of environmental damage from vehicle users. Cities in Europe and China have begun to implement a combination of these measures. Additionally, Chinese cities, including Beijing and Shanghai, have capped the number of cars that can be sold in a year exempting only zero-emission electric vehicles.

Indian cities are still far behind in implementing any of these strategies. The only strategy that has been taken on board as part of the National Urban Transport Policy and local policies or master plans in cities in a few cities is the parking policy.

The genesis of this is the series of rulings from the Supreme Court and the deliberations of the Environment Pollution (Prevention and Control) Authority (EPCA), which had asked for parking policy as a demand management measure in 2005–06. This had categorically underscored that parking for personal vehicles

cannot be considered a public good. Its provision needs to be based on the user-pays principle to eliminate subsidised parking. The National Urban Transport Policy 2006 asked for parking as a restraint measure by limiting availability of parking space and levying high parking fees to curb use of personal motor vehicles. Subsequently, the Lt Governor Committee-2014 and Master Plan of Delhi 2021 defined the Parking Management District approach for optimal use of scarce public land; parking management strategies on the user-pays principle; and prioritisation of pedestrians, cyclists, users of mass public transit, emergency vehicles, differently abled persons, paratransit and non-motorised vehicles over personalised motor vehicles. In fact, the Transit-Oriented Development (TOD) Policy asked for area-wise caps for private vehicle parking in TOD zones. The Master Plan of Delhi (MPD) 2041 has linked parking provisions in areas based on public transport accessibility index of areas in the city and restricted on-street parking near metro stations and near multi-level facilities.

In 2019, the Transport Department of the National Capital Territory of Delhi finally notified the Maintenance and Management of Parking Rules, 2017 along with the Parking Management Area Plan (PMAP) for the National Capital Territory of Delhi.

However, the principle of demand management is not understood well and despite the policy changes at the national level and in a few cities such as Delhi or Bengaluru, on-ground implementation is slow and contested. The approach has remained supply-driven and includes isolated decisions to build multi-level car parking facilities that remain underutilised due to pricing distortions and free parking in the area and incentives to the real-estate industry to provide more parking in built-up areas.

LESSONS FROM DELHI

Delhi is the only city in the country to have a notified parking policy and rules as a demand management measure. The trigger

has been the Clean Air Action Plans in the city asking for demand management measures. The comprehensive Clean Air Action Plan that was notified under Sections 3 and 5 of the Environment Protection Act following the Supreme Court directive led to the notification of the parking rules. On September 23, 2019, Delhi government notified the Delhi Maintenance and Management of Parking Rules, 2017 along with the release of the *Parking Management Area Plan (PMAP) for National Capital Territory of Delhi: A Guidance Framework*. The Parking Rules, 2017 were notified under Section 212 of Motor Vehicle Act 1988. This aligns with Clause 2.5.3 of the Comprehensive Clean Air Plan, earlier notified in June 2018 to improve the air quality. This is the first-ever legislative backing to parking management as a vehicle-restraint measure in the country.

The objective has been to reduce pollution and congestion and bring down the total demand for parking space from personal vehicles while providing other modes of transport, i.e. buses, commercial vehicles etc. This includes time-based variable pricing as per duration, location and size of vehicles, parking permits in residential areas, preventing parking in non-designated areas and imposition of penalty as a deterrent for illegal parking.

However, the fundamental shift in approach has been to adopt an area-wide approach to have parking management area plans (PMAP) instead of spot fixing with multilevel car parks as stand-alone projects. The entire PMAP approach is based on restraint principles on the ground that free parking on public land and on-street is not a public good and it is not the responsibility of the government to provide it. Parking supply should be determined by the market on a payment basis. Vehicles are parked for 96 per cent of their lifetime on roads. More than 80 per cent of parked fleet are personal vehicles, which puts enormous pressure on street space. Parking demand is insatiable and needs to be contained as it diverts land for other essential services such as health services in neighbourhoods and housing for the poor.

Parking caters to the need of a small vehicle-owning minority. All other uses of public land, including social events, hawking and night shelters for poor, need permission and payment. Parking also induces more gated development.

PMAP requires delineation of parking management area plans ward-wise. It will inventorise, identify and demarcate on-ground legal parking areas—on-street and off-street—in designated areas. It will assess the accumulation of demand for parking—on-street, off-street and multi-level parking facilities—as well as all other street activities, including walking, cycling, vending, etc. to provide organised space for all. Identification of parking slots will ensure that parking is not allowed on footpaths, in green areas or parks, or near intersections etc. Parking facilities will be managed as shared, priced and public parking for maximum utilisation of the assets; multi-level parking will be allowed only if the larger PMAP requires it. Parking in residential areas will also be developed based on PMAPs along with the local resident welfare associations and residential parking permits, and ensuring that narrow roads have at least one protected lane for easy passage of emergency vehicles. Legal parking areas will require IT-based facility management, and parking contracts will have to be reformed accordingly. PMAP also needs to include strategies for organised parking for other vehicle segments, including buses and commercial vehicles.

Parking will have to be considered a complete street management to address the needs of all road users in the following order of priority: pedestrians, cyclists, public transport related to multi-modal integration, paratransit, pick-up and drop-off requirements, hawking zones, resting areas etc. All interests will have to be balanced equitably while providing for parking. This will follow the relevant guidelines of the Indian Road Congress and Street Design Guidelines.

PMAP will include variable parking pricing based on duration and the user-pays principle. The Delhi Rules have proposed

a formula for fixing the base price and variable and dynamic parking charges to moderate and influence demand for parking. A differential between off-street and on-street parking lots will be maintained—on-street parking needs to be twice as much as off-street parking. Penalty for illegal parking is also included. The municipalities will require to use part of the parking revenue for local area development (pedestrian safety, non-motorised lanes and development of parking lots etc.) to build local public support.

This demand management approach of PMAP has questioned the current obsession with only making parking facilities or multi-level parking, with the expectation that this supply-driven approach will solve the problem. But in reality, unless on-street parking is restricted and managed in an integrated way, multi-storey parking will not be used. Low on-street parking fee discourages use of multi-level parking. Ingress and egress can aggravate local congestion if not planned well.

PMAP technically while organising the parking well also caps the availability of parking in a given area. Following the notification of the Parking Rules, the Supreme Court directed piloting the PMAP concept in three selected areas representing different land uses. Accordingly, three areas—Lajpat Nagar III (South Delhi Municipal Corporation—SDMC), Kamla Nagar (North Delhi Municipal Corporation—NDMC) and Krishna Nagar (East Delhi Municipal Corporation—EDMC)—were identified for implementing the Parking Area Management Plan (PAMP) and report was submitted for the same in December 2019.

These were implemented successfully as local solutions were identified related to identification of parking for residents and guests, spillover from adjacent areas managed and restricted, access for emergency vehicles provided, authorised parking area for demand for excess parking designated, parking from pedestrianised stretches removed, and parking stickers and signages etc. provided.

In Kamla Nagar, on-street parking for local residential roads was demarcated in 2019. Parking was prohibited on major roads and roundabouts. On-street parking was discouraged and car users were to use the multi-level car parking (MLCP) at Spark Mall that otherwise had utilisation of only 40 per cent of its capacity. Measures addressed conflict points due to entry and exit of vehicles and ensured soft segregation of traffic flow and road marking. There was provision of paratransit services to connect public transport. It led to pedestrianisation of the central market stretch. Parking stickers were to be issued by the resident welfare associations (RWAs) along with emergency stickers to residents. All designated parking became paid parking. Night-time and daytime charges were to be fixed in negotiation with Spark Mall. A monthly rate for residential parking was to be reached and enabled. All of this was done in consultation with the resident welfare and traders associations.

Implementation of the pilot schemes led to the Supreme Court directive of August 10, 2020, which directed that a draft parking policy for the NCR region in consultation with the concerned state government (urban local bodies and stakeholders in the NCR states of Haryana, Uttar Pradesh, Rajasthan and Delhi) needed to be framed and submitted on August 19, 2020. But the pandemic disruption and lack of interest stymied its implementation.

Challenges in implementing demand management measures

Travel demand management measures for low-carbon trajectory has been the slowest to develop in Indian cities. There is also active resistance to the idea. Even though a few other cities, including Bengaluru, have adopted parking policies integrating demand-management principles, their implementation has not been at scale. A few cities are attempting to bring in demand management. In 2021, Bengaluru decided not to provide for parking space in its busiest metro stations to retrain private transport. In August 2022, a new report said that Bengaluru was to conduct a due diligence parking demand assessment survey on streets with heavy parking demand to manage parking.

On-street parking practices in Pune reflect how better management can impact the flow of traffic in cities. In areas with narrow roads, Pune Traffic Police have adopted the odd–even practice, where parking on odd days is on one side and on even days on the opposite side. However, a comprehensive approach to parking demand management and restraint is missing.
Even though there has from time to time been reference to congestion pricing in Mumbai or Delhi, there is no roadmap for its implementation.

The Union Budget of 2021–22 has also taken on board the concept of special mobility zones in cities to promote sustainable modes in designated areas. But no city has been able to implement this. Bhubaneswar is developing a concept plan for a low-emission zone around the Lingaraj Temple as specific support is available. But these strategies are not yet part of any city policy.

The toughest battle is to implement carbon or pollution pricing for mobility. If parking charges are a proxy of that approach, there is enormous resistance in cities. This is despite the fact with increased car ownership and inadequate parking to meet the growing demand for parking in neighbourhoods, market forces are coming into play. In several localities of Delhi, the Resident Welfare Associations (RWAs) are self-organising—and are demarcating and pricing parking areas within the locality. For example, the apartment blocks in Patparganj in East Delhi have implemented a rule by which one car has free parking but parking for a second or third car is priced at Rs 200–500 per month. Similarly, in Alaknanda in South Delhi, Yamuna Apartments and Kaveri Apartments have set a rate for the first car and higher amounts for second and third cars. In Anupam Apartment Complex in Saket, RWAs charge a monthly subscription based on size of the flat and number of cars owned. Cars in rented-out garages will also be counted as the cars of the owner. If a car is junked or not in use, it is still counted. Clearly, there is higher charges for multiple car ownership.

This shows that there is an appetite for priced parking even in residential areas and the supply is becoming market-driven. But municipal policies are not responding to this.

WHIFF OF CHANGE

The appetite for parking caps and restrictions is kicking in in landlocked cities in the hills, including Gangtok in Sikkim, Shimla in Himachal Pradesh and Aizawl in Mizoram.

The Sikkim Transport Department notification has made it mandatory for buyers to produce an availability-of-parking-space certificate before vehicle registration. The Superintendent of Police, Traffic, is mandated to issue the certificates after physical verification of the parking space. Inspection is conducted by motor vehicle inspector and details submitted to the transport department along with a rough map of the site. The traffic police frames guidelines to implement the notification in Gangtok, and car dealers have received notices from the transport department directing them not to sell cars without first asking for the availability-of-parking-space certificate.

Aizawl has regulation and control-of-vehicles parking. To own and buy a car, the owner of any type of motor vehicle, including a two-wheeler, needs to have a garage within his own residential or business compound or in some other place or a garage hired from any other person for parking the vehicle.[21] Before purchasing any type of motor vehicle, including a two-wheeler, the purchaser or person intending to purchase any such motor vehicle shall be required to obtain from the Transport Department certification stating that parking for the vehicle intended to be purchased is available in a garage within their own residential or business compound, in a garage that will be hired from another person, or in some other place.

There is also a directive from the High Court of Jodhpur in Rajasthan that makes availability of parking space mandatory to car ownership. But this needs a more detailed strategy for enforcement, monitoring and verification.

NEED A STRATEGY TO BUILD PUBLIC SUPPORT

To build support for restraint measures, people need to perceive benefit from the measure. Globally, city authorities carry out campaigns as well as inform and disseminate how these measures will benefit the public. In fact, globally, parking rules provide for Special Benefit Areas to indicate how the revenue will utilised for local area improvement. Municipalities earmark parking revenue or local area development, enhanced public services and improved streetscapes, footpaths, public transportation etc.

Global experience shows how cities indicate the way parking revenue will be utilised. For example, in downtown Pasadena, California, Parking Meter Zones (PMZs) were established, with parking priced. Revenue from parking was dedicated to area improvements, including new street furniture and landscaping, police patrols, street lighting, more street and sidewalk cleaning, pedestrian facility improvements, and marketing. Each parking meter has a sticker saying, "Your Meter Money Will Make a Difference: Signage, Lighting, Benches, Paving." In Ventura, California, the municipality introduced a bylaw that states, "All moneys collected from parking pay stations, and meters shall be placed in a special fund, devoted to purposes within the parking district." In Aspen, Colorado, a downtown marketing campaign was organised to educate motorists about parking meters and parking violations. This has reduced parking problems. The city of Regina in Canada has linked parking management to public safety. All these measures help to build support for parking management and pricing.

In addition, there are also instances where cities have linked parking charges to emissions levels of vehicles as a clean air measure. Boston froze their parking requirements at a level that is only 10 per cent higher than the 1973 level to meet the Federal clean air standards. In New York, very high parking fees and limited parking supply lowered car ownership far below the average rates in other US cities. In Amsterdam, parking fees have

been expanded to meet EU directives regarding NO_2 and PM10 emissions. Car plate numbers are registered with emissions information. Trucks are allowed to unload for a maximum of 15 minutes in spots where they are not allowed to park. In Zurich, total NO_2 emissions are considered when determining the amount of parking to be allowed. In Japan, proof-of-parking regulations and ban on night parking on streets have prevented perceived parking shortages. Vehicle owners need a "garage certificate" from the police department for vehicle registration. This is reissued if there is a change in ownership or address.

Indian cities also require massive public campaigns to communicate how car users as well as non-car users will benefit from a vehicle-restraint and demand-management policy. With organised parking, reliable and predictable information about parking availability, cruising time, fuel cost and pollution reduce. Efficient billing makes payment more transparent and accurate. Chances of finding a space improves and reduces waiting time. This decreases traffic chaos due to indiscriminate on-street parking. Fees will also allow equitable sharing of local parking spaces.

Non-car users will also benefit from organised parking. Organised parking will protect footpaths and allow barrier-free walking. It will free up public spaces for cycle tracks, rickshaw parking, autorickshaw parking, playgrounds etc. Access to bus-stops, metro stations will be improved as will safety of children, women and the elderly. Visibility of shops, shopping experience and throughput of customers will improve. The overall environment, green areas and public recreational spaces will be enhanced and it will be easier for emergency vehicles such as ambulances, fire trucks, police, etc. to negotiate.

Similarly, urban local bodies also benefit as this augments public revenue that can help to fund a variety of schemes related to local area improvement, mobility strategies, walkability improvements, street lighting, maintenance, etc. Local residents benefit as people

from other areas cannot park in their area without permit. All of these provide immense public health, noise and climate benefits.

Importantly, this approach of parking as a demand management measure can a catalyse a variety of commuter decisions that can reduce vehicle trips and the attendant problem of pollution and carbon emissions. People combine trips to reduce several individual trips, avoid peak time to not pay higher parking charges or circumvent unavailability of parking, share cars with family members and colleagues, look for cheaper parking areas off-street, take autos or a taxi, use shared transport, ride share, bike share or just walk or cycle within short distances. They can take a metro or a bus, especially if they are long-duration parkers. Park and ride or park and walk can be practised. Reduced duration of parking can also reduce congestion.

Thus, in Indian cities as well as cities of other developing countries, parking policies will have to be the first step towards vehicle restraint. Parking area management plans are needed for integrated management of all street uses. Additionally, capped parking supply, pricing to regulate usage and behaviour, shared public spaces to maximise asset usage, good IT management and local area development are needed.

This will have to be supported by scaling up public transport and its integration, infrastructure for walking and cycling, targeted pedestrianisation and electric mobility, and ride sharing. Once these measures are implemented city-wide, more layers of restraint, including congestion and road pricing and low-emissions zones, can be added.

URBAN MOBILITY NEEDS ROBUST REGULATORY AND FUNDING FRAMEWORK

Under the federal structure, implementation of public transport, walking and cycling infrastructure, road and congestion pricing, pedestrianisation and low-emission zones are the responsibility of state governments. Several of these aspects are governed by the

Town and Country Planning Act and the Master Plans in cities. But the legal mandate for these interventions is often not clear and is largely discretionary at the city and state levels. Walking and cycling infrastructure is addressed in an ad hoc manner as part of overall road building and road widening for vehicles and are not designed as independent initiatives.

On the other hand, at the Central level, there is no legislation to drive this change or create a mandate. The Ministry of Housing and Urban Affairs (MoHUA) is responsible for framing policies—the National Urban Transport Policy etc.—and service-level benchmarks that are non-binding. These are advisory in nature.

The ministry has a funding arm, which is sometime linked with reforms, and is an important instrument to drive change in cities. Performance-based bus funding under JNNURM, metro funding, post-2017 metro rail policy reforms, and direct funding under the Smart Cities Mission and AMRUT are powerful instruments to enable change on ground. But these are not regular programmes.

Even though metro rail systems have infused considerable capital, the mandated reforms for constructing footpaths and cycle ways are sometime ignored at the city level as they are seen as escalating costs of the overall projects. The fiscal strategies for transportation have not yet been able to integrate the polluter pays principle and direct disincentives for personal automobility and demand management measures as a means to mobilise resources.

While detailed fiscal strategies have been adopted for the metro rail system, similar systems have not been developed for bus funding. State governments rely on basic operations and do not develop dedicated funding strategy for buses to address the capital and operational costs. There has to be a mandate for the state governments and the urban local bodies to generate their resources through innovative taxation systems and congestion charging.

There is need for a Central government scheme for viability gap funding for bus services. Bus transport corporations and undertakings are governed under the Central Motor Vehicle Act and Rules, but this is largely related to licensing of operations etc. This needs to be reformed further for a more robust funding and management strategy for bus services as a shared responsibility.

It is not yet clear how international climate finance can work for the transport sector. In the past, under the Clean Development Mechanism (CDM) regime, Delhi metro was able to access finance for its regenerative braking system for energy savings and also for inducing modal shift in the city. But urban transport solutions are not limited to transit infrastructure—it needs a bouquet of measures and customised funding strategy.

5

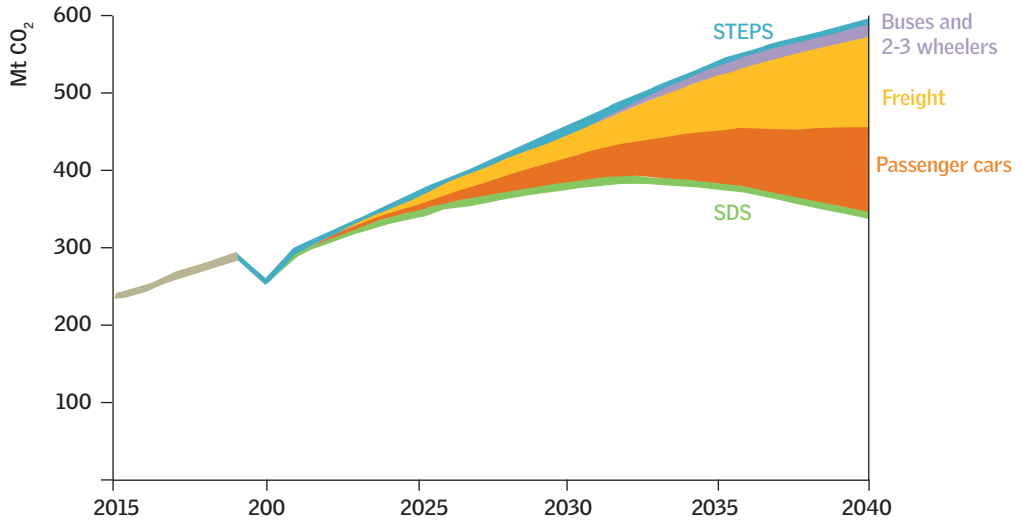
ROAD-BASED FREIGHT TRANSPORT

ROAD-BASED FREIGHT TRANSPORT

Road-based freight contributes the most to energy demand and carbon emissions from the transportation sector. This sub-sector will continue to grow with the economy. It will require a roadmap for a modal shift to a more efficient railway system and a green freight programme.

According to the International Energy Agency (IEA), freight will have the biggest CO_2 emissions impact in India (see *Graph 34: Biggest CO_2 emissions impact from freight in India*). According to the International Council on Clean Transportation (ICCT), the contribution of CO_2 emissions by road freight in 2020 in India is estimated to be 44 per cent of total road transport CO_2 emissions and is projected to increase to 49 per cent in a business-as-usual scenario. In the absence of any intervention, the emissions share of vehicles could increase to over 70 per cent by mid-century.[1] As per the 2021 report of US non-profit Rocky Mountain Institute (RMI), CO_2 emissions due to the freight transport sector in India are currently 220 million tonne, and road freight is responsible for 95 per cent of it.[2]

Graph 34: Biggest CO_2 emissions impact from freight in India



Note: Scenarios are Stated Policies Scenario (STEPS) and Sustainable Development Scenario (SDS)

Source: IEA 2021 India Energy Outlook

As per a 2017–18 Ministry of Commerce economic survey, the road logistics market in India is expected to grow at a compound annual growth rate of 8 per cent from 2020 to reach US $330 billion by 2025. Such growth will be driven by rapid expansion of the e-commerce sector and growth of the retail sales market, among other factors.[3]

As per NITI Aayog report *Fast Tracking Freight in India*, India currently generates logistics of about 4.6 billion tonne of freight annually, resulting in a transportation demand of over 3 trillion tonne-km at the cost of Rs 9.5 trillion (US $129.6 billion).[4] Further, a framework has been adopted to reduce logistics cost significantly—i.e. by almost Rs 10 lakh crore—and reduce the logistic cost as a share of GDP from 14 to 10 per cent. Indian freight transport demand is expected to increase five-fold to 3–16 trillion tonne km (t-km) over 2020–50.

As per the 2021 RMI analysis report,[5] shifting from road to rail can be the most effective handle to decarbonise the freight transport sector, which can reduce CO_2 emissions by 4.3 gigatonne between 2020 and 2050 if planned well. Following mode shifting, optimising truck usage to reduce empty running and improved axle load can minimise the releases by 2.8 gigatonne in the same 30-year period. Improving vehicle technology by using efficient vehicles and EVs can reduce emissions by another 3.2 gigatonne. Overall, this will lead to a reduction of 52 per cent cumulatively (or 10 gigatonne) by 2050 over a business-as-usual (BAU) scenario.[6]

ADDRESSING FREIGHT TRANSPORT

So far the interest in finding solutions to road-based freight has been limited. Concerns over air pollution and exposures have driven some local solutions. City-based solutions are largely oriented towards rerouting of trucks to divert traffic through bypasses or regulate time of the entry of these vehicles and confine them to night-time entry. The only additional measure that Delhi has taken to control pollution is to impose environment

compensation charge on each entry of truck and commercial vehicles daily to make it more expensive for them to transit through Delhi. Additionally, entry of trucks registered before 2006 is banned, and overloading is checked. Delhi also stops truck entry as an emergency measure during smog episodes in winter.

There have been efforts to control overloading. MoRTH has come up with an amendment to standardise the maximum load on trucks. The permissible safe axle weights of goods vehicles were advised way back in 1983. All these years the government focused on significant enhancements in improving tyre technology, vehicle design, pavement design etc. But existing Indian norms are lower than global axle weight norms. Thus, the lower axle weight has been cited as one of the key reasons for high logistics cost and occurrence of overloading. MoRTH has taken a step and revised the maximum safe permissible axle weight for transport vehicles. The notification to revise the maximum safe permissible axle weight was issued on July 16, 2018.[7]

However, local solutions have limited impact as freight movement is intrinsically linked with trade, warehouses and logistics, and unless these aspects and their spatial organisation and integration are addressed holistically, it is not possible to address the problem. Heavy-duty vehicles are the most polluting segments on the road and being users of diesel also emit high-heat-trapping black carbons that are more heat-trapping than even CO_2.

The overall policy thrust has remained on expansion of network of highways that is further propelling the expansion of trucking. The draft Logistics Policy of India (Ministry of Commerce [Logistics Division] 2019) has asked for adaptation of green freight transport and logistics. However, its primary focus is on reduction of logistics cost and improvement in the efficiency of freight and logistics operations. The key objective of the policy is to reduce the logistics cost from 14 per cent to 10 per cent of the GDP and create an additional 10–15 million jobs in the sector. It does not

DELHI MASTER PLAN 2041 AND FREIGHT

The Delhi Master Plan review 2041 has referred to shifting of wholesale and warehousing activities from the city centre to the outskirts and supporting hospitality-related interventions such as hotels along integrated freight complexes. It proposes establishment of intensive Economic Growth Corridors in NCR along the Outer Orbital Rail Corridor (OORC) and Dedicated Freight Corridors (DFC), especially the NCR portions of the Delhi–Mumbai Industrial Corridor (DMIC)— which are expected to be completed by 2032—and feeder routes to DFC, to be completed simultaneously in NCR. The DMIC corridor—including the link from Gurugram, Manesar, Rewari, Dharuhera and Bawal—is to be implemented on priority. Multi-Modal Logistics Parks (MMLPs) and dry ports should be developed to ensure seamless movement of freight.

The Master Plan review has further proposed that all metro centres, regional centres, sub-regional centres and urban areas with population of 1 lakh and above have Integrated Freight Complexes (IFCs) at the urban peripheries to serve heavy goods traffic that are integrated with road and rail systems within and outside NCR.

IFCs shall be taken up on priority and completed by 2026 in the NCR towns of Sonepat, Palwal, Bahadurgarh, Jhajjar, Gurugram, Jind, Karnal, Bhiwani, Mahendragarh, Bulandshahr, Baghpat, Ghaziabad, Muzzaffarnagar, Alwar, Behror and Shahjahanpur and Neemrana. Five IFCs, namely Madanpur Khadar, Ghazipur, Narela, Dwarka and New Site in Urban Extension (Rohtak Road) Tikri Kalan, located on various highways, were also proposed in the Master Plan for Delhi (MPD)-2021 for integration of goods movement by road and rail in Delhi to be implemented expeditiously. Plans where these provisions are not kept need to be reviewed and revised. Land needs to be provided for IFCs, which should be integrated, with the intra-urban transport network system fully covered. Closed carriages and/or freight should only be allowed for sand, coal, fly ash, construction material and other such items in the region.

It has further proposed that for highways at least one fast-charging station should be planned and set up for every 100 km.

The Master Plan for logistics in key districts of Jhajjar, Sonipat, Gurugram, Charkhi-Dadari, Ghaziabad, Gautam Buddh Nagar, Bulandshahr, Baghpat and Alwar should be prepared. Considering that the DFC and DMIC projects include part of Haryana and Uttar Pradesh sub-regions, it is recommended that logistics infrastructure such as Inland Container Depots (ICDs), Container Freight Stations (CFS) and Integrated Freight Complexes be set up in these sub-regions at strategic locations.

directly set any vision, objectives or targets for reducing the share of road-based freight and logistics emissions.

The new PM Gati Shakti programme has the potential for enhancing logistics efficiency and reducing logistics cost. This has been launched for integrated infrastructure development in

the country for a holistic approach to logistics efficiency.

The National Logistics Policy 2022 (NLP) proposes to establish a Services Improvement Framework. It has come up with an integrated data collection model named Unified Logistics Interface Platform (ULIP), an open-source platform that integrates multiple systems of different stakeholders and works on a request-response-based system. This portal provides the source of information for transport-demand identification. With transparency and visibility, truckers will be able to reduce empty movement and waiting time, thus reducing operations and maintenance costs. It supports informed decision-making and "just-In-time" inventory management. The programme also comes up with real-time process and cargo movement monitoring on a single platform, which aims for standardization of warehouses—this is essential for reducing costs, improving efficiency, and ensuring global compatibility and competitiveness. Standardisation of pallet sizes allows standardisation of palletisers, racking, material handling equipment, trucks, and warehouse design. This will result in economy of space and facilitate automation, thereby eliminating manual transfer of goods and improves the overall productivity and work efficiency.

NITI Aayog and US-based non-profit Rocky Mountain Institute have found that trucking costs are the key drivers in the transportation component of total logistics cost—accounting for more than 65 per cent of that cost—and that addressing operational causes of low productivity and efficiency in the trucking segment could create economies of scale. Solutions that have been proposed for improving efficiency and reducing costs include:[8]

- Improving quality, digitisation and automation of warehousing;
- Proposal of inter-modal logistics parks;
- Improved infrastructure for coastal shipping and railways;
- Continued investment into road network;

- Standardisation of logistics practices;
- Enhancements of parking and loading bays;
- Optimised truck routes;
- Urban logistics spaces;
- Consolidation centres and pack stations;
- Deploying big data in distribution;
- Lean supply chain management;
- Digitisation of inter-modal infrastructure;
- Digitisation of loading information, truck routing and dispatch, parking/unloading;
- Intelligent transportation systems (ITS);
- Electric delivery vehicles;
- Digital enforcement;
- Zoning and land use for logistics;
- Zoning for logistics sprawl;
- Night-time deliveries;
- Congestion feebates;
- Interoperable transport data;
- Metropolitan planning councils;
- Networked city-level innovation and incubation centres;
- Limiting the high-mileage polluting vehicles on the road;
- Strengthening pollution-under-control rule; and
- Bioethanol and biodiesel

Moreover, several green freight measures have been identified by the Government of India (see *Table 4: Green freight measures of Government of India*).

ECO-DRIVING AND OPERATIONAL MEASURES

There has been some focus on improving truck operations through eco-driving and operational measures—eco-driving behaviour and a range of technical approaches—to reduce energy consumption in trucking in the short term (see *Table 5: Operational measures to reduce fuel consumption*). For internal combustion engine (ICE) vehicles, the difference in fuel consumption due to driving style can be 15–25 per cent.[9]

The freight sector can improve their internal operations,

Table 4: Green freight measures of Government of India

Public sector initiatives, plans, projects, policies or infrastructure	Description
Logistics hubs	Government of India has started a programme to develop multi-modal logistics parks which aims to: • Reduce logistics costs • Improve freight aggregation • Improve distribution, storage and warehousing • Enhance various value-added services as labelling, packaging, tagging and crating
Initiatives undertaken by Logistics Division	Included in sectoral plan for road transport: • Measures for modernisation of fixed and rolling infrastructure and regulatory regime in alignment with NLP • Highways planning with space for truck parking, maintenance activities and pit-stop facilities for drivers • Installation of GPS on trucks • Proliferation of GST e-way bill to reduce stoppages and spontaneous inspection • FASTag toll lanes and geo-fence-based toll collection without toll booths, etc. Progress: Broad directions finalised in the NLP and shared with MoRTH
Freight smart cities	Follow a planned approach through a multi-stakeholder institutional framework to improve efficiency of city logistics while: • Reducing congestion • Reducing pollution • Creating opportunities for accelerated economic growth
Inter-modal infrastructure improvement	• Dedicated freight corridor • Sagarmala project • Port improvement projects • Road improvement projects • Freight economic corridors (inter-corridors and feeder routes are being identified for improvement)
Logistics optimisation	Logistics Efficiency Enhancement Programme (LEEP) aimed to enhance the freight transportation by improving constrains with • Cost, time, tracking, transferability of consignments through infrastructure, procedural and information technology (IT) interventions
Overloading/axle norms	The new axle load norms rolled out in August 2018 • Increased the average rated payload of trucks by about 20 per cent and barred operators from overloading
Scrappage policy	• The vehicle scrapping policy was released in 2021 by MoRTH • Heavy duty vehicles will have to undergo mandatory fitness testing by October 2023. If they fail they will be declared ELVs
Fuel efficiency standard	On August 16, 2017, Government of India and Bureau of Energy Efficiency (BEE) published final fuel efficiency standards for heavy-duty commercial vehicles (HDVs)
Fuel and vehicle standard	India has leapfrogged from BS-IV to directly adopt BS-VI emission norms in 2020
Green warehouses	Logistics policies of Haryana and Jammu and Kashmir propose that GRIHA III norms and Green Norms Incentives (LEEDS ratings) be applied for warehouses
Electric vehicles	• To enhance manufacturing of electric and hybrid vehicle technology and ensure their sustainable growth • FAME India Scheme Phase I and II (Faster Adoption and Manufacturing of [Hybrid &] Electric Vehicles in India] from April 1, 2015
Vehicle restrictions	Truck traffic is restricted on certain roads and during specific periods across all major urban areas

Public sector initiatives, plans, projects, policies or infrastructure	Description
Capacity building	MoUD, Government of India has financed development of a toolkit Urban Freight Transport Planning & Management under Sustainable Urban Transport Project (SUTP) jointly initiated with the support of Global Environment Facility (GEF), UNDP and World Bank
Institutional	The Logistics Division in the Department of Commerce was created on 7th July 2017 to ensure "integrated development of logistics sector". The division is headed by a Special Secretary to Government of India and • It has been given the order to develop an action plan for the integrated development of the logistics sector in the country by way of policy changes • Improvement in existing procedures • Identification of bottlenecks and gaps • Introduction of technology in this sector
Motor Vehicles (Amendment) Bill, 2019	The Motor Vehicles (Amendment) Bill, 2019 to address the issue of road safety

Source: CSE compilation from various sources

eliminate empty trips and encourage efficient tonnage by analysing the data collected by using a variety of tools and features. Stakeholders can identify and improve their ineffective processes using data analytics. All modes of freight and their stakeholders are making supply chain optimisation a priority with the use of contemporary data analytics solutions.

Automation will help reduce the time and resources needed for smooth first-mile and last-mile transportation. With the rise in e-commerce, companies are increasingly focusing on technologies and management systems to automate last-mile delivery, but similar attention is needed for first-mile transportation as well. Using route-optimisation software, companies can manage to deliver material from one place to another, i.e. for the first mile or last mile, in the shortest possible time frame. Also, customers as well companies can track field service personnel through which they can be informed about the status of parcels. With the help of real-time data provided by automated technologies, better measurement of KPIs and process improvements by using data analytics is possible. Also, with automation, companies can easily take care of sudden labour shortages or increased demand for labour while reducing material damage and handling time.

Table 5: Operational measures to reduce fuel consumption

Low-friction lubricants	The use of low-viscosity lubricants is estimated to reduce transmission and engine friction to the extent of yielding fuel savings of 0.5 per cent in summer and 2 per cent in winter.
Less engine idling time	It is estimated that engines are left idling for approximately 1,000–5,000 hours per year mainly in order to heat or cool the cabin. Using the engine for this purpose is extremely inefficient, as an idling truck engine is estimated to consume an average of 2.3 litre per hour, or 3.8 litre per hour with the air conditioning on.
Lower speeds	Most trucks can improve fuel economy by reducing road speeds. Carriers can adopt a top speed policy for their drivers as a way to save on fuel costs. Speed reduction can be implemented through engine speed regulators, driver training and electronic engine monitoring.
Driver training and programme follow-up	Good driving practices can have a big impact on fuel economy, irrespective of any technological improvements that may be applied. They include the way drivers accelerate, driving techniques, choice of routes, number of stops and the use of accessories.
Improved aerodynamics	It is estimated that improving truck aerodynamics can dramatically boost fuel efficiency at highway speeds. Technological advances in aerodynamics brought down the friction coefficient for a typical truck from 0.8 in 1970 to about 0.6 in 2000. However, using all aerodynamic options on the market could reduce it further to 0.45.
Wide-base tyres	Replacing double tyres with wide-base tyres improves rolling resistance and reduces truck weight and thence fuel consumption.
Tyre inflation	Maintaining proper tyre pressure reduces rolling resistance and fuel consumption caused by low pressure. An automatic inflation system can maintain optimal tyre pressure.
Fare reduction	Vehicle weight can be reduced by replacing some truck and trailer components with lighter materials or simply eliminating them.

Source: Compiled by CSE from various sources

Eco-driving can especially help hybrid and electric vehicles. A few studies indicate that the difference in fuel consumption due to different driving behaviours can reach 50 per cent for hybrid vehicles,[10] and the impact of eco-driving on the energy consumption of electric vehicles can reach approximately 25 per cent.[11] Since hybrid vehicles (HV) and electric vehicles (EV) can store kinetic energy of the moving vehicle during braking, their energy consumption is more sensitive to driving behaviour than ICE vehicles.

It is however interesting to note that several companies have undertaken their own initiatives to reduce energy intensity of their freight systems. These include initiatives such as selecting sustainable modes of transport, improving truck loading and

Table 6: Voluntary initiatives of corporate groups to adopt freight measures

Pepsi India	Pepsi India has started using inland waterways for transporting containers from Kolkata to Varanasi
Coca-Cola India	Coca-Cola India has established an emission charge to reduce carbon emissions associated with the "drink in your hand" by 25 per cent by 2020. They are mainly trying to introduce sustainable packaging and "light weighting" their products to reduce logistics and manufacturing emissions
Unilever in India	Unilever in India has improved truck loading by right-sizing and reorganised supply chains
Reckitt & Benckiser India	Reckitt & Benckiser India (RB India) reduced logistics and freight costs by 2 per cent and annual carbon emissions by 1,000 metric tonne by introducing a transport management system (including truck-placement efficiency and Carrier Scorecard [CS]) designed to bring transparency across functions and resolve conflicts amongst stakeholders. This tool enables a process-driven transportation management cycle.
Rivigo	Rivigo (which owns about 3,000 trucks) has devised a relay model which ensures that drivers are at the wheel for a maximum of four to five hours at a stretch, do not clock in over 12 hours, and reach home the same day, thus reducing road accidents. GoBOLT company uses two drivers in a long-distance truck to reduce transport costs and accidents.
Indian Oil Corporation	Indian Oil Corporation has transformed 900 of its 27,000 fuel stations into a driver rest place. The resting area has toilets, sleeping rooms with mattresses, TV, kitchen and safe parking.
Flipkart	Flipkart aims to switch to a full electric fleet by 2030. Blinkit, a start-up, plans to deploy 500 electric three-wheelers for last-mile deliveries across its 13 operational markets by the end of 2019.
Magma Fincorp	Non-banking finance company Magma Fincorp has taken up a driver training programme under the corporate social responsibility in association with the Petroleum Conservation Research Association. The target is to train about 150,000 drivers over three years.
IKEA India	IKEA India has committed to source 100 per cent renewable energy by 2020 and to transition to electric vehicles across its entire global fleet by 2030.

Sources: *Times of India,* Flipkart, *Business Standard,* IKEA Group's Corporate Climate Action in India, *Economic Times,* Coca-Cola, TERI

transport management systems, and fleet electrification of last-mile delivery (see *Table 6: Voluntary initiatives of corporate groups to adopt freight measures*).

TRUCK ELECTRIFICATION

Globally, electrification of truck fleet is considered the most feasible means of decarbonisation. Even though it is still in a nascent stage and currently expensive, as global experience shows, with product development and economies of scale this

Table 7: Electric trucks in the global market

Model	Axle configuration	Gross combination weight	Battery capacity	Range
Volvo FM Electric (Regional)	Tractor: 4×2, 6×2, 6x4 Rigid: 4×2, 6×2, 6×4, 8×2, 8×4	Up to 44 tonne	180–540 kwh, 2–6 batteries	Up to 380 km
Volvo fh Electric (city to city)	Tractor: 4×2, 6×2, 6x4. Rigid: 4×2, 6×2, 6×4, 8×2, 8×4	Up to 44 tonne	180–540 kwh, 2–6 batteries	Up to 300 km
Volvo FMX Electric (urban construction)		Up to 44 tonne	180–540 kwh, 2–6 batteries	Up to 320 km
Volvo FL Electric (door-to-door deliveries)	Rigid: 4×2	Up to 16.7 tonne	200–395 kwh, 3–6 batteries	Up to 300 km
Volvo FE Electric (Compact and capacious)	Rigid: 4×2, 6×2	Up to 27 tonne	200-265 kwh, 3–4 batteries.	Up to 200 km
Rhino 5536		Up to 60 tonne	258.08 kWh battery	Up to 185 km
Tesla SEMI			~900 kWh battery	Up to 500 miles
Olectra tipper	Rigid: 6X4			Up to 220 km
Scania Electric truck	4x2 tractors or as 6x2*4 rigids	Up to 64 tonne		270 to 300 km
Lion Electric Powertrain		Gross Vehicle Weight Rating – 26,000 lb	252kWh	Up-to 200 miles
Mercedes Benz E-Actros			240 Kwh	Upto 200 km
Volta Zero		16 tonne		Upto 200 km
IVECO Nikola Tre			480 kWh	Upto 400 km
Ashok Leyland Boss 1218		12000 Kg of gross vehicle weight and approximately 5 tons of payload		Upto 300-350 km
Tata Ultra T.7 EV		GVW- 8750 Kg	62.5 KWh	Upto 120 km

Source: Compiled from various sources

will be an affordable option. Even in India, after BSVI and the upcoming BSVII emissions standards in 2027, emissions control systems in IC trucks will be substantially advanced, complex and expensive. Ensuring their optimal real-world performance will be challenging. Moreover, energy demand from the heavy-duty vehicle segment is expected to increase the maximum in the future, which will be challenging to tame with a fossil-fuel-powered fleet.

Decarbonising heavy-duty vehicles (HDVs), especially long-range trucks, poses a much larger challenge for manufacturers. With a focused policy, it is possible to promote electric trucks. This is consistent with the global trend as is evident in China and in California, USA. Globally, electrification of the fleet has started

and e-companies are aiming to address this as much as possible, from defining the right truck to addressing concerns related to charging, operating range and securing deliveries. Whether to deliver in or between cities, companies are trying to provide an electric transport solution with zero exhaust emissions.

In India, around 85 per cent of truck production is shared by three players—Tatas, Mahindra and Ashok Leyland. It is possible to pilot schemes to demonstrate the application. This can be done through a collaborative approach between truck manufacturers, large truck-fleet operators and the government at a regional scale. Already several state-level EV policies and national policies have advocated setting up of highway-based electric charging facilities.

NEXT STEPS

The freight sector requires priority measures to reduce energy and carbon intensity. There is a need to:

- Adopt strategies to shift a sizeable share of freight from roadways to railways;
- Discourage long-haul road freight by imposing distance-based charging;
- Improve multi-modal integration with railways with improved last-mile connectivity;
- Ensure energy transition by promoting clean fuels electric truck fleet, hydrogen fuel cells, advanced batteries and low-carbon fuels. Increase the share of low-emission vehicles km (e.g. electric, hydrogen, clean biofuels and biogas);
- Enforce proper logistics management and integrate them with multi-modal transportation;
- Tighten fuel efficiency regulations;
- Implement intelligent transportation system (ITS) for real-time data generation and processing to improve fleet management, and routing; and
- Encourage electric and/or alternative-fuel vehicle penetration and increase in efficiency for all transport modes (including average loads and vehicle capacity).

6

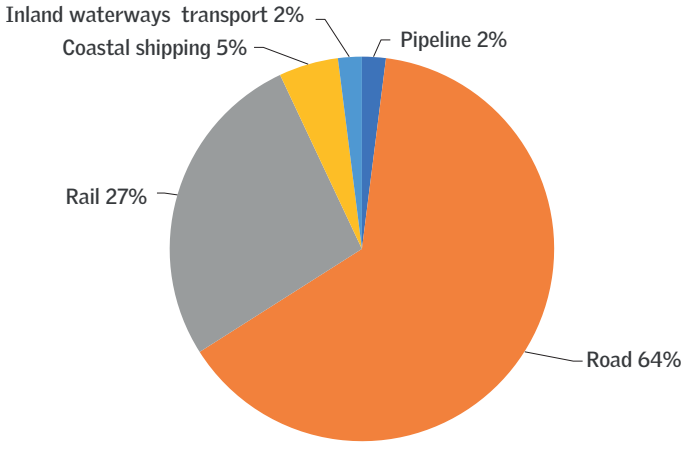
LONG-RANGE TRANSPORT: RAILWAYS AND AVIATION

RAILWAYS

The modal share of railways has been in continuous decline due to competition from other modes of transport, especially road. India became a decidedly road-dominant economy in the beginning of the 1980s and railways lost out with freight traffic in addition to its already declining share in passenger traffic. The overall share of railways is about 27 per cent. Globally too, rail accounted for 30 per cent of the global surface transport in 2015 (see *Graph 35: Share of freight logistics in India by mode {FY 2019}*). However, as India's Long-Term Low-Carbon Development Strategy states, Indian Railways is one of the world's largest railway networks, spread over ~68,000 km, and carrying nearly 23 million passengers daily. But the railways require a lot more augmentation.

According to Indian Railways estimates, if the modal share of railways remains the same, by 2050 road freight is projected to be the biggest contributor to CO_2 emissions followed by air transport, mainly due to increased express deliveries of products.[1] The National Rail Plan 2030 envisages the share of rail-based freight to grow to 40–45 per cent by 2030 from 27 per cent in 2020, with augmentation of capacity to meet the future growth in demand

Graph 35: Share of freight logistics in India by mode (FY 2019)



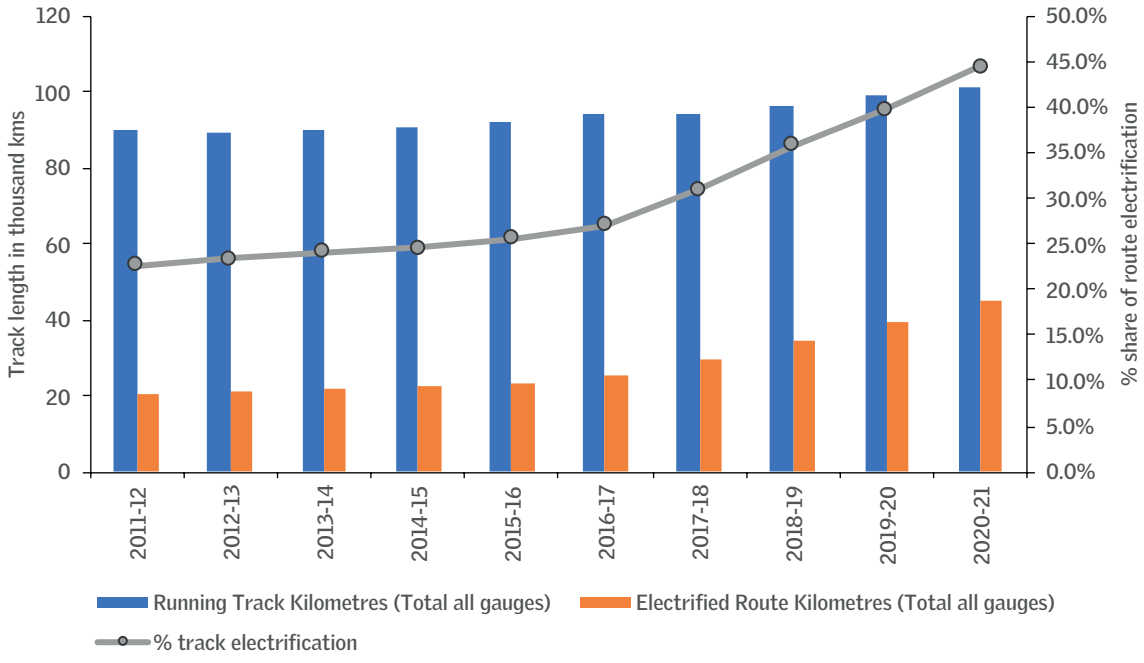
Source: Statista

right up to 2050. However, railways have begun to see an increase in route kilometres over the past years.

ARE THE RAILWAYS GEARING UP FOR CHANGE?

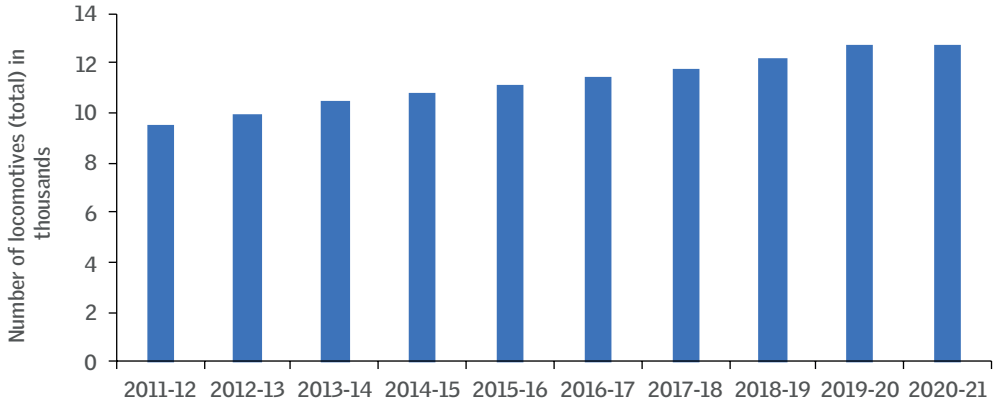
Expansion of railways is slow and incremental and has nearly plateaued in recent years, especially during the pandemic. The railways augmented rolling stock (locomotives) during the decade 2011–21. While the volume of passenger traffic has stagnated, that of freight has shown a small increase. Passenger traffic plummeted drastically during the pandemic. According to CRISIL 2020 estimates, the National Highway Authority estimated in May 2020 that the national lockdown would lead to a 17 per cent reduction in intercity highway traffic for the year. In fact the actual reduction could be more significant as states imposed their own rules and restrictions (see *Graph 36: Expansion in rail network [all gauges], route electrification [all gauges] and share of route electrification [2011–21]*, *Graph 37: Rolling stock [locomotives] of*

Graph 36: Expansion in rail network (all gauges), route electrification (all gauges) and share of route electrification (2011–21)



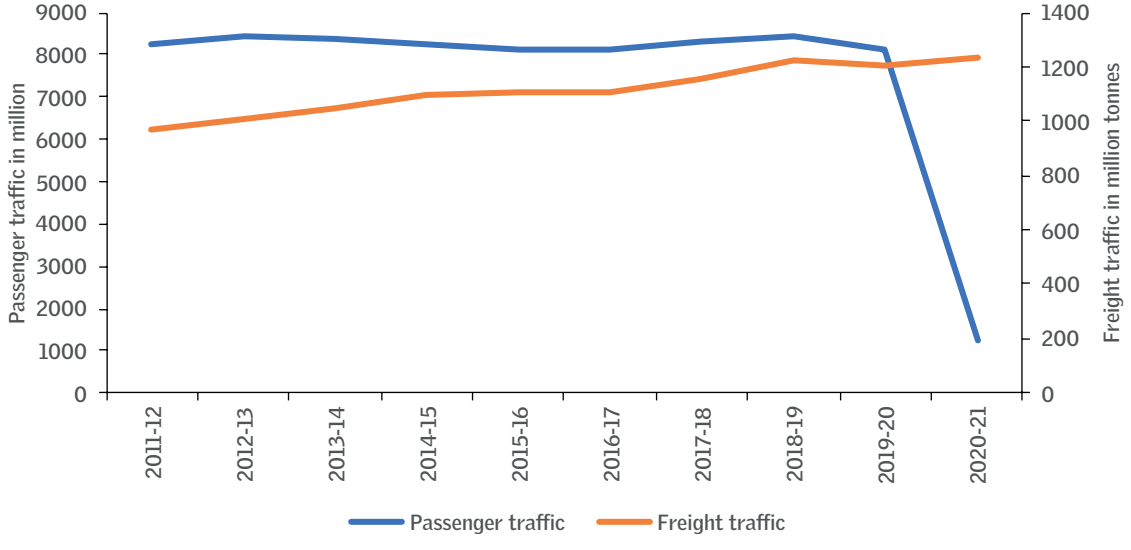
Source: Ministry of Railways, 2021

Graph 37: Rolling stock (locomotives) of India Railways (2011–21)



Source: Ministry of Railways

Graph 38: Volume of passenger traffic (suburban + non-suburban) and freight traffic (revenue) in India (2011–21)

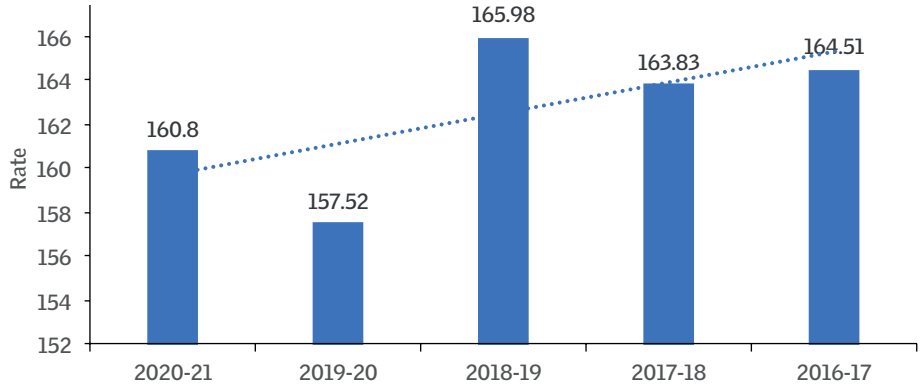


Source: Ministry of Indian Railways, Indiastats, 2022

India Railways [2011–21]) and *Graph 38: Volume of passenger traffic [suburban + non-suburban] and freight traffic [revenue] in India [2011–21]*)

As per the Indian Railways Handbook 2020–21, the current rate of transporting per net tonne kilometre is about Rs 1.6, which is

Graph 39: Average rate per NTKMS (in paisa)



Source: Indian Rail Year Books, 2016 to 2021

three times cheaper than the price of road transportation. Yet last-mile connectivity of accessing rail nodes and the delays are a disincentive.

Railways are considered to be the cleanest transport mode as most rail transport—if electrified—do not have tailpipe emissions. But emissions from infrastructure development need to be accounted for. Moreover, its deployment is possible only in high-demand areas.

ADDRESSING SOLUTIONS

Interventions in the rail sector need to aim for carbon neutral with zero tank-to-wheel emissions, which is possible with significant scaling up of electrification of networks and application of clean tail-pipe energy sources such as hydrogen, batteries and clean biofuels. This also requires improved operations and new infrastructure. As per India's Long-Term Low-Carbon Development Strategy, Indian Railways aims to become net zero by 2030, leading to 60 million tonne of annual mitigation of CO_2 .

Fuel use in railways: The rail system needs to transition to clean and renewable electricity. Indian Railways, the fourth largest railway network in the world, is the single largest consumer of

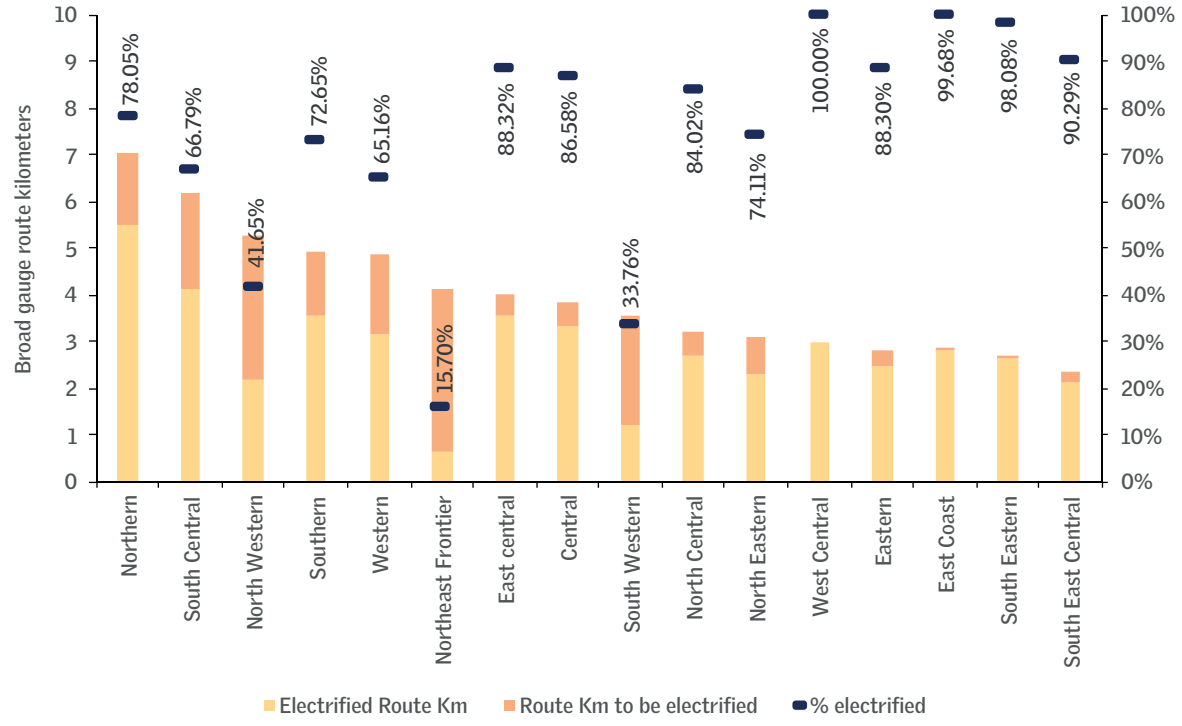
electricity in India. It consumes over 20 billion kWh of electricity annually,[2] which is around 2 per cent of the country's total power consumption, in addition to primary energy usage, mainly diesel. Of this, about 2.5 billion units of electricity is used for non-traction usage, amounting to a bill of about Rs 1,700 crore per annum.[3]

By 2021, about 44,000 km of 68,000 km were electrified by the Railway Department, which is about 65 per cent of the existing total broad gauge network. This is significant growth compared to the past five years. The zone-wise status of electrification of broad-gauge rail lines in Indian Railways shows while some zones, such as the Eastern, South Eastern, South East Central and Central, have achieved substantial electrification, the rest, especially North East Frontier, North Western and South Central, are yet to scale up (see *Graph 40: Zone-wise status of electrification of broad-gauge rail lines in Indian Railways*). While it is critical to move out of coal and diesel and quickly electrify, it is also necessary to move to renewable energy as quickly as possible.

As per the Long-Term Low-Carbon Development Strategy, electrification of railways is already well on course, with over 80 per cent of the broad-gauge network already electrified (till March 2022). With the expansion of electricity generation through non-fossil fuel sources, electric transportation will also become less carbon-intensive.

Indian Railway's electricity use offers a potential area for saving energy and also transforming energy sources. The Bureau of Energy Efficiency (BEE) has marked out 16 traction units of the Indian Railways as well as six production units as designated consumers in the second cycle of the Perform, Achieve and Trade (PAT) scheme, a regulatory instrument to reduce specific energy consumption in energy-intensive industries, with an associated market-based mechanism to enhance the cost-effectiveness through certification of excess energy saving which can be traded.

Graph 40: Zone-wise status of electrification of broad-gauge rail lines in Indian Railways



Source: Ministry of Railways, 2021

Hydrogen fuel cells are also being explored as a possible solution. Hydrogen fuel cell technology can use existing rail infrastructure to electrify trains. The fuel cells and the hydrogen tanks are mounted on the roof of the train. When in motion, the fuel cell powered passenger train emits only water vapour, which is the only byproduct of the hydrogen and oxygen reaction in the fuel cell.

Capacity augmentation: The Railways currently has a 27 per cent share in goods transport and the last budget envisages to take it to 45 per cent in the next few years, which further requires more wagon capacity. Broadly, this will require 20,000 wagons per year. According to the National Rail Plan of the Indian Railways, the Indian Railways will need over 5.44 lakh wagons by 2031.

The National Rail Plan has also taken "capacity ahead of demand" as part of its vision, to be "future ready" by the end of 2030. Indian Railways is working on a series of measures to augment capacity. The Union Ministry of Railways has planned to procure 90,000 wagons in the next three years at an investment of close to Rs 31,000 crore. The entire manufacturing and supply will be under the make-in-India policy. Add to it, the opening of the 3,300-km-long Eastern and Western Dedicated Freight Corridors have further increased the demand for container-carrying wagons. The government has focused on strengthening infrastructure, and over the next few years, Indian Railways is expected to come out with large contracts to upgrade both passenger coaches and wagons.

Environment and sustainability of the railways: Indian Railways is also working on improving energy efficiency, renewable energy usage and waste management. It aims to reduce transit time of freight substantially by increasing average speed of freight trains to 50 kmph. As part of the National Rail Plan, Vision 2024 has been launched for accelerated implementation of certain critical projects by 2024 such as 100 per cent electrification, multi-tracking of congested routes, upgradation of speed to 160 kmph on the Delhi–Howrah and Delhi–Mumbai routes, upgradation of speed to 130 kmph on the Golden Quadrilateral–Golden Diagonal (GQ–GD) route and elimination of all level crossings on the entire GQ–GD route.

Solutions require identification of new dedicated freight corridors; identification of new high-speed rail corridors; assessment of rolling stock requirement for passenger traffic as well as wagon requirement for freight; assessment of locomotive requirement to meet twin objectives of 100 per cent electrification (green energy) and increasing freight modal share; assessment of the total investment in capital that would be required; sustained involvement of the private sector in areas such as operations and ownership of rolling stock; development of freight and passenger terminals, and development/operations of track infrastructure.

LONG-RANGE TRANSPORT: RAILWAYS AND AVIATION

In accordance with India's Long-Term Low-Carbon Development Strategy, dedicated railway freight corridors are being planned and the National High-Speed Rail Corporation Ltd is being set up to finance, construct and maintain high-speed rail corridors. The National Logistics Policy is expected to provide for adoption of an efficient, economical and environmentally sustainable modal mix. Moreover, the Sagarmala Programme aims to enhance the performance of the logistics sector with regard to port modernisation, port connectivity, port-led industrialisation and coastal community development. The Gati Shakti National Master Plan is planning for a GIS-based digital platform to bring together 25 Central ministries and/or departments and all states or Union Territories for integrated planning and coordinated implementation of infrastructure projects.

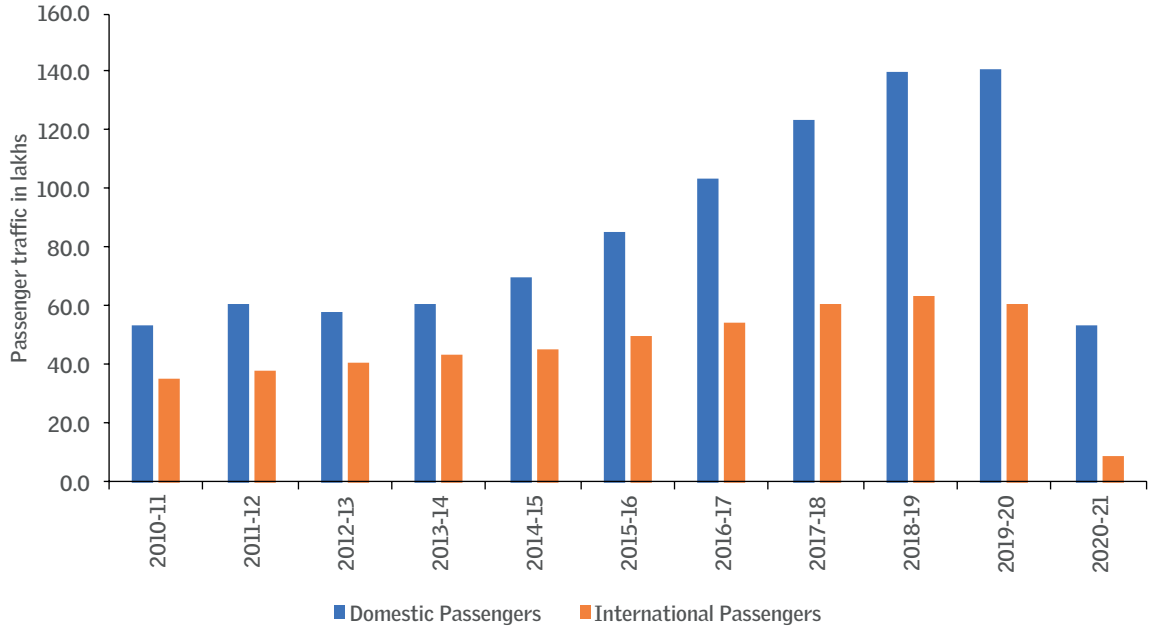
All these initiatives will require measurable and verifiable indicators to assess time-bound progress.

AVIATION

It is not easy to achieve modal shift from aviation to other modes at a scale as both railways and roadways can substitute air travel only on high demand and limited routes. However, road transport may still continue to remain popular on a wider scale due to the flexibility it offers.

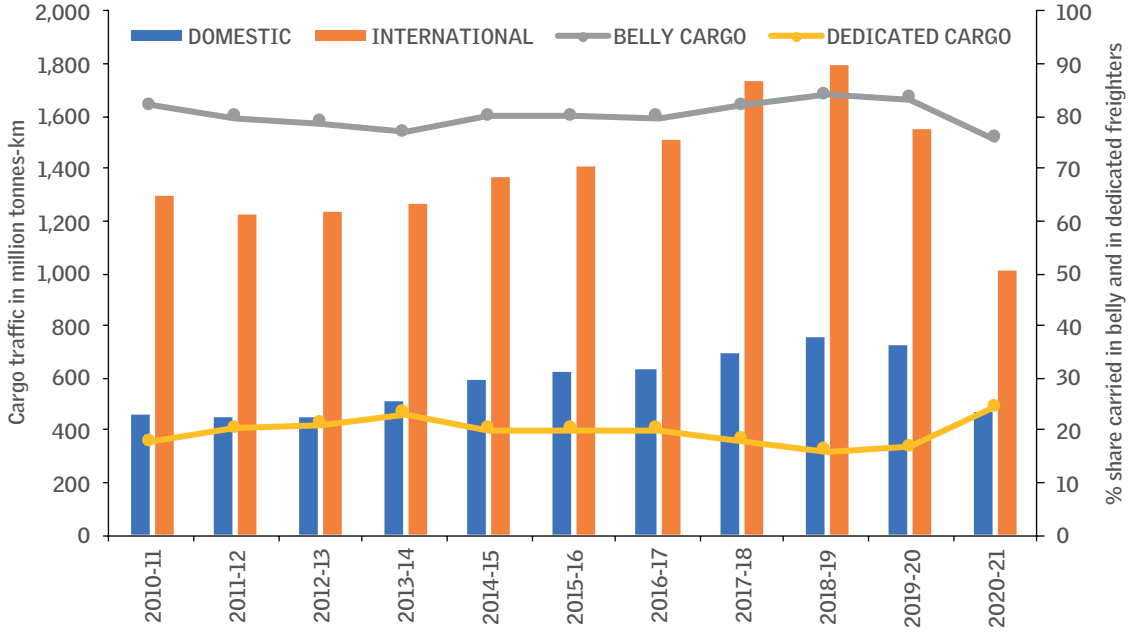
India is at the stage of take-off when demand for aviation travel and freight are expected to increase manifold. Domestic-sector travel has increased appreciably over the last decade (see *Graph 41: Passenger traffic [domestic and international] carried by scheduled carriers in India [2010–21]*). In the case of cargo, the share of international cargo is substantial (see *Graph 42: Cargo traffic [domestic and international] carried by scheduled carriers in India and proportion of domestic cargo carried as belly cargo and in dedicated freighters [2010–21]*).

Graph 41: Passenger traffic (domestic and international) carried by scheduled carriers in India (2010–21)



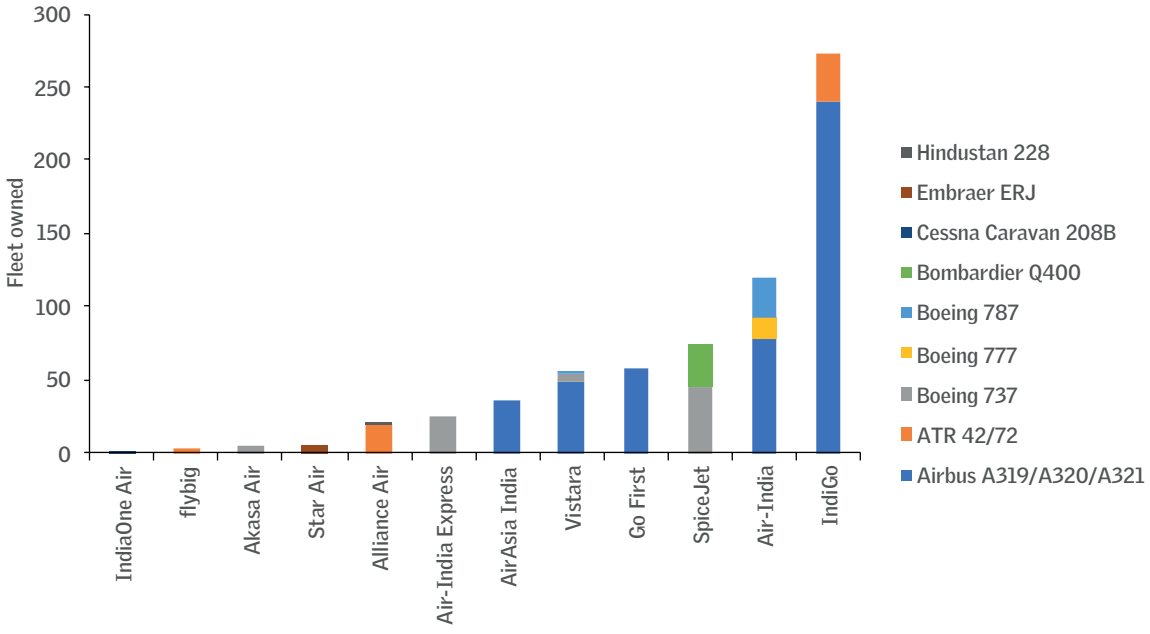
Data source: Indiastats, 2022

Graph 42: Cargo traffic (domestic and international) carried by scheduled carriers in India and proportion of domestic cargo carried as belly cargo and in dedicated freighters (2010–21)



Source: Indiastats, 2022

Graph 43: Total fleet owned by Indian airlines till September 2022



Notes: 1. SpiceJet's Bombardier Q400 numbers exclude three Q400 freighter conversions

2. Graph includes data for grounded aircrafts for technical/operational reasons

Source: Know India, 2022

The change is reflected in the way fleet ownership is increasing in the country (see *Graph 43: Total fleet owned by Indian airlines till September 2022*).

LIMITED SOLUTIONS FOR AVIATION

Options for aviation include low-carbon alternative fuels and improving fuel efficiency. Electrifying aviation is still not possible as the energy density of batteries cannot support such operations. Alternative fuels include hydrogen, ammonia and synthetic fuels, but these technologies have not matured yet.

Currently, improving energy efficiency is the key strategy to reducing emissions. This will also have to be supported by carbon pricing and taxes but there is a limit to the extent this can be leveraged given the cost impacts on travel.

Globally, even though the fleet has increased substantially there has also been an overall improvement in CO_2 emissions since 1990 due to improved technology level of the air fleet (see *Graph 44: Trend in CO_2 emissions from the aviation sector since 1990* and *Graph 45: Fuel efficiency changes since the 2009 ATAG Summit*). Between 1990 and 2019, fuel efficiency improved by 54 per cent in the global industry. This improvement was possible by airlines investing in 15,000 more fuel-efficient aircraft technologies since 2009. Increased load factors and other operational measures also helped in improving performance.

Due to the financial crisis in 2009, there was significant improvement in fuel efficiency and a slump in CO_2 emissions in the sector before 2010. But a rebound in traffic and a large jump in weight load performance factor was noticed in 2010, with both passenger and cargo load factors improving as part of the recovery from the global financial crisis.

According to Air Transport Action Group (ATAG) analysis, fuel efficiency in 2020 worsened (from 0.85 $C0_2$ tonne per revenue tonne kilometre [RTK] to 0.95 tonne per RTK) along with CO_2 emissions per passenger km (from 104 gm in 2019 to 162 gm in 2020). This was not surprising since airlines in countries such as USA were required to continue serving airports even if there was no passenger traffic, while other airlines maintained services for cargo purposes.

Thus, the load factor and revenue passenger kilometre reduced drastically, resulting in a higher fuel efficiency figure. However, a similar improvement in fuel efficiency to the economic crisis of 2009 is expected in subsequent years after 2020, when the revenue kilometers start bouncing back. IEA's fuel uplift (measurement of fuel provided by the fuel supplier to a flight) data, used for analysing these changes, is only available 18–22 months after the year ends, thus restricting a comparison between 2020, 2021 and 2022 at this point in time.

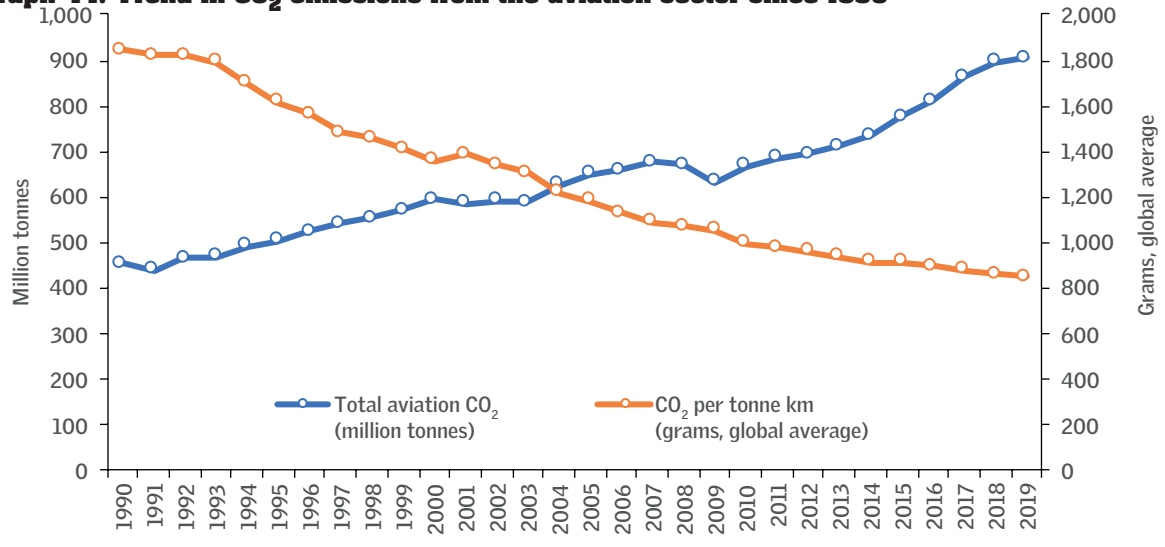
LONG-RANGE TRANSPORT: RAILWAYS AND AVIATION

The International Civil Aviation Organization (ICAO) adopted a new aircraft CO_2 emissions standards globally in 2017 and is also implementing the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA).[4] Accordingly, aircraft operators will collectively offset CO_2 emissions that exceed a threshold based on the average level of CO_2 emissions in 2019–20. CORSIA will become mandatory in 2026 after the trial phase in 2021–23 and a voluntary phase in 2024–26. Least-developed countries may be exempted. After the pandemic disruption, CORSIA was amended to use CO_2 emissions in 2019 as the base.[5]

Overall, the aviation strategy has to hinge on aircraft fuel-efficiency and retiring of older, more polluting aircraft. Use of synthetic aviation fuel to expand and to be mandated in the future and hybrid aircraft with electricity-assisted jet propulsion may also be possible in the time horizon of 2030–50 (see *Graph 44: Trend in CO_2 emissions from the aviation sector since 1990* and *Graph 45: Fuel efficiency changes since the 2009 ATAG Summit*).

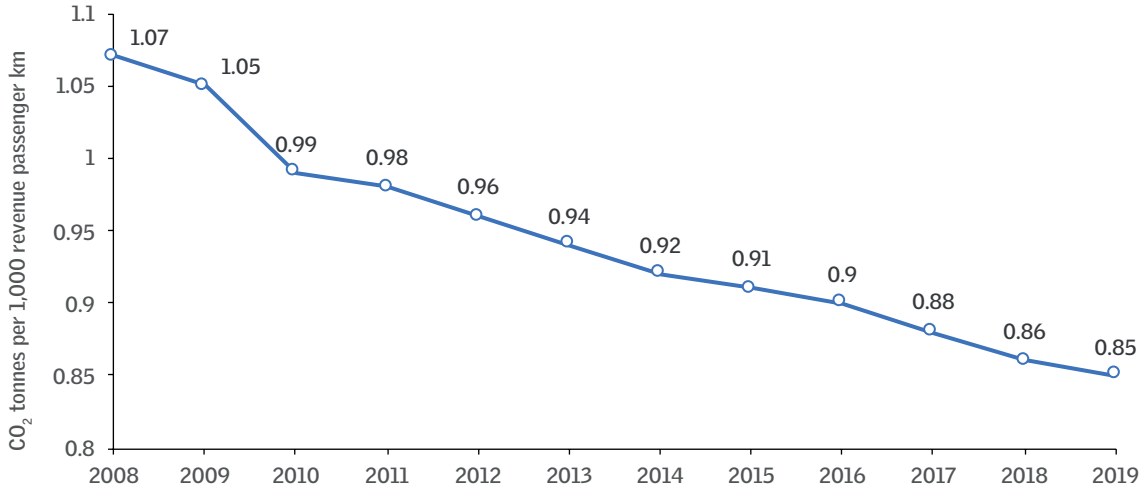
Setting and implementing global rules for international freight modes is a challenge as the requirements of reducing

Graph 44: Trend in CO_2 emissions from the aviation sector since 1990



Source: Air Transport Action Group, 2021

Graph 45: Fuel efficiency changes since the 2009 ATAG Summit



Source: Air Transport Action Group, 2021

international maritime and aviation emissions are not included in the Nationally Determined Contributions (NDCs). They fall under the purview of international organisations such as the International Maritime Organization (IMO) and the International Civil Aviation Organization (ICAO). Policy action on freight has remained weak.

India's Long-Term Low-Carbon Development Strategy report estimates that civil aviation was 6 per cent of the total transport emissions in India in 2016. Currently, the options for low- or zero-carbon airplanes are extremely limited. It suggests the way forward in terms of radical new aircraft designs (e.g. the "blended wing" concept) to improve fuel efficiency by 25 per cent compared to the most efficient planes today. Furthermore, flexible usage of airspace, single engine taxing, continuous descent approach, airport carbon accreditation programmes in the aviation sector, carbon offsetting and reduction scheme in international aviation are some of the feasible solutions.

LONG-RANGE TRANSPORT: RAILWAYS AND AVIATION

NEXT STEPS

Long-range transportation will require priority interventions, including the following:

- Time-bound improvement in rail and inland waterways based improvement are critical;
- Linking of economic recovery programmes with freight decarbonisation and supply chain resilience;
- Aligning price incentives with freight decarbonisation ambitions for carrier buy-in;
- Scaling up ready-to-adopt freight decarbonisation measures quickly to cut costs and emissions;
- Strengthening international co-operation to combat freight emissions;
- Accelerating standardisation procedures to speed up the adoption of new clean technologies;
- Pushing for clean fuels; pricing of carbon-based fuels can be considered; and
- Transport network improvement.

IMPACT OF E-RETAIL AND E-COMMERCE

Conventional retailing supply chain is designed to enable the consumer to purchase goods at the retailer's store. The "last-mile" in freight distribution is therefore covered by the consumers themselves, where they travel to the store to purchase the goods. Although retailers offer local deliveries to fulfil purchases for heavier purchases such as furniture and bulky electronic appliances, even this activity involves the consumer making the choice of product to be delivered at the physical store. The retailers maintain an in-store inventory, supported by a distribution centre that stores products for replenishing the inventory. Therefore, locations play an important role in a conventional retail model. The locations will define the market area or the consumer base for the retailer, so retailers assume significant costs to retail accessible and favourable locations.

Online retailers indulging in e-retail or e-commerce have challenged the conventional paradigm in the retailing sector

by acting as an intermediary between the suppliers and the consumers (see *Figure 1: Retail logistics and e-commerce paradigm*).

Often the terms e-commerce, e-retail and online retail are used interchangeably. E-retail and online retail are businesses that enable business transactions online, but may have a physical store or logistics centre for supply. E-commerce platforms on other hand are mere aggregators of e-retail businesses and do not have a physical address (see *Table 8: Retail logistics and e-commerce paradigm*).

Changes have been made in the e-commerce model, where the

Table 8: Basic difference between e-retail and e-commerce

E-retail	E-commerce
One brand one website Can have physical store (online and offline) Booking can happen online, transaction can happen from retail store, store or logistic centre	Brand aggregator No physical store (only online) No physical interaction
Product distribution Consumer (of product) only buys, doesn't sell	Technology solution to enable business Consumer (of technology) is anyone who makes use of the technology to access products of services.
Entails all three basic business transition models B2B—Business to business B2C—Business to consumer B2G—Business to government	Entails only consumer transactions E-commerce has breached the traditional business models and three new models have been added. In addition to B2B, B2C and B2G, there are: C2C—Consumer sells to other consumers or social commerce (through social networks) C2B—Consumer sells to primary product business owners to use it for furnished products B2G—Consumer sells to government
B2C transaction of e-retail is a subset of e-commerce Example: Lenskart, Boult, Tanishq, Mahindra, jewellery brands, apparel brands, Reebok, Puma etc. These businesses have their own e-retail websites, but larger e-commerce platforms are also available for consumers like us.	E-commerce platforms can list e-retailers without having physical space Example: Amazon, Flipkart, Myntra, e-bay, Nykaa etc. Service based—Dunzo, Blinkit, Zomato, Urban Company etc. These can list products from small sellers, artists and non-branded products

Source: Business Standard, Flipkart

locations are now more flexible because distribution centres have been replaced by e-fulfillment centres. The e-fulfillment centres or EFCs are operated by the online retailers, which can store large volumes of items for short periods of time. Once the orders placed online are processed, orders are then packaged out of EFCs and delivered by postal or parcel services. EFCs are the key components of this strategy for material flows, on which a whole array of online retailers depend.

Further, customers can now interact virtually with the retail store on a platform. This platform covers the cataloging of products and payments, as well as shipping data for customers. The products are then shipped through parcel services. Hence, the consumer is part of the supply chain where they can interact with products directly in the distribution centres (EFCs) while also tracking their shipping. The deliveries are the responsibility of the retailer.

However, e-commerce comes at an expense of a time-delay for delivery of the product. Therefore, grocery and pharmaceuticals have seen a lower share of e-commerce than other non-essential products such as apparel, cosmetics and electronics. Q-commerce is another retail model that has emerged very recently which addresses this issue of delayed deliveries. Q-commerce or quick commerce is defined as the delivery of consumables within a very small period of time from the time of ordering. This time period may vary from less than an hour to a few hours depending on the product and/or the service provider. India's q-commerce market is expected to grow by 10–15 times, from 0.3 billion in 2021 to more than 5 billion in 2025.[6] The rise is expected to originate from the shift in consumer behaviour from value seeking to convenience seeking, leading to periodic purchases (daily or weekly) in small quantities.

E-commerce broadly follows four business transaction models and each model has a separate logistics requirement. Logistics refers to the overall process of organising a complex chain

TYPICAL E-COMMERCE BUSINESS TRANSACTION MODELS

Companies may operate in one or more of the following models simultaneously:

- Business-to-consumer (B2C): The most common and among the earliest forms of e-commerce is the B2C business model of e-commerce. Under this model, the business sells their products and services directly to the end user. Any product or service purchased by an individual directly from online retailers or businesses is covered under the B2C transaction model. In simpler terms, anything consumers buy in an online store is done as part of the B2C transaction. The decision-making for a B2C purchase is much shorter and has a much lower value than the next category, the B2B model.

- Business-to-business (B2B): Under this model, a business sells its products or services to another business. B2B transaction decisions are generally longer, with higher sales value. These transactions are more recurring than B2C transactions. A popular example is Snapdeal.

- Consumer to business (C2B): These businesses allow individuals to sell their goods and services to other companies. Typically, C2B businesses act as a third party to facilitate communication between a company that posts a work or job to be completed, and individuals offer their products and services to do the job. Some examples would be Round One (referral recruitment) and Upwork.

- Consumer to consumer (C2C): A C2C business is a third-party online marketplace that connects consumers for an electronically facilitated transaction. These businesses make their fee usually by charging a transaction or a listing fee. A good example of companies that have pioneered this model would be Craigslist or eBay.

of activities to reach efficiency. In the context of this paper, logistics comprises both materials management (manufacturing along a supply chain) and physical distribution (movement of products). Urban mobility in a city is concerned with the physical distribution that deals with the movement of goods from points of production to final points of sale and consumption. Two fundamentals in the e-retail system impact urban mobility in a city: one, flexible distribution centre locations and, two, the responsibility of retailers to deliver to consumers.

The logistics sector of the business-to-consumer (B2C) and business-to-business (B2B) models are related with the manufacturing and shipment of products, while the consumer-

to-business (C2B) and consumer-to-consumer (C2C) models are services industries that deal with intellectual properties provided by individuals to businesses and other individuals.

The scope of this assessment is limited to understanding the impact of online commerce on urban mobility. Therefore, the logistics covered for the e-commerce market will be limited to the product shipping sector, which involves the movement of goods, and not the service industry. Under the B2B and B2C models, the products bought online undergo a series of logistics activities before reaching end users. Each of these activities have different transportation requirements in the supply chain.

First-mile logistics involves transportation of goods from sellers to e-fulfillment centres (EFC) or the mother warehouse, based on the type of fulfillment the order needs. Fulfillment can be either inventory-led or marketplace based. An inventory-led fulfillment model is followed when an e-commerce company sources its products directly from sellers and brands and stocks it. A marketplace model has no inventory, and the e-commerce company is the meeting ground for consumers and sellers to interact without storing any products. If the company follows a marketplace model, the company can ship orders directly to the consumer, without the need for warehousing or EFCs. EFCs are physical locations that store product, from where a third-party logistics (3PL) provider can help the e-commerce company with the order fulfillment process, which involves the picking, packaging and labelling for shipping the products.

After fulfillment is complete, products are received at the 3PL processing centres for sorting and processing the products based on delivery locations. Products are further connected in the supply line via line haul. Line haul is the movement of products across different modes of transportation—by road, rail, air or waterways—between cities. The choice of mode will depend on transit time and cost metrics. Airlines, for example, will save time but can cost up to three to four times more than surface modes.[7]

Line haul essentially connects the main supply centres to the main demand centres.

After the product consignments reach the final delivery hubs, the parcel service working with the 3PL will deliver the product to the consumer. This last part of the process is called the last-mile delivery of the product.

Each activity in this process has a direct or indirect impact on urban mobility and environment. This interface between logistics and mobility or environment is a testament to not just how rationally a business performs, but also to how well a government can adapt to integrative environment management.

OVERVIEW OF INDIA'S E-RETAIL MARKET

India's e-retail sector is the fastest growing channel for commercial transactions in the country. Between 2018 and 2020, the market grew from US $21.9 billion to US $52.6 billion, a growth of over 140 per cent in two years.[8, 9] A Payoneer report ranked India's e-commerce market ninth in cross-border growth in the world.[10] Internet and social media, affordable smartphones and unified payments interface (UPI) have aided the e-commerce boom.

This rapid growth has been triggered by the ever-increasing internet and smartphone users. Several strong government initiatives towards e-commerce have also built the case for a stronger market structure. According to an IAMAI-Kantar ICUBE 2020 report, the number of urban internet users in 2020 increased by another 4 per cent to 323 million since 2019 (which saw 309 million users). This accounted for 67 per cent of the total urban population of India in 2020. The report estimates that by 2025, India will have 900 million internet users.

E-commerce is one of the most availed services, used by 45 per cent of the country for some kind of an online transaction while another 28 per cent users use it specifically for online shopping.[11]

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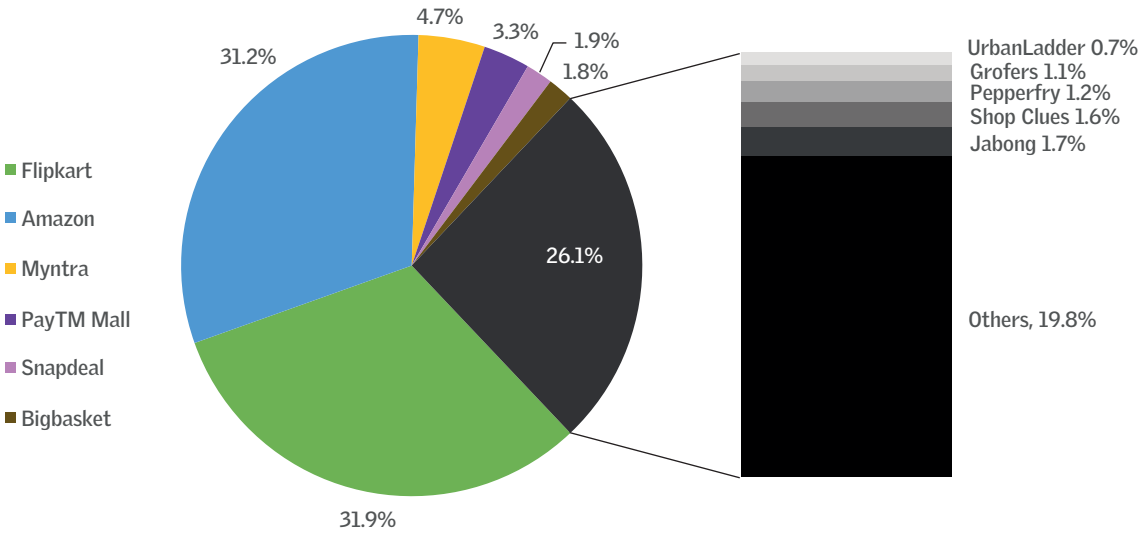
Graph 46: Market share of B2C e-commerce companies in India



Data Source: S&P Global, 2019

E-retail market in India is a US $50–60 billion market, most of which has evolved in the last decade alone. While e-commerce has drastically improved access to products and services, it has impacted how goods are transported to the end user, and led to paradigm change in hyper-local logistics.

This needs investigation of the "last-mile" market that enables movement of products without two parties having to interact in a physical space to identify and choose products and shop .

The momentum built up only with the introduction of Amazon in India in 2013. Flipkart and Myntra followed suit a few years later. Newer platforms mushrooming today have a more competitive playing field. Platforms have expanded from only websites to social media.

Social media has been both a boon for consumers and small-scale retailers. While it allows all kinds of retail transactions, there are huge implications on how transportation and the hyper-local logistics network enables it.

Today, the e-commerce space in India is dominated largely by B2C companies. Flipkart and Amazon are leading the e-commerce market. In 2018, Flipkart controlled 38.3 per cent of the market when including its fashion specialty sites Myntra and Jabong, while Amazon had a market share of 31.2 per cent.[12]

According a to recent Morgan Stanley report, in 2021 the e-commerce space was dominated by the electronics and appliances market capturing 51 per cent of the share, followed by the fashion market with 30 per cent e-commerce space.[13] Owing to this trend, several e-commerce companies have been seen to acquire other fashion companies, such as Myntra's acquisition by Flipkart in 2014 and the acquisition of Exclusively.com by Snapdeal in 2015.

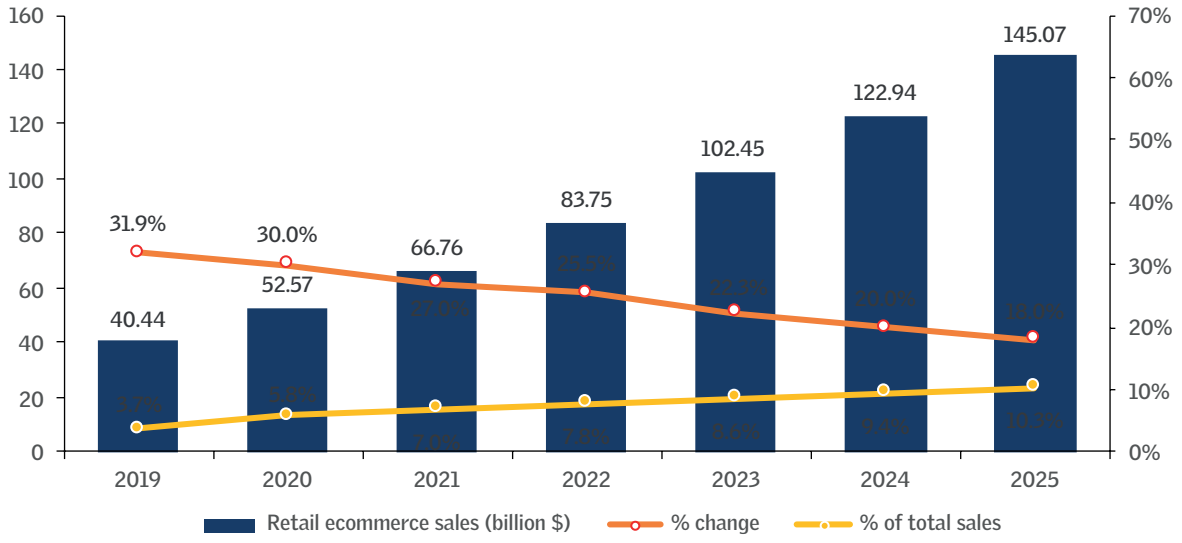
Globally, the B2C market segment accounts for 99 per cent of e-commerce transitions. As of 2021, Global Business to Consumer consumer segment is a US $3.86 trillion economy and is expected to grow at a 7.6 per cent compound annual growth rate (CAGR) every year.[14] A study by PGA labs suggests that the Indian segment can grow at a CAGR of 24 per cent up to $145 billion. Projections by various agencies highlight that by FY 2026 the e-commerce market will have 350 million[15] consumers and will contribute to the movement of 15 million daily shipments.[16] The e-commerce market not only influences the third-party logistics market, but is completely dependent on it.

This growth is a factors of three aspects. It is contributed by a vast network of e-commerce companies dealing in e-commerce segment through a network of logistics companies.

INDIA'S E-RETAIL AND E-COMMERCE SECTOR AFTER THE PANDEMIC

The pandemic fast forwarded e-commerce adoption by at least three years.[17] In 2019, e-commerce penetration in India was barely 4 per cent, and it was projected to reach 7 per cent by the end of 2024.[18] In 2021, a market study by nonprofit MMA Global found

Graph 47: E-commerce retail sales in India (2020–25)



Data source: eMarketer, 2021

that e-commerce penetration in India was already above 6 per cent. It projected that e-commerce penetration was set to expand three times in four to five years. Grocery, education and health will witness the highest growth.

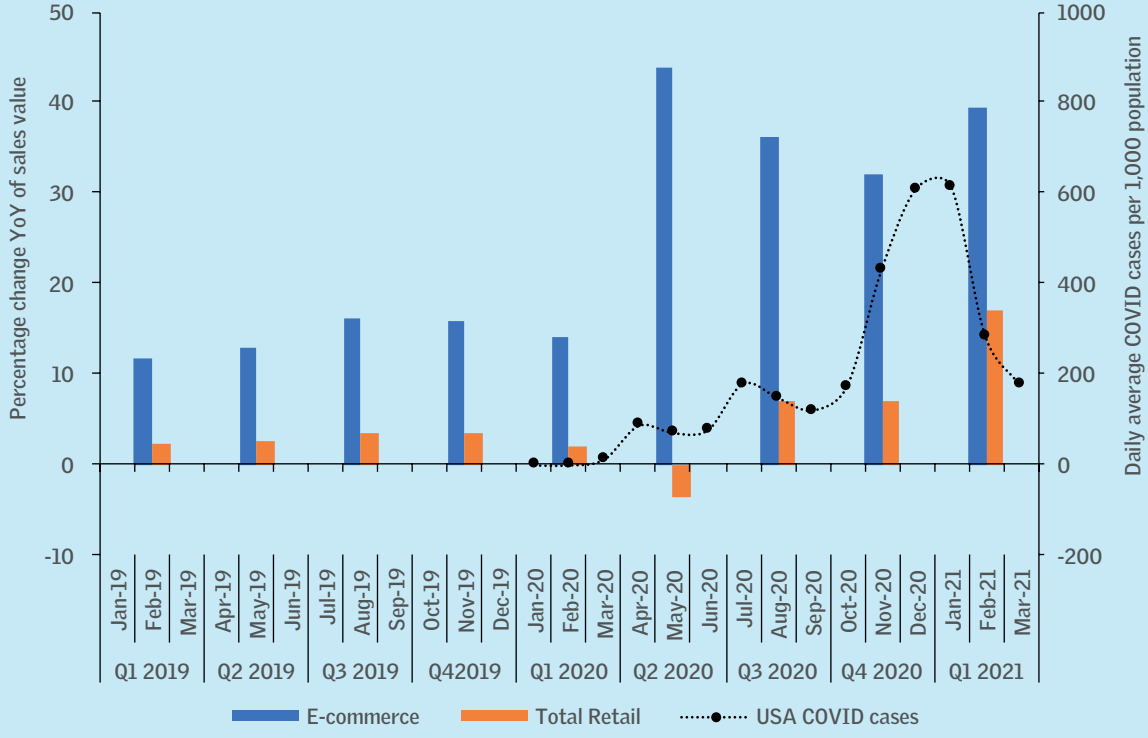
The delivery network has become bigger. Two years of the pandemic resulted in a significant increase in deliveries, added more vehicle movement on roads and more ambient air pollution from CO_2 emissions. According to the World Economic Forum, delivery vehicles in major cities are projected to grow by 36[19] per cent by 2030, and delivery emissions by 32 per cent. This will also result in a trickle-down effect on inner-city congestion.

Following the health crisis faced by the country in two severe Covid-19 waves, digital shopping solutions provided by e-commerce gained considerable traction. More e-commerce have companies started looking for alternative warehousing locations to help in the continuity of their business, while also mitigating delivery delays.

The pandemic and global e-retail boom: The share of e-commerce in total retail sales increase from 16 per cent to 19 per cent in 2020 during the Covid-19 crisis. Cumulative e-retail sales in the largest economies increased by more than 22 per cent.

USA: USA was one of the worst Covid-hit countries in the world, with three waves each being worse than the previous.

The first wave started with every other country in the world in March 2020 and peaked in April 2020. The second wave hit mid-June and peaked in July 2020 and the third wave, much bigger than second, hit in October 2020 during the winter holiday season and peaked in January 2021.



Source: US Census Bureau, Our World in Data[1]

The spike in e-commerce sales was coherent with the infection rates in the country. E-commerce in USA was up by about 45 per cent YOY during the Q2 2020 (April–June 2020), while the traditional retail market went down by 4 per cent during the same time frame. Similarly, during Q3 2020 and Q4 2020, the share of e-commerce remained above 30 per cent, and again as the third wave hit in early 2021, e-commerce went up, reaching 40 per cent higher YoY.

The overall e-commerce market in USA saw a 33 per cent rise in 2020 compared to 2019, and the share of e-commerce in total retail sales reached 11 per cent in 2020 compared to 8 per cent in 2019.

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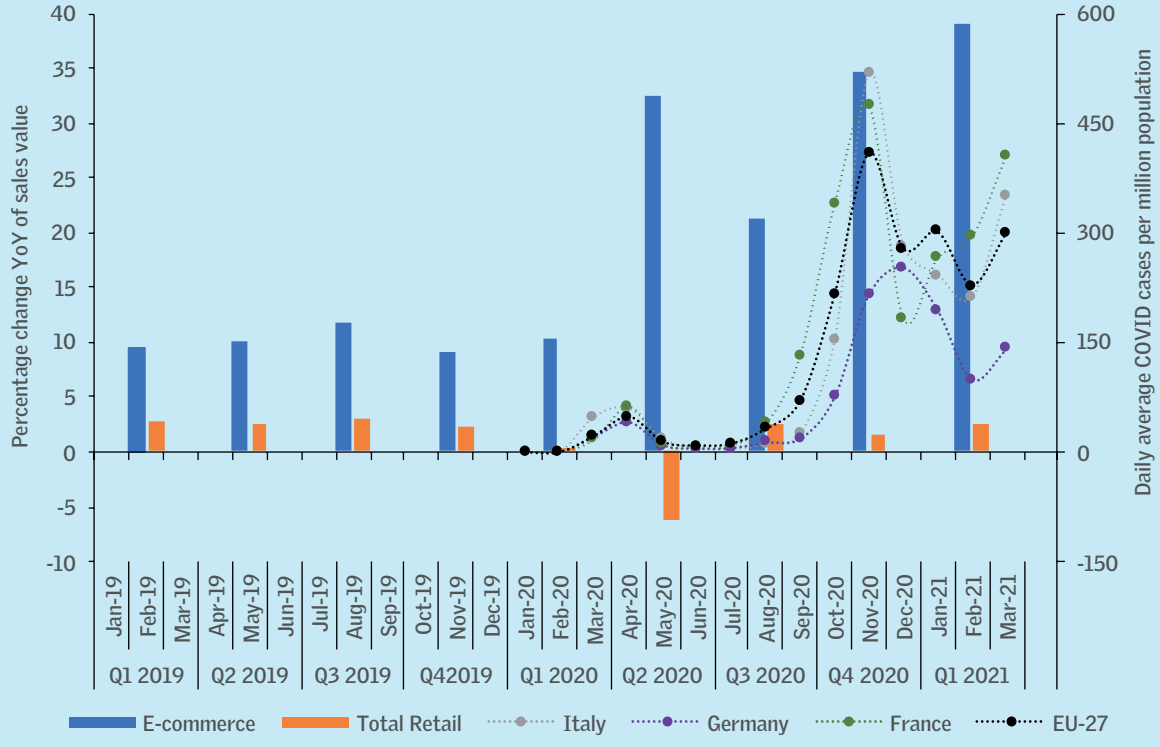
Europe: For most countries in Europe, Covid-19 infections peaked at the end of March 2020, and the third wave hit in October and November 2020.



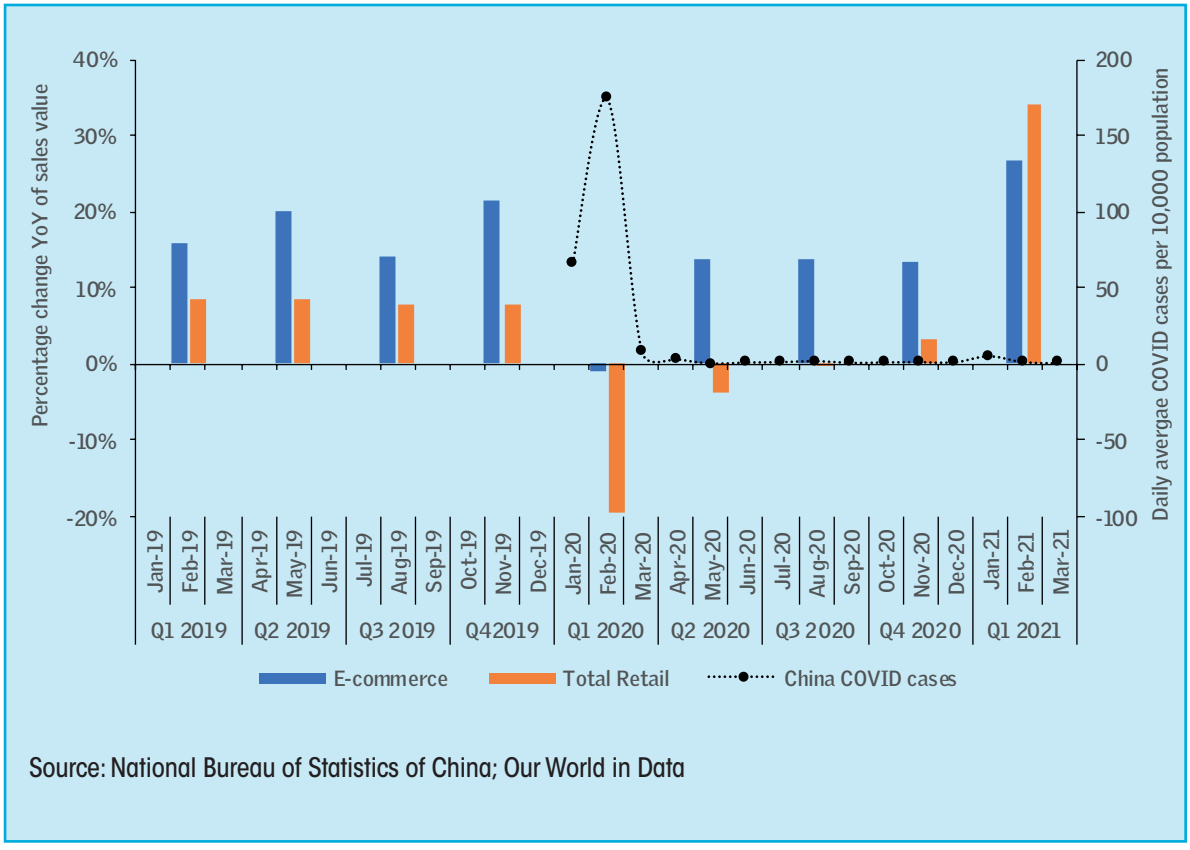
Note: Total retail data for EU–27 excludes motor vehicles and motor cycles.

Source: Eurostat, Our World in Data

E-retail in EU-27 increased by more than 30 per cent in Q2 2020 (April–June 2020), and the YOY change continued to rise throughout the year, reaching 35 per cent in Q4 2020 (October–December 2020) and 40 per cent in Q1 2021 (January–March 2021).

Countries such as France, Germany and Italy, which were the hardest hit during the pandemic, saw 25–35 per cent consumers switching to home deliveries, most of them for good. 10–15 per cent consumers also are willing to shift to digital purchases with the option of in-store collections, skipping the need for in-store browsing.[20]

China: Covid-19 infections peaked early in China during the Q1 2020 (January–March 2020), and the country saw one of the quickest recoveries in the world, seeing less than 10 daily cases per 10,000 of population by the end of the year. Brick-and-mortar retail dropped by 20 per cent during Q1 2020.The pandemic, during its peak, encouraged a vast majority of consumers to switch to e-retail.The top e-retailers in China such as Alibaba.com and JD.com saw increased gross merchandise value (GMV) rise by up to 20 per cent and 38 per cent respectively.[21]



Source: National Bureau of Statistics of China; Our World in Data

According to a market analysis by eMarketer, the pandemic has speeded up e-commerce adoption by at least three years. By the end of 2021, it is expected that the e-commerce segment will have a 7 per cent share in total retail sales—this was less than 4 per cent in 2019—in India. According to the projections before the pandemic, this level of penetration was expected only by 2024.[22]

In 2020, the overall retail sector plunged by 18 per cent YoY, due to the Covid-19 restrictions. However, the e-commerce sector grew by 30 per cent regardless.[23]

Similar trends were noticed around the globe, where the biggest world economies such as the USA, Europe and China saw a rise in e-retail sales as the number of Covid patients increased and people preferred contact-less transactions for their pharmaceutical and leisure shopping requirements.

IMPACT OF E-COMMERCE ON THE LOGISTICS SECTOR

A strong and growing e-commerce space translates to growing logistics requirements in the nation. Growing demand from tier 2 and below cities and rising consumer expectations for speedy delivery of products, coupled with technological disruptions such as the rise of big data, internet of things (IoT) and artificial intelligence (AI) applications, is rapidly driving the demand for the logistics market in India.

The overall logistics sector in India accounted for 11 per cent of the country's GDP in 2019, and has remained a backbone for many industries.[24] During FY 2015–20, the e-commerce-related logistics market in India grew at a compound annual growth rate (CAGR) of 23 per cent based on revenue and 27.4 per cent based on the number of shipments.[25]

With rapid growth, e-commerce companies may get overwhelmed with large consumer demand, and therefore due to sheer volumes fulfillment and delivery of all orders becomes difficult. Therefore, most companies turn to third-party logistics (3PL) companies for their logistics requirements, which typically entails warehousing, packaging, sorting and delivery/shipping to consumers, all while keeping the consumer in the loop with information about the status of their products.

There are three types of logistics service providers (LSPs) in the market.

- *Traditional logistics service providers* have recently ventured into the e-retail logistics business after the rise in e-retail demand in India to stay relevant in the market. With their experience and expertise, these companies have managed to hold a 23 per cent market share in the e-retail logistics space.[26] These companies however lack certain technological

capabilities required by e-retailers to cater to consumers. Gati Limited, BlueDart, FedEx, Safexpress and Future Supply Chain Solutions Limited are some of the top traditional LSPs in India.

- *E-commerce-focused logistics-service providers* have emerged in the market dedicated for e-retail, which use a technology-centric approach in their business models. These companies have a 28 per cent market share and are rapidly increasing as individual players make strategic investments and tie-ups to expand their operations.[27]

- *Captive logistics service providers* are the in-house logistics arms of larger e-retailers that carry out large volumes of operations (nearly 70 per cent) for the e-retailer. One such example of a captive LSP is Ekart Logistics, which is a subsidiary of Flipkart under Instakart Services Private Limited. GoJavas is another example operating under Pigeon Express Pvt. Ltd. Apart from the major logistic operations carried out for parent companies, LSPs also provide services to other e-retailers as well. Ekart, for example, also provides its services to PayTM and Shopclues, and has plans to increase its revenues from non-Flipkart companies.[28] Captive LSPs have a 49 per cent market share among e-commerce 3PLs in India.[29]

The pandemic saw major developments in terms of investments and business expansions in e-commerce specific and captive LSPs, since these two are more immersed in the e-commerce business with better technological advancements. The age-old traditional logistics sector is yet to adapt in this space that requires digitisation of the whole logistics process. Competition this tough means that services as basic as transparent tracking and accurate delivery time frames can turn the verdict of relevance away from majority of traditional LSPs in the e-retail space.

E-RETAIL AND DECARBONISATION CONNECT

According to the *United Nations Climate Change Annual Report 2018*, the e-retail industry is one of the top 10 carbon-intensive business sectors. A recent study on carbon emissions from the last-mile delivery network of global delivery and e-commerce businesses find that the top six businesses alone accounts for 4.5 megatonne of CO_2 emissions.[30] This is equivalent to CO_2 emissions from one million petrol passenger vehicle journeys.

Last-mile hyper-local delivery accounts to at least 50 per cent[31] of total delivery-related carbon emissions and is a significant segment from a climate perspective. For India and Europe, this can be more. The study studied 90 e-commerce business across India, Europe and North America. It estimates that the last-mile delivery network in India emits about 500 thousand tonne of CO_2.[32] It also recognises that though the Indian e-commerce market is currently small in comparison, it is estimated to become one of the biggest e-commerce markets in the world. And, in terms of carbon emission per delivery, it depicts a similar profile for Europe and North America.

Proper assessment of e-commerce and e-retail on traffic intensity and local congestion have not been studied well in Indian cities. But this requires early interventions to identify the strategies for interventions.

NEXT STEPS

E-retail is an emerging challenge in Indian cities. Its impact on traffic and freight intensity and its implications for carbon emissions have not been evaluated adequately yet. But this requires early and action.

E-commerce has added millions more tonne-kilometres and increased vehicle activity, which is adding to the carbon and energy intensity of urban transport. It requires a combination of policies related to urban planning for rationalising distribution systems, zoning, and a range of instruments to internalise the carbon impacts through distance-based charges, carbon pricing etc.

7

THE WAY FORWARD

THE WAY FORWARD

Transformation of transportation strategy needs well-distributed and equally stringent action in all sub-sectors of transportation to make a difference and to meet the goals of India's Long-Term Low-Emission Development Strategy. The integrated action plan needs time-bound action that is monitorable and verifiable. Each of the strategies will require clear metrics and indicators to detail the implementation strategy and assess progress.

Based on the review of strategies for decarbonisation across different transportation segments and existing and planned policy approaches, CSE recommends the following for the way ahead:

- **Roadmap to be implemented for stringent improvement in emissions and energy consumption in internal combustion engines and to meet zero emissions target:** India is on its way to implementing real-world emissions regulations from 2023 onwards and framing Bharat Stage VII (BSVII) emissions standards for implementation in 2027. This requires equally strident steps to significantly improve fuel economy regulations for fuel savings.

- **Ambitious electrification programme to be implemented to meet at least 30–40 per cent electrification by 2030–35, with higher targets for two- and three-wheelers and buses**: While implementing a longer-term incentive programme at the Central and state level along with a charging infrastructure plan, adopt supply mandate or zero emissions mandate for the vehicle industry. This is needed for long-term visibility of the policy landscape and to bring more certainty in the market.

- **All classes of cities should have time-bound targets to improve the modal share of public transport, walking, cycling and shared mobility** that are locally appropriate. This needs to be measurable and verifiable so that at least 90 per cent of motorised trips are public transport trips.

- **Targeted improvement in expansion of bus services and its funding strategy is needed:** State-level mandate for strengthening bus transport and its services with IT-based monitoring and passenger information system should be created. Financial instruments for mobilisation of resources at the city and state levels should be adopted with Central support to make these systems self-sufficient for modernisation and improvement.

- **Infrastructure needed for walking, cycling and safe access should be expanded and network developed** for functional use to induce change. This requirement should be integrated and mandated in all road infrastructure projects and funding strategies.

- **Vehicle-restraint measures and demand-management measures** should be enforced to curb use of personal vehicles. Hidden subsidies for personal vehicles should be removed through a variety of measures such as differentiated taxation, congestion and emissions pricing, parking caps and pricing for demand management. Low-emission zones to promote walking, cycling and zero-emission vehicles should be instituted.

- **Compact city design** and **form-based code** should be **adopt and mandated** to reduce travel distances and contain urban sprawl and gated development.

- **Transit-oriented development should be implemented** with planned densification, mixed-use and mixed-income development to improve access to public transport for the maximum number of city dwellers.

- **A modal shift in freight transport should be induced** from roadways to railways along with truck electrification and green freight programmes. The targeted modal share of 45

per cent for railways should be achieved by 2030 and more ambitious targets beyond. E-retail and e-commerce should be reformed for efficient deployment.

- In **aviation**, improvement in fuel efficiency, clean fuels and retirement of older fleets should be ensured.

- Innovative **fiscal instrument and polluter-pays principles** should be adopted for financing of the transportation sector. Dedicated state-level funding is needed to accelerate the transition.

- A **mechanism for climate finance** should be designed that works for transportation strategies.

- A **public communication strategy** should be implemented to influence policies and politics to build support around transportation and mobility solutions.

- **The institutional arrangements and mandate for the implementation of the sectoral plans should be defined.**

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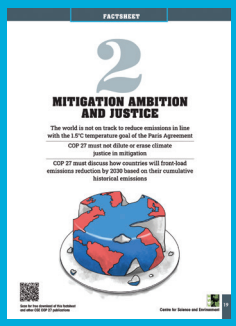

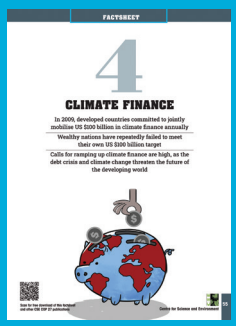

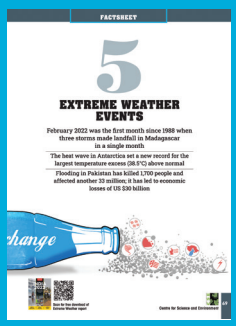

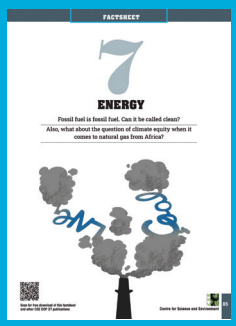

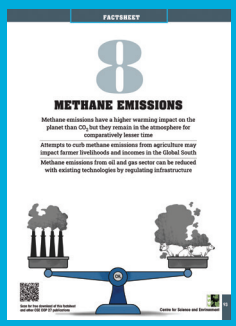

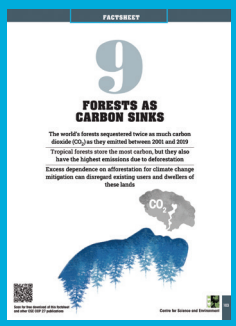

Centre for Science and Environment
41, Tughlakabad Institutional Area, New Delhi 110 062
Phones: 91-11-40616000 Fax: 91-11-29955879
Email: cse@cseindia.org Website: www.cseindia.org