SHAKTI
SUSTAINABLE ENERGY
FOUNDATION

The Energy and Resources Institute
Creating Innovative Solutions for a Sustainable Future

ROAD MAP FOR ELECTRIFICATION OF URBAN FREIGHT IN INDIA

ROAD MAP FOR ELECTRIFICATION OF URBAN FREIGHT IN INDIA (PART-I)

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About Shakti: Shakti Sustainable Energy Foundation seeks to facilitate India's transition to a sustainable energy future by aiding the design and implementation of policies in the following areas: clean power, energy efficiency, sustainable urban transport, climate change mitigation, and clean energy finance.

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Defining Urban Freight

As per ALICE (Alliance for Logistics Innovation through Collaboration in Europe) 'Urban freight transport is defined as all movements of goods in to, out from, through or within the urban area made by light or heavy vehicles, including also service transport and demolition traffic, online shopping trips made by private households and waste (reverse logistics). This excludes all personal movements' (ALICE n.d.).

As per Prof. S. Sriraman (Sriraman 2020 'All movements of goods generated by the economic needs of a local business unit, i.e. all deliveries and pick-up of supplies, materials, parts, consumables, mail and refuse that a business needs to operate. It also includes home deliveries to households, as they are generally done by means of a commercial transaction'. In this report, movement of goods in urban areas using commercial vehicles with Gross Vehicle Weight (GVW) less than 3.5 tonne is considered as urban freight. These are also referred as Small Commercial Vehicles (SCV) as per SIAM vehicle classification.

Urban freight plays an essential role in the social and economic development of cities. With the number of rapid urbanization, the demand for freight movement has increased exponentially. As per UN DESA 2014, by 2050, over 814 million people would be living in Indian cities, which may usher more commercial activities and movement of goods.

Globally, urban freight represents 10% to 15% of vehicle equivalent miles travelled in city streets and 2–5% of the employed urban workforce (World Bank & DFID n.d.).[1] In cities, the urban freight movement involves transportation through two-wheelers, small/light commercial vehicles (S/LCVs), and heavy commercial vehicles (HCVs).

Two-Wheelers

These ususally provide delivery services, such as food deliveries, document shipments or small packets and parcels, from service provider to consumer

Light Commercial Vehicles

- These provide both distribution services and consumer delivery services
- These are used to transfer both perishable and non- perishable goods, waste products, and other whole sale and retail items within the city

Medium and Heavy Commercial Vehicles

These vehicles are usually used to carry bulky material such as construction material, furniture, perishable, parcels,milk supply, water supply, solid waste

FIGURE 1 Types of urban freight vehicles

[1] Details available at http://siteresources.worldbank.org/INTTRANSPORT/Resources/336291-1239112757744/5997693-1266940498535/urban.pdf

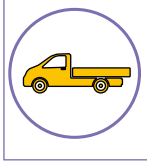
BOX 1: As per ARAI Vehicle category, the LCV vehicles are categorized into following categories

Three-wheeler (Goods Carrier - Pick-up van)

- Goods vehicle – Pick-up van (L5N)
- These vehicle types are with pick-up load platform bodywork and intended for carriage of goods. The GVW is usually less than 1 tonne

Three-wheeler (Goods Carrier - Delivery van)

- Goods vehicle – Delivery van (L5N)
- These vehicle types are with delivery deck bodywork and intended for carriage of goods. There weight is usually less than 3.5 tonne vehicle



Four-wheeler (N1 category)

- A vehicle used for carriage of goods and having a GVW not exceeding 3.5 tonne

The small commercial vehicles[2] (SCV's) segment, comprising trucks, vans and three-wheelers, is the most visible mode of transportation in cities. As per the Road Transport Yearbook 2016–17, amongst the total registered transport vehicles,[3] LCV and truck account for a share of 30.6% and 19.3%, respectively. In the category of newly registered LCVs in 2016-17, the share of three-wheelers and four-wheelers stood at 7.8% and 18.4% of the total share of transport vehicles. At the city level, among the total registered transport vehicles, LCV has a share of 26.9% of the total vehicle share of which four-wheeler vehicles comprised 16.2% and three-wheeler vehicles accounted for 10.7%, respectively (as per data of million-plus cities, March 2017).

There are negative externalities associated with the urban freight vehicular movement. Vehicular emissions serve as a major contributor to air pollution. Globally, freight transportation in cities is among the largest contributors to greenhouse gas (GHG) emissions, causing severe impact on the environment. In India, SCVs ply mainly on diesel and are the key GHG emitters/ contributors. In India, LCV goods vehicles contribute 17.33 gm/km of particulate matter annually (Bedi and Chauhan 2017). Some state governments concerned about the environmental problem caused by air pollution emitted by SCV switched to CNG. The SCV segment also has a significant impact on energy security at the national level. In 2016, the total registered LCV in India was about 1 crore and has witnessed a decadal increase of 2.5 folds.

To overcome the associated negative externalities produced by urban freight because of running on fossil fuel, switching to e-freight serves as an ideal solution. The decarbonization objective of urban freight requires a shift from fossil fuel-based powertrain vehicles to electric vehicles as they are the cleanest form of commercially available vehicles. Advancement in electric vehicle technology has been adopted by various companies globally, and many countries have made policy interventions to promote the adoption of electric vehicles in the transportation of goods in the urban setup.

Locally, SCVs create various transport challenges such as congestion, road accidents, air pollution, and noise pollution. According to the World Health Organisation (WHO), noise is second only to air pollution as a major environmental health concern. Indian cities are among the top 15 most polluted cities in the world. It is also observed that the SCV movement pattern involves constant stops at various loading and unloading points. The loading and unloading are done near the commercial centres and other business hubs and often lead to encroachment of road space, causing congestion. As per the Ministry of Road Transport and Highway's (MoRTH), Road Transport Yearbook 2018, with 16.6% share light-duty vehicles (LDVs) along with cars, vans, and taxis ranked the second highest contributor to road accidents (persons killed category).

[2] In this report, LCVs is used where reference to MoRTH data as well as wherever data analysis regarding the same has been conducted by TERI. Within LCVs there are Small Commercial Vehicles (SCVs) which are 3.5 tonne GVW vehicles

[3] As per MoRTH, transport vehicles are defined as the vehicles used for commercial purposes

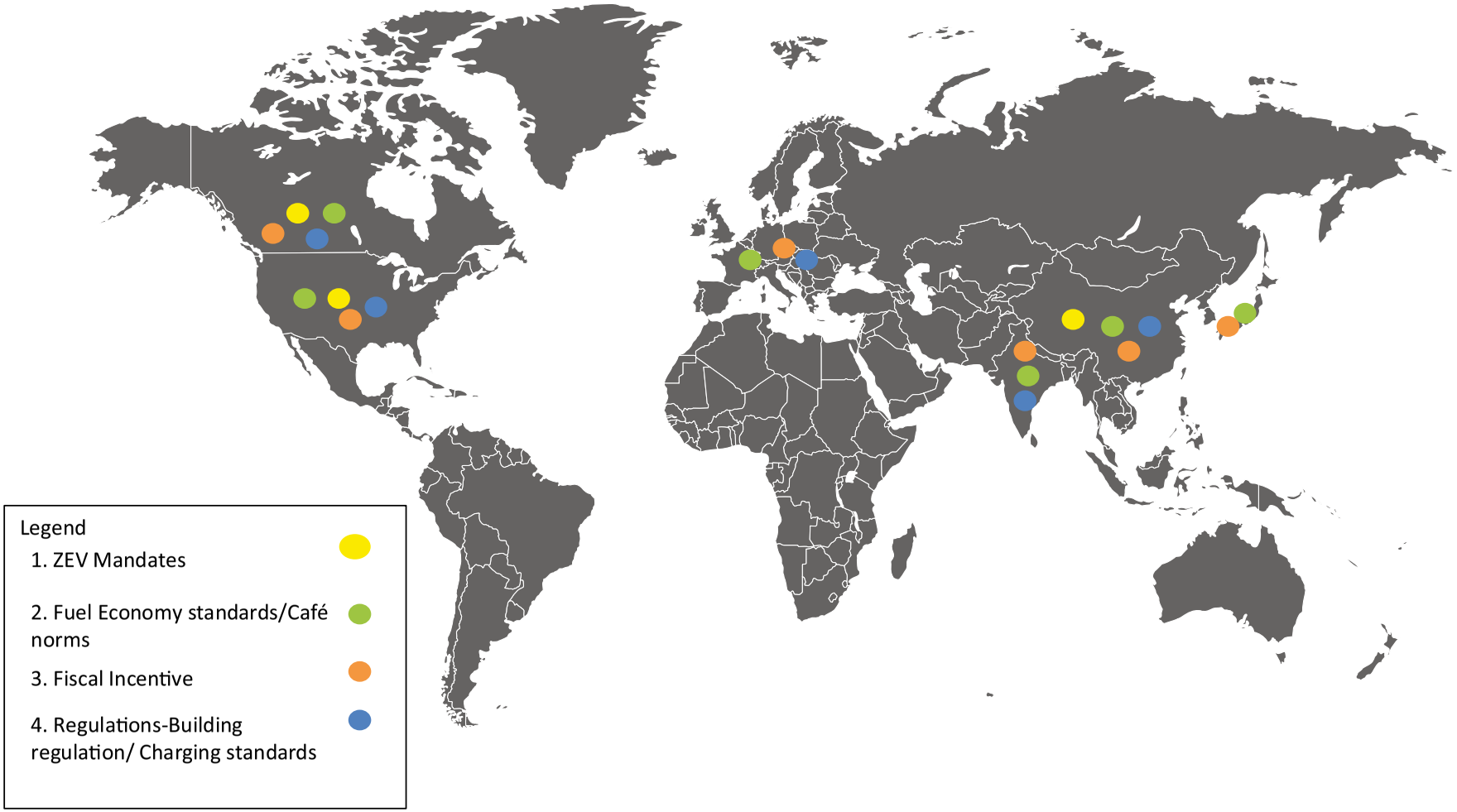


Figure 2 Global initiatives for e-urban freight

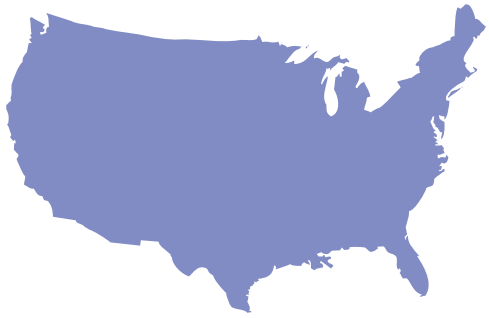
2. e-Urban Freight: Global Scenario

The transport sector is responsible for 28% of global energy demand and 23% of total energy-related CO_2 emissions (IPCC, 2019). Of this, the share of freight transport stood at 45% of total transport energy and LDVs consumed almost half of the total transport energy (IPCC, 2018). To minimize the GHG impact, adopting electric vehicles for urban freight transport movement will be an ideal solution.

Electric freight transport is being promoted worldwide with projects such as FREVUE (Freight Electric Vehicles in Urban Europe), e-mobility NSR, ELCIDIS (Electric Vehicle City Distribution), CITELEC (European Association of Cities interested in Electric Vehicles) in Europe, electric three-wheelers in China, and electric vans in North American states. These vehicles find varied applications, ranging from grocery delivery, courier, express, parcel (CEP) to waste collection and disposal. Decarbonization of the transport sector requires a decision regarding the approaching cost parity for SCVs with that of conventional vehicles, lower acquisition, and operational costs. In this chapter, we have selected case studies that have electrified the freight segment with special focus on SCVs.

USA

In the USA, 29% of the total energy is consumed by the transportation sector (Enrg.iq, 2016). Light-duty vehicles with a weight of less than 8500 lbs (approx. 3.5 tonne) are classified as class 1 and class 2a vehicles. These vehicles are used for intra-city movement, such as parcel delivery, postal services, waste management, among others. The USA has taken various policies and industry initiatives to promote LDV electrification. A large number of delivery companies have added electric vehicles into their fleet. Some of the aggressive policy measures adopted by



Key Policies

- California prepares it sustainable freight action plan with long-term 2050 vision and following targets
- Increase freight system efficiency by 25% within 2030.
- Deployment of over 100,000 zero-emission freight vehicles and associated equipment, maximizing the number of vehicles powered by renewable by 2030 (CEPA, 2016).
- California's Zero Emission Vehicles (ZEV) program requires major manufacturers of light trucks to attain a certain number of ZEV credits depending on the number of vehicles produced and delivered for sale in the state (Center for Climate and Energy Solutions, 2019).
- California also proposed Advanced Clean Truck Regulation, which is part of a holistic approach to accelerate a large-scale transition of zero-emission medium-and heavy-duty vehicles.
- The Electric Vehicle Project from the DoE deployed about 12,500 public and residential charging stations in 18 cities (U.S DOE, 2013)

California are mentioned in the box. Some of the industry initiatives are mentioned as follows:

- ***FedEx Express*** is operating electric vehicles for commercial and residential pick-up and delivery services. Thousand Chanje V8100 electric delivery vehicles will be deployed (FedEX, 2020). The company also plans to electrify 42 FedEx stations in California in 2020. This EV program will have the potential to help FedEx save 2000 gallons of fuel while avoiding 20 tonnes of emissions per vehicle each year (FedEx, n.d.).
- In 2019, DHL launched the Zero-Emission Program 2050, with a plan to roll out 63 electric delivery vans in the USA as an initiative towards increasing carbon efficiency. About half of the planned EV deployment will serve the San Francisco bay area. DHL plans to operate 70% of its own first- and last-mile delivery with clean pick-up and delivery solutions (DHL, 2019).
- In 2017, UPS and the New York State Energy Research and Development Authority (NYSERDA) announced their plan to invest $500,000 in developing and funding the transition from diesel to EVs (UPS, 2017). In 2018, UPS announced its plan to deploy 50 plug-in electric delivery trucks as pilots in Atlanta, Dallas, and Los Angeles (UPS, 2018).

Key Learning: Most delivery companies have collaborated with the cities, where the city provides a policy mechanism in which ZEV credits are given to different companies and the companies invest in infrastructure to reduce their carbon emissions as a part of their sustainability goals. Thus, a target-based approach is adopted by both the cities and the companies. Different models such as leasing and public-private partnership can also be explored for LDV electrification.

China

Between 1990 and 2012, China's CO_2 emissions grew by 25.3% (from 2.51 billion tonne to 9.86 billion tonne per year) (GIZ, 2014). China's transport energy use is projected to nearly quadruple between 2002 and 2025, from 4.3 EJ in 2002 to 16.4 EJ in 2025 (IPCC, 2018). The CO_2 emissions from the transport sector accounted for approximately 10% of the country's total emissions in 2008 and will likely double by 2020 in absolute terms (Wei Le, 2015).

- In 2006, the government began to promote new energy vehicles (NEVs, including plug-in electric vehicles), as per the Eleventh Five-Year Plan (2006–2010)
- In 2009, the Ten Cities, Thousands of Vehicles Demonstration Program was launched. The initial focus of this program was on government vehicles such as buses, garbage trucks, and taxis.
- Zero Emission Vehicle Mandate: China introduced the credit purchase system where the manufacturers need to buy credits from other companies that import 10% EV rule. This percentage will increase to 12% in 2020 and is applicable to any company which makes or imports 30,000 vehicles.
- Subsidies: The government provides subsidies to manufacturers, but these have been reduced since 2019. Electric plug-in cars with a range of 400 km are eligible for subsidies of RMB 25,000.
- Purchasers are given tax exemptions. Registration fee waiver has also helped in the increase in the sale of EVs.
- A mandate requires that the Chinese government procure only electric vehicles.
- By 2020, a target of 120,000 stations and 4.8 million EV charging posts has been set (Sandalow, 2019).

Freight accounts for only 15% of the total vehicles in China (excluding motorcycles), yet contributes more than 50% of vehicle CO_2 (Green BIZ, 2017). The N2 category usually consists of mini-trucks and light-duty vehicles with a weight of less than 3.5 tonne. Electric three-wheelers also come under the LDV category and are used by various urban delivery companies. These vehicles are used primarily in CEP (Courier, Express, Parcel) and in waste and disposal management (World bank, 2014).

The rapidly falling prices of battery and the availability of electric vehicles have led to China's electric vehicle market revolution. This is due to the adoption of the three-step policy mechanisms mentioned here:

- Since 2005, introduction of policies that speed up the production of new energy vehicles.
- By May 2010, 20 new energy vehicle demonstration pilots in major cities.
- From June 2010, subsidized the private purchase of new energy vehicles.

Owing to restriction in urban operations and registration of diesel vehicles, the cumulative production of pure electric delivery vehicles exceeded 100,000 units by the end of 2016. These vehicles were used in express delivery, flower/pet market delivery, laundry, and many other types of urban delivery (ICCT, 2018).

Electric Logistics Vehicles in Shenzhen

Shenzhen has banned the registration and nonlocal transfer of light-duty diesel vehicles since November 2017 (ICCT, 2018). Between 2015 and 2018, Shenzhen's fleet of electric logistics vehicles, vans, and light/medium trucks expanded from 300 to approximately 61,857 (RMI, 2019).

Some of the factors that acted as a catalyst include the availability of 45 varied ELV models in the market, the emergence of leasing companies, urban access, strict emission control, and a range of subsidies that made the up-front cost of ELVs comparable to diesel vehicles., As of 2018, an additionally 40,600 chargers were installed, and industrial electricity prices were lowered to push the penetration of ELVs (RMI, 2019).

Key Learning: The comprehensive approach of pushing the entire supply chain, thereby giving subsidies and incentives should be in place.

Deployment In European Countries

The European Union aims to reduce its carbon emissions by 60% by 2050. Notably, the European Union is also the second-largest importer of fossil fuel (Taefi, 2013). To decarbonize the transport sector, Europe has been experimenting with electric freight vehicles to understand the limitations, enablers, impacts, and learnings. Several regional projects such as FREVUE (Freight Vehicles in Urban Europe), e-mobility NSR, ELCIDIS (Electric Vehicle City Distribution), CITELEC (European Association of Cities interested in electric vehicles) have been contributing to this cause.

Denmark

In 2013, 14% of the total transport emissions in Denmark was from LDVs (Aarhus University, 2015). Till 2013, most of the LDVs were running on diesel, petrol, and LPG based. Denmark aims to achieve carbon-free city logistics by 2030. For the same, there have been several initiatives to include electric vehicles as a freight option in the light vehicle category, especially for inner-city logistics.

Initiatives

- **Pilots by Danish Energy Agency (DEA):** The DEA funded pilots in Copenhagen and Frederiksberg. The electric truck is used for public disposal of waste in Frederiksberg and book distribution in Copenhagen.
- **Mail delivery:** Post Denmark has been experimenting with 3 Mercedes Benz Vito e-cell vans since 2011 under the EDISON project. The result of the project shows that CO_2 emissions from the electric car are 63% lower compared to an equivalent diesel-powered car.
- **Cash management:** Loomis is invested in electric vans for operations in the city centre of Aarhus and Copenhagen.

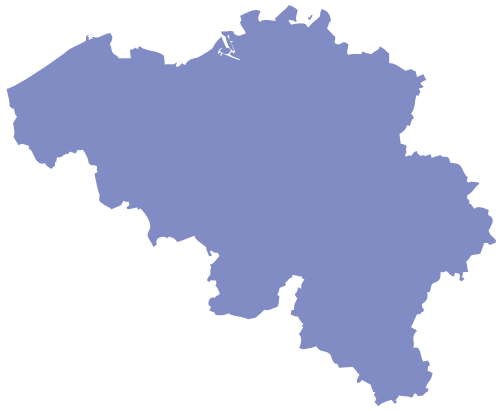
Key Learning: The DEA based on pilot partnerships with the public and private companies encouraged the adoption of electric vehicles.

Key Policies

- Electric vehicles were exempted from registration tax and annual green taxes until 2015, whereas ICE cars are charged at 180% (Christensen, 2017)
- Free parking facilities for electric vehicles in the cities of Odense and Frederiksberg (HEVTCP, 2020).
- Low emission zones have been segregated in larger Danish cities.
- Funding of €6.7 million was given towards promotion and test of EV between 2008 and 2015.

Germany

The transport sector is responsible for 20% of the energy-based GHG emissions in the country, out of which 82% is contributed by road transport (North sea e- mobility network, 2012). The light commercial vehicles are estimated to grow by 29.3% from 2004 to 2025, mainly due to the expansion of delivery traffic. The substitution of conventional light commercial vehicles with electric commercial vehicles for freight delivery in urban areas would have a significant impact on decarbonizing Germany. Therefore, Germany has been introducing various policies and initiatives to push its EV plans.



Key Policies

- Electric vehicles are exempted from registration tax in Flanders.
- The Flemish Minister of Innovation launched the Living Lab Electric Vehicles program to facilitate and accelerate the innovation and adoption of electric vehicles in the Flanders region. Five platforms have been established within the Flemish Living Lab Electric Vehicles. Among them, EVA (Electric Vehicles in Action), EVTecLab, iMOVE come under electric freight vehicles.
- I Move and Ev Tec Lab is a testing initiative in electric vehicles with a consortium of 18 companies and research institutions.
- Electric Vehicle in Action (EVA) is an initiative involving both private and public partners to stimulate electric vehicles. (Taefi, 2013). Referred (World Electric Vehicle Journal, 2013)

Initiatives

Under the NDPEM, various initiatives launched by the CEP departments include.

Postal Services

- City express initiated an on-going pilot with four converted electrical vehicles in 2011. (North sea e-mobility network, 2012).
- DHL, by using clean pick-up and delivery solutions for 70% of first and last mile services, such as electric

vehicles. DHL has an electric fleet of 120 EVs (ongoing) of various classes under 3.5 tonne to deliver mail, parcel and express goods in Germany (DHL, 2019).

Pilot Project

- In 2010-11, Cologne launched its E-mobility pilot program with a federal government subsidy. Under this program, 10 Ford Transit, 10 Transit Connect, 5 Ford Focus BEV were introduced. The project aimed to test the applicability of electric vehicles in city logistics. The fields of application were parcel service, collection, and transportation of waste from public dustbins, and the collection and transport of greenery and lobs from public parks. This pilot became a replicable project which later was scaled-up.

Key learning: The short trips urban freight vehicles offer huge potential for electrification.

Belgium

Almost 69.1% of freight activity was road based in 2009 in Belgium and 75% of the freight comprised trucks and light trucks.

Initiatives

- **Postal services:** Ecopostale is a courier company carrying out its activities in Brussels city using eight electric tri-cycles and a light-weight electric truck. The electric truck drives 80 km each day and delivers outside Brussels as well, and makes only one trip per day. Conducting 10,849 deliveries, Ecopostale saved 975 litres of fuel and avoided 20,71,960 gm of CO_2.
- **City-based** Antwerp municipality uses 8 electric trucks for utility tasks for carrying garbage bins, loading leaves, and branches, carrying light machines like lawnmowers.
- **Contract-based electric waste disposal**: SITAIR provides CO_2 free garbage collection at Brussels Airport. Using one electric truck amounts to reducting 130 tonne of CO_2 emission per year. This initiative is extended to 35 airports.

UK (London)

The 2008 Climate Change Act has set a target of reducing UK's GHG emissions by at least 80% by 2050, relative to 1990 levels. Thus, the UK has designed an aggressive strategy for reduction in all the sectors, including urban freight (Department of Transport Britain, 2017).

Key Policies

- In 2009, Electric Vehicle Delivery Plan for London was launched. Under the same, charging infrastructure, vehicle subsidy and communication programmes were initiated.
- Clean Air zones were earmarked
- EVs qualify for 100% congestion charge discount and tax benefits.
- Electric vans are exempt from van benefit charge for five years.
- A range of tax incentives has been introduced for business owners. An incentive of £8,000 on pure electric vans was issued.
- A commitment has been made towards adding 50,000 electric charge points to the London network within 2025 (Taefi, 2013).
- Industry-led EV innovation project Optmise prime was launched in 2020

Initiatives

The following initiatives were carried out due to the proposed policy measures.

- **Postal Services**: Abby Courier services own a fleet of 3 electric vehicles which mainly operate in southwest London. These vehicles handle a payload of 60 kg and have a range of 70 miles over 10 hours. It saves roughly £95 every week and is exempt from congestion tax and road tax.
- Gnewt Cargo Ltd. uses an EV fleet of electric scooters, bicycles, and vans for inner-city delivery and logistics. It has over 100 electric vehicles in its fleet, reducing carbon emissions by 6% per parcel.

Trade-based Services

- Melrose and Morgan, a food and grocery shop, own an electric Aixam Mega Van, which covers a maximum daily journey below 25 miles. The motivation was to decrease the operational cost.
- Pharmacy chain "Boots" has added five electric Renault Kangoo iVans in a pilot scheme. The company estimates a reduction of 22 tonne of carbon per year with the introduction of electric vans. The vans will deliver es in Nottinghamshire and Derbyshire (Government Europa, 2019).

Industry-led project

- Under the industry-led project, Optimise prime, various organizations were bought together including Hitachi Vantara, UK Power Networks, Centrica, Royal Mail, Uber, Scottish & Southern Electricity Networks, Hitachi Europe and Hitachi Capital. Under Optimise prime, Royal Mail has started operations of 190 electric vans.

Key learning: The savings nudge private players to shift to electric.

Portugal (Lisbon)

As part of the FREVUE project, Correios de Portugal (CTT), the national postal service of Portugal, introduced and operated 17 electric freight vehicles into their fleet which delivered and collected mail across several predefined routes. Based on the positive experience, CTT decided to procure another seven EFVs (Frevue, 2020). Some other international case studies are listed in Table 1.

Table 1 Green logistic case studies

Case	Location	Description	Benefits
E-CEP-Service Trial by Schachinger & Greenway	Perg, Austria	Electrified Citroen jumper vans are used to transport parcels from a distribution centre in Perg to business customers around Perg	❍ Neither noise emission nor exhaust fumes; thus E-van received well by drivers ❍ Huge marketing opportunity
La Petite Reine: Home deliveries using cargo cycles and electric vans	Pairs, France	La Petite Reine delivers purchases from big stores to consumer homes using electrically-assisted cargo tricycles and electric vans manufactured by Lovelo It has a payload of 180 kg for an empty weight of 110 kg and a volume of 1.5 m^3.	❍ Cargo cycles are used in dense city centres, including pedestrian areas where diesel vans are not allowed ❍ Positive image among clients and support of authorities ❍ Avoided use of trucks for 599,393tonne-km and generated a saving of 89.12-tonne oil equivalent ❍ Noise and air pollution reduced to zero
Norway National Transport Plan 2018–29	Norway	Norway's target 100% transition of LDVs to electric by 2025.	❍ Huge emission reduction caused due to LDV's

Source: Compiled by TERI

Note: The key learnings from the global experiences will be reflected in the road map in Part 2 of the report.

3. e-Urban Freight: Indian Scenario

To curb pollution and to achieve a greener future, switching to electric vehicles for intra-city logistics seems to be the only solution. India needs to understand the drivers of the global electric vehicle -based freight delivery market before this targeted transition can be achieved locally. To this end, this chapter gives an overview of the polices and industry practices, particularly in the intra-city freight segment. The chapter also aims to derive the learning on policy, regulatory, and infrastructural support required to promote electrification in the urban freight sector.

In India, original equipment manufacturer (OEMs) are planning to introduce small electric commercial vehicles. The work on electric variants of Tata's Ace and Mahindra & Mahindra (M&M)'s Jeeto is in progress. Electric vehicles, manufactured and assembled by Indian companies, have been used in freight activities such as waste collection and e-carts for deliveries-. Companies such as Flipkart, Grofers, Big Basket, Gati, and many others have already begun or have started their plans for the inclusion of electric vehicles in their supply chain.

The government policy interventions at both the national level and state level which support the transition to electrification of the freight segment are listed in the next section.

Policy Interventions

At the national level, the National Electric Mobility Mission Plan (NEMMP) has envisaged electrification of light commercial vehicles (LCV) and projected penetration of 30,000–50,000 LCVs by 2020. The plan was further supported by Rs 10,000 crore FAME II subsidy scheme, which accounts for incentives to the electric LCV vehicles. These policies have nudged the states to create an ecosystem for electric vehicles both in manufacturing and in adoption. Thus, various state policies have been formulated to further push the penetration of electric vehicles. Apart from the national-level policies and schemes, there are specific interventions taken by state governments, which are accelerating the adoption of electric urban freight vehicles.

Some of the state-run interventions and few state EV policies are mentioned here:

- **Deliver Electric Delhi**: The Delhi government is running a pilot project for the freight vehicles called Deliver Electric Delhi, in which 1000 electric vehicles will be used for deliveries over a year in partnership with 30 companies. Some of the participants include Flipkart, Amazon, BigBasket, Grofers, Uber Eats, Zomato, Hero Electric, Mahindra Electric, Tata Motors and even logistics company such as Blue Dart Express (Business Insider, 2019).
- **Smart Waste Vijayawada**: The Government of Andhra Pradesh is using smart waste electric disposal vehicles in the city of Vijayawada. The vehicles have been supplied to the government by Gayam Motor Works. Each diesel auto replaced will reduce about 35 tonne of carbon emissions over five years. As much as 200,000 tonne of carbon emissions can be reduced by replacing 5000+ municipal disposal vehicles across the state with electric vehicles (Data quest, 2017).

These policies support both manufacturing and adoption of electric freight vehicles within the state. However, to strengthen the adoption it is required that the policies have more robust regulations.

Table 1 State policies and interventions for urban freight

State electric vehicles policy	Incentives/Provisions for freight vehicles
Karnataka Electric Vehicle and Energy Storage Policy, 2017	❍ The policy proposes a transition of mini goods carriers in Bengaluru to electric in a phased manner to achieve 100% electrification by 2030 (GoK, 2017). ❍ E-commerce and delivery companies in Bengaluru are encouraged to replace their fleet of two/three wheelers to Ev's in a phased manner to achieve 100% electrification by 2030 (GoK, 2017)
Delhi Electric Vehicle Policy 2020	The policy encourages fleet owners to adopt electric goods carriers (e-Carriers) by providing: ❍ A purchase incentive of Rs 30,000 to the first 10,000 e-Carriers to be registered in Delhi ❍ Interest subvention of 5% on loans and/or hire purchase scheme for purchase of e-carriers Exemption from the prohibition on plying and idle parking of lights goods vehicles on identified roads of NCT of Delhi during specified timings as notified by the Transport Department. The purchasers of e-carriers will also be eligible for a scrapping incentive for scrapping and then registering the old ICE goods carriers registered in Delhi. Up to Rs 7500 of the incentive shall be reimbursed by the GNCTD to the purchase of e-carriers
Uttar Pradesh Electric Vehicle Manufacturing and Mobility Policy 2019	❍ Phasing out of all conventional commercial fleets and logistics vehicles (electric vehicle three-wheeler, four-wheelers, mini-goods vehicles) and achieve 50% EV mobility in goods transportation in identified 10 electric vehicles cities by 2024 and all cities by 2030 (Government of Uttar Pradesh, 2019).
Tamil Nadu Electric Vehicle Policy 2019	❍ SCV's used for delivering light loads such as mini goods vehicles in cities will be encouraged to convert to electric vehicless. ❍ E-commerce and delivery companies in Tamil Nadu will be encouraged to transition their vehicles to mini goods electric vehicless gradually. ❍ There will be no requirement of a permit for the three-wheeler goods, e-carriers. ❍ 100% road tax exemption for all e-carriers registered till March 2022.
Draft Kerala Electric Vehicle Policy	❍ The Kerala electric vehicle policy targets 1000 goods carrier for electrification with incentives on road tax, parking.
Draft Telangana Electric Vehicle Policy	❍ Encourage all freight and logistics firms to use electric vehicles in a phased manner ❍ Intra-city goods delivery services to switch to electric vehicles only by 2030 in a phased manner ❍ Encourage all app-based and e-commerce delivery services to migrate 25% of their vehicles fleet to electric vehicles by 2022 and 100% by 2030 ❍ Use of battery-operated application vehicles will be encouraged in government departments such as municipal corporations, postal services, across the state.
Andhra Pradesh Electric Vehicle Policy, 2018	❍ Phasing out all fossil fuel-based commercial fleets and logistics vehicles in four cities by 2024 and all cities by 2030. ❍ The policy targets to have 10 lakh EVs, combined across all segment of vehicles, by 2024. ❍ Target to have 1,00,000 slow and fast charging stations by 2045.

Source: Compiled by TERI

Industry Practices in India

The Indian policy ecosystem has encouraged private freight companies to adopt electric vehicles. The motivation for adoption is mostly to reduce carbon footprint. This is further coupled with the policy support provided by the government initiatives for scaling up electric adoption in India. Some of the industries that have adopted electric freight vehicles in use are as follows:

- Amazon India is planning to introduce 10,000 electric delivery vehicles in India by 2025. These vehicles will be both electric three- (including e-rickshaws) and four-wheelers and will be manufactured in India. In 2020, Amazon India has planned to operate commercial electric vehicles in 20 Indian cities including Delhi NCR, Hyderabad, Pune, Nagpur and Coimbatore (Green Car Congress, 2020).
- Flipkart is targeting transition of about 100% of its delivery fleet into electric vehicles in India by 2030. Initially, Flipkart had deployed 8 e-vans in Hyderabad, 10 e-vans in New Delhi, and 30 e-bikes in Bengaluru. Flipkart will also be coming up with the corresponding charging infrastructure for these electric vehicles in its fleet, a necessary step for a large-scale deployment of such vehicles. The charging stations will be installed at the operational hubs of the company (Flipkart, 2019).
- Grofers has at present 50 electric three-wheelers in Jaipur and 100 electric three-wheelers in Delhi. Further, it plans to deploy 500 electric three-wheelers across its 13 operational markets. The electric vehicles will reduce the last-mile delivery costs by up to 50% and carbon footprint by more than 40%. The electric vehicles can run for 60–70 km with a single charge, with a load-bearing capacity of 30 orders, costing Rs 20,000–25,000 per month. Diesel and CNG four-wheelers, in contrast, have a higher load-bearing capacity of up to 50 orders but cost Rs 60,000–65,000 to run. Grofers has partnered with eFleet Logix which operates in Delhi and Jaipur that will lease the three-wheeler electric vehicles to Grofers. The eFleet Logix is a third-party logistics company that provides an end-to-end solution from the vehicle, drivers to battery upkeep to setting up charging station infrastructure with help from the government (Business Insider, 2019).
- Big Basket has deployed 200 electric vehicles for deliveries in Hyderabad and Delhi-NCR and solar power in warehouses across Bengaluru, Gurugram, and Chennai. The company has tied-up with Mahindra e-Supro, Gayam Motors Works and Euler Motors to increase the number to 3000 by 2020 (ET retail, 2019).
- IKEA India has plans to adopt around 20% of its delivery fleet to be electric, which will later increase to 40% in the second year and 60% in the third year of IKEA's operation (Indian Retailer.com, 2018). Recently, the company has targeted for 100% of home deliveries to customers to be done by electric vehicles (EV) or other zero-emission solutions in all its 30 countries (IKEA,2020).
- Green DOT provides e-logistic services for food, e-commerce, and merchandise industries. It operates three-wheeler-based electric vehicles and offers services to players such as Amazon, Blue Dart, DHL, Aramex, Grofers, Natures Basket, Lenskart, in the e-commerce sector, and Fresh Menu, Burger King, KFC, etc. in the food-tech industry (Deccan Chronicle, 2019).
- Blue Dart targets to operate 70% of its local first and last mile services using clean pick-up and delivery solutions, such as bicycles and electric vehicles by 2025. For the same, Blue Dart piloted electric vehicles in Gurugram for its clean pick-up and last-mile e-tail (online retail) delivery services. These three-wheeler-based electric vehicles have a payload capacity of 500 kg and approximately 100 average-sized shipments. They are powered by lead-acid batteries which can reach a top speed of 40 kmph with a range of about 80 km per charge (Blue Dart, 2017).
- Altigreen Propulsion Labs and Cell Propulsion are two companies retrofitting their LMV. Altigreen has piloted the retrofitted of TATA Ace and has observed a 21% increase inefficiency.

4. Commercial Vehicles: Market Review

Roadways remain the dominant mode of freight transport in India, accounting for 67% of the total freight movement. Road freight caters to both inter- and intra-regional freight movement.[1] From 2007 to 2017, the tonne km by road increased at 10.6% CAGR (Figure 1) (MoRTH, 2019).

India has been rapidly urbanizing in recent times and is one of the emerging market economies. As a result, production and consumption of consumer goods are also likely to increase significantly. To maintain an efficient flow of goods and services, the volume of freight traffic is, therefore, bound to increase, which will impact the total energy consumption by road transport. Goods vehicles constitute less than 5% of the total registered vehicle fleet in the country (MoRTH, 2019) but account for more than 40% of the diesel consumption from road transport (PCRA, 2014). They are also the primary polluters.

Vehicle Classification

MoRTH classifies vehicles into two categories: transport and non-transport. As per this classification, freight vehicles such as multi-axle/articulated vehicles, trucks and lorries, and LMV/LCV, come under the transport vehicle category, which are primarily used for commercial purpose. Vehicles such as tractors and trailers are classified as non-transport vehicles, though they are also used for

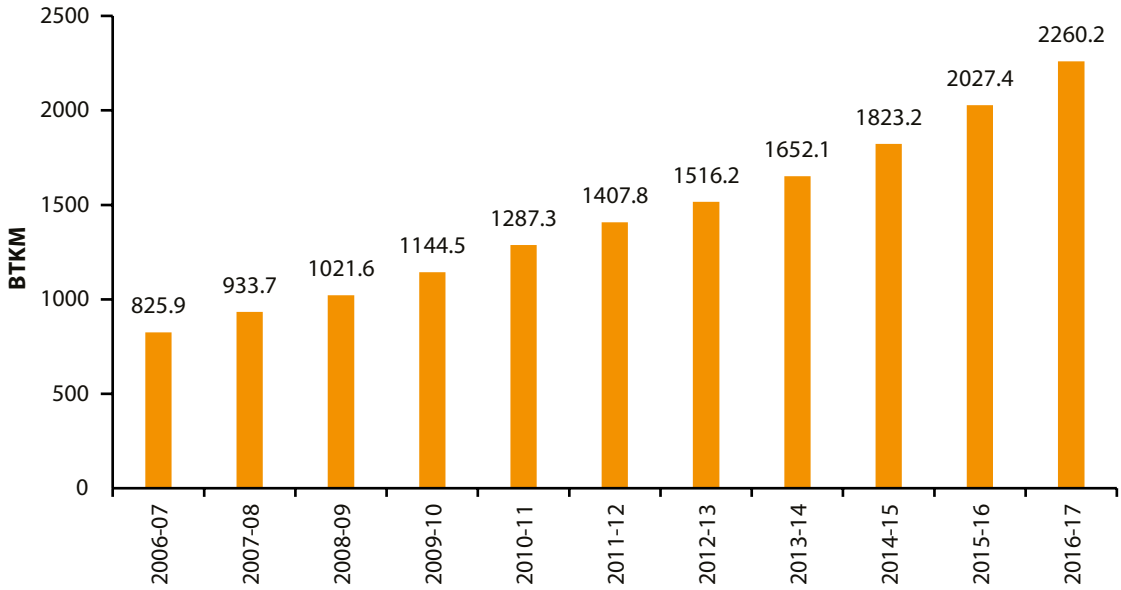


Figure 1: Billion tonne-km by road transport

Source: MoRTH

[1] Details available at https://niti.gov.in/writereaddata/files/document_publication/Freight_report.pdf

moving goods such as construction material, agricultural produce. Within the transport vehicle segment, multi-axle/articulated vehicles, trucks and lorries are further classified as medium or heavy commercial vehicles (M/HCVs) depending on the tonnage and gross vehicle weight (GVW).

Figure 2 shows the number of registered goods vehicles from 2006 to 2017. In this period, the total registered M/HCVs grew at a CAGR of 6% while LCVs grew at a CAGR of 12%. In 2016-17, within the LCV segment four-wheeler vehicles accounted for 53% share while three-wheelers had a 47% share, respectively.

Sales Trend

As per the SIAM classification of goods carriers or freight vehicles, the study has analysed three major segments: M/HCVs, LCVs, and three-wheelers.

The annual domestic sales of freight vehicles grew from around 1.6 lakh in 2001-02 to 7.2 lakh in 2016-17 with a CAGR of 11% (Figure 3).

In the freight segment, from 46% in 2001-02 the sales of M/HCVs declined to 35% in 2016-17 (Figure 4). In the same period, the sales of three-wheelers declined from 26% to 15% while that of LCVs increased from 27% to 50%.

Figure 5 shows growth pattern of sales of all the three segments over the last seven years. In 2013–14, all the three segments of vehicles observed a negative growth in sales. As per the latest estimates, LCVs and three-wheelers registered an 8% and 13% increase in sales in 2016–17 respectively, while M/HCVs sales declined by 1%.

Classification of Small Commercial Vehicles

The LCV segment is further classified into multiple categories based on the GVW criteria. As the focus of this study is on freight vehicles below 3.5 GVW, which are small commercial vehicles (SCVs) this section will further analyse the pattern of growth of this vehicle segment.

The four-wheeler SCVs comprise mini trucks and pick-up trucks. The share of sales of these two vehicle categories increased from 34% in 2001–02 to 90% in 2016–17 (Figure 6). This increase indicates that the demand for short run freight services is increasing day by day and is largely dependent on the small goods carriers.

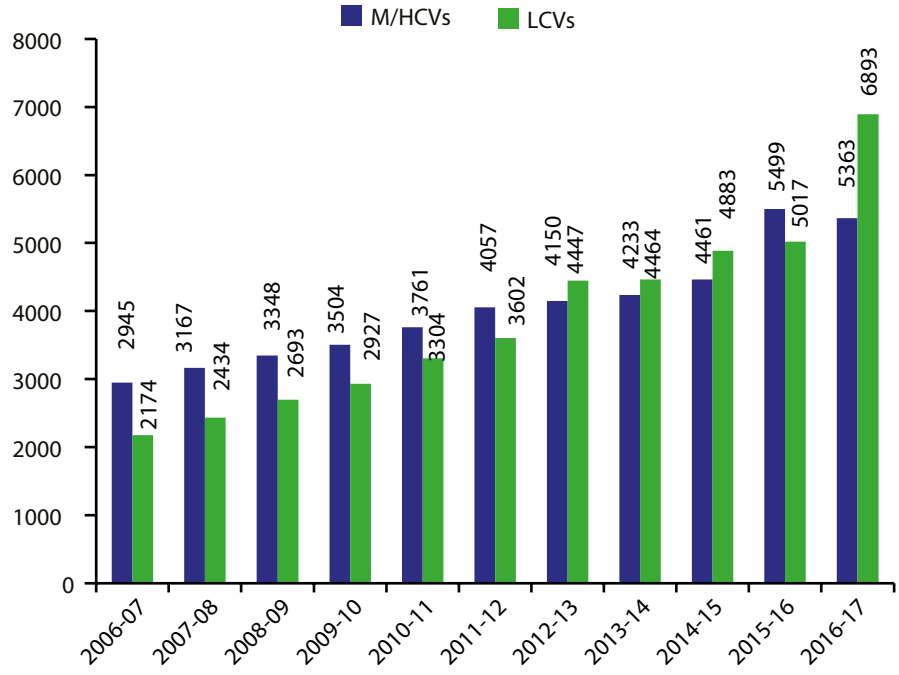


Figure 2 Total registered freight vehicles in India (in '000)

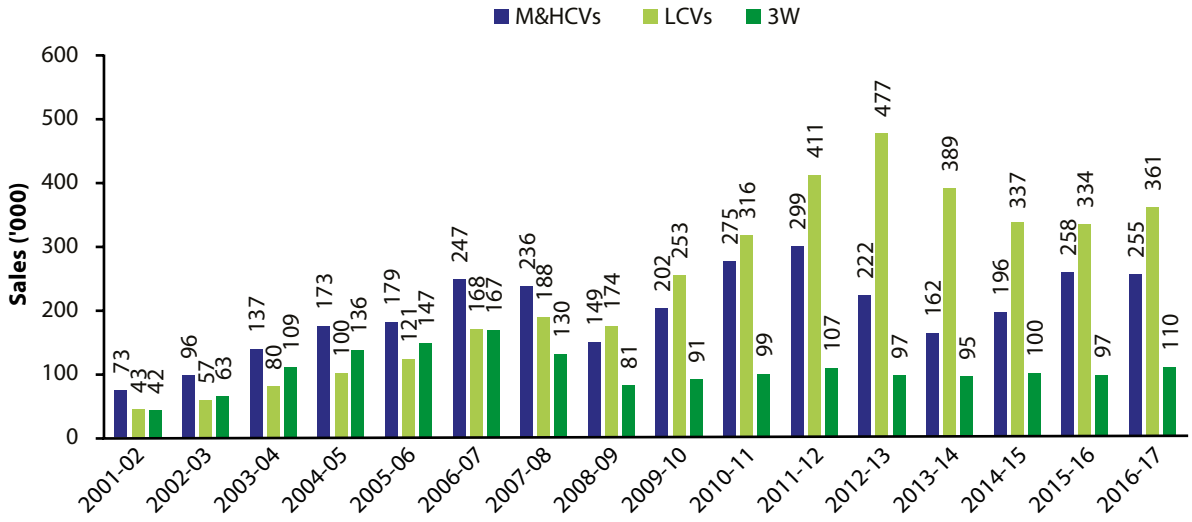


Figure 3 Annual domestic sales of commercial vehicles in India

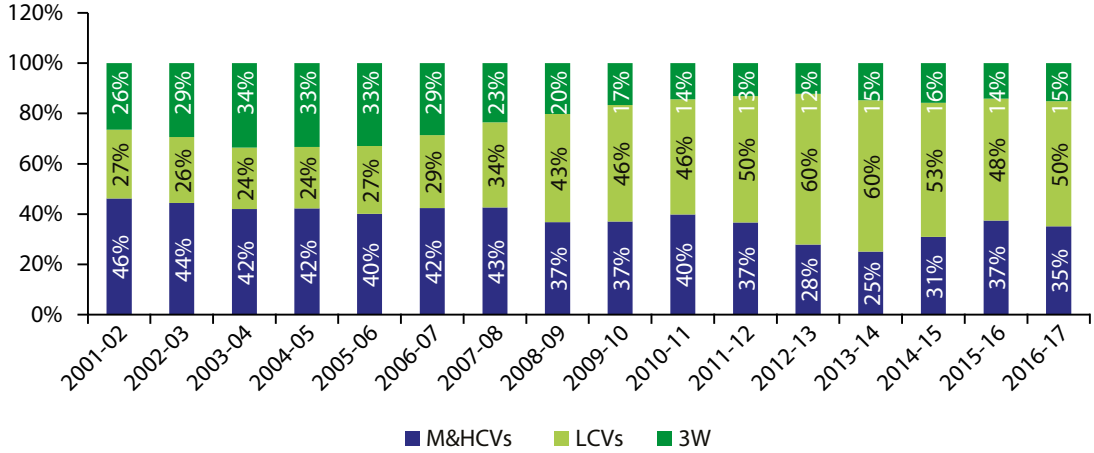


Figure 4 Share of different carriers in total sales of commercial vehicles

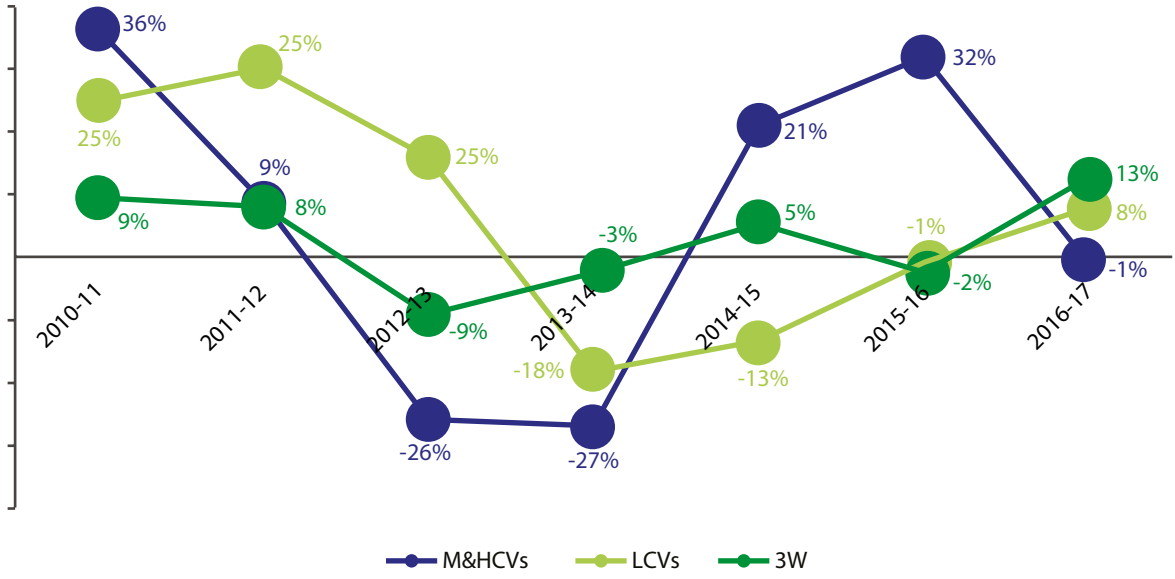


Figure 5 Category-wise growth pattern of sales of commercial vehicles

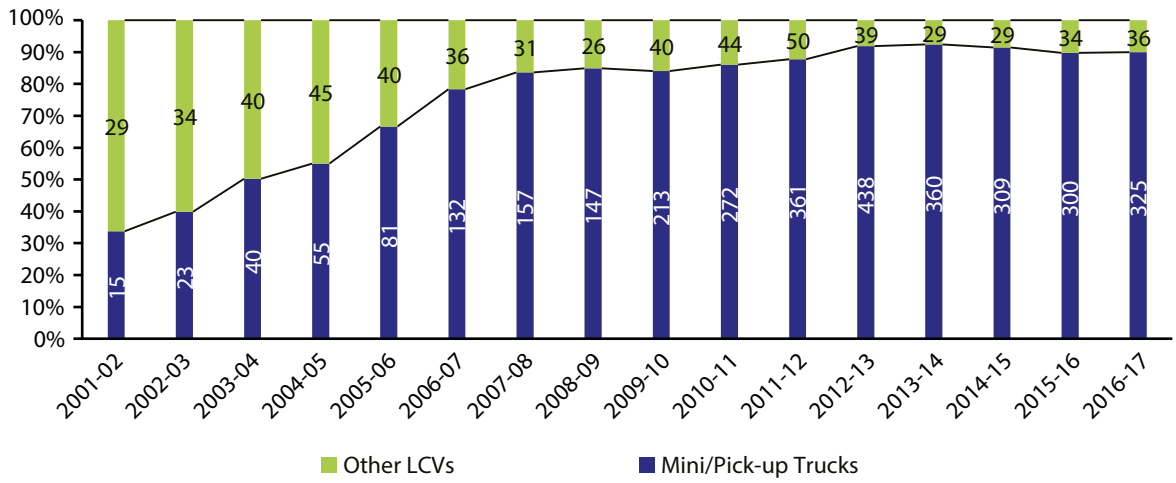


Figure 6 Share of <3.5 tonne vehicles in total LCVs in India (values in '000)

The sales trend of SCVs over the last few years suggests that pick-up trucks have a higher demand than mini trucks (Figure 7). Pick-up Trucks have observed a 14% CAGR increase over the last few years while mini trucks have registered a -14% CAGR decline.

Overview of ICE Freight Vehicle Market

The Indian urban freight vehicle market is mostly dominated by the internal combustion engine (ICE)-based vehicles. Both three- and four-wheeler segments are available in petrol, diesel, LPG, and CNG. The usage of these vehicles varies with the purpose of transportation which is further determined by the payload or the carrying capacity of the vehicles. Recently, the market share has turned even more heterogeneous with the entry of electric vehicles in India. However, market research of the current ICE vehicle players is required to understand the potential of electric vehicles in the freight segment. Figures 8 and 9 show the key market players in the four-wheeler and three-wheeler urban freight vehicles.

As per Figure 8, the dominant players in the four-wheeler segment are M&M Limited and Tata Motors with a sales

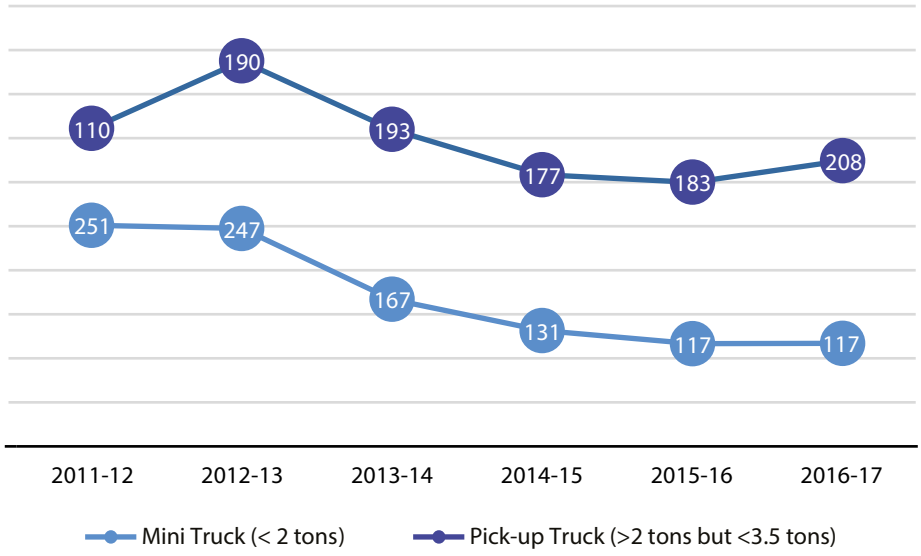


Figure 7: Sales trend of SCVs in India

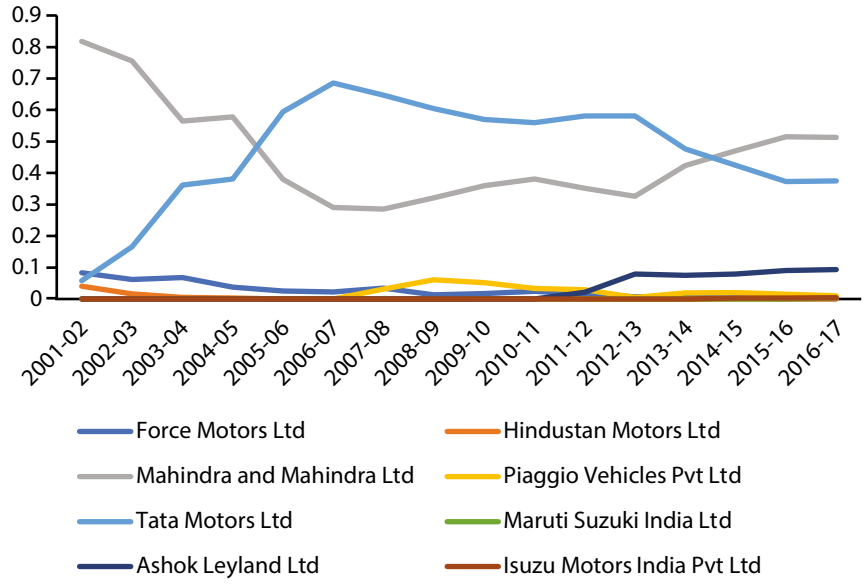


Figure 8 Growth of four-wheeler SCVs in India

Source: SIAM

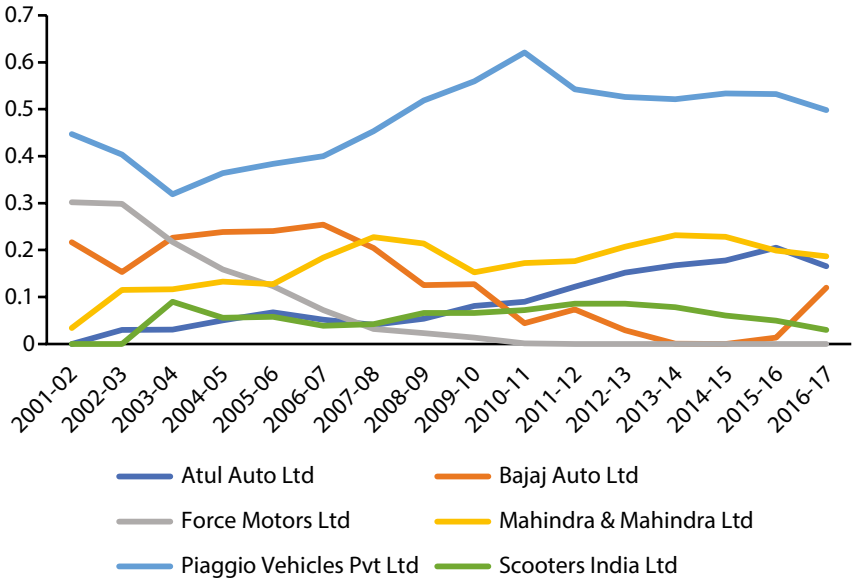


Figure 9 Growth of three-wheeler SCVs in India

Source: SIAM

share of 51.3% and 37.4%, respectively in 2016-17. M&M has been the prime manufacturer of goods carrier four-wheelers since 2000. While the sales was only 14,573 in 2000, it increased to 324,500 in 2016–17. The share of Tata Motors also increased gradually between 2000 and 2016. In 2011–12, Ashok Leyland entered the four-wheeler goods space and by 2016–17 became the third largest company in the sales share followed by Piaggio Vehicles Private Limited, Isuzu Motors India Private Limited, and Force Motors Limited.

In the three-wheeler segment, Piaggio is the dominant player and has a constant high share with 49.8% sales share. The other players in the three-wheeler segments are M&M, Bajaj Auto Limited, and Atul Auto Limited with sales share of 18.7%, 12%, and 16.5%, respectively.

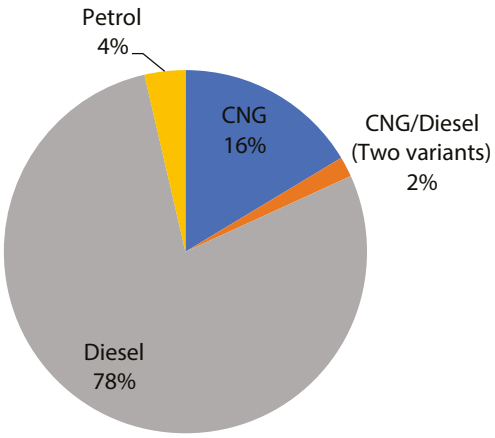


Figure 10 Fuel type of ICE models sold in India

Most of the top-selling models for urban freight are energy-intensive models. Based on our analysis of the 55 models of the top key players – M&M, Tata Motors, Bajaj, Piaggio and Atul Auto – the following conclusions were derived.

Fuel Composition

Among the 55 analysed models, 78% were diesel-based and 16% were CNG-based, 4% were petrol-based, and 2% were the CNG–diesel variant. The high share of the non-renewable fuel sources indicates high-energy consumption and increase in the vehicular emissions from the urban freight sector. The limited usage of alternative fuels such as CNG is because of its limited availability.

Among the top-selling manufacturers, Mahindra has only 5 CNG-based models among the 30 variants of SCVs.

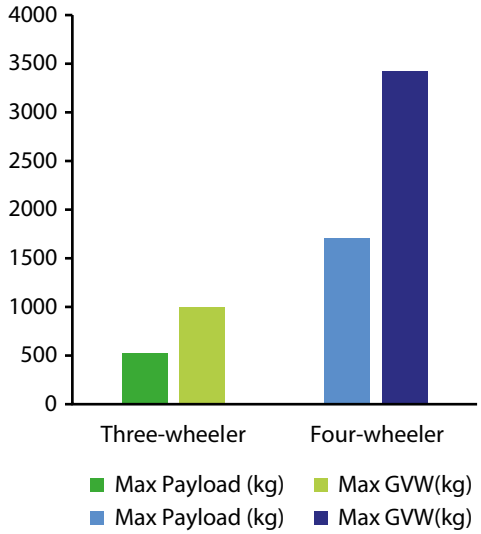


Figure 11 ICE vehicle payload and GVW

Similarly, Tata Motors has 3 CNG-based models among the 12 variants. Piaggio, with its dominant share in the three-wheeler freight vehicle, has a diesel-based variant available. However, its contemporaries Bajaj and Atul Auto have both diesel- and CNG-based variants available.

Vehicle Weight and Payload

The maximum gross vehicle weight of the three-wheelers variants of Atul Auto and Bajaj is 995 kg. The GVW for Piaggio is 975 kg. These vehicles can have a payload of around 425–525 kg. In the four-wheeler SCV segment, Mahindra and Tata Motors have maximum GVW of 3425 kg and 2300 kg, respectively. The payload of these two variants varies between 500 kg and 1700 kg.

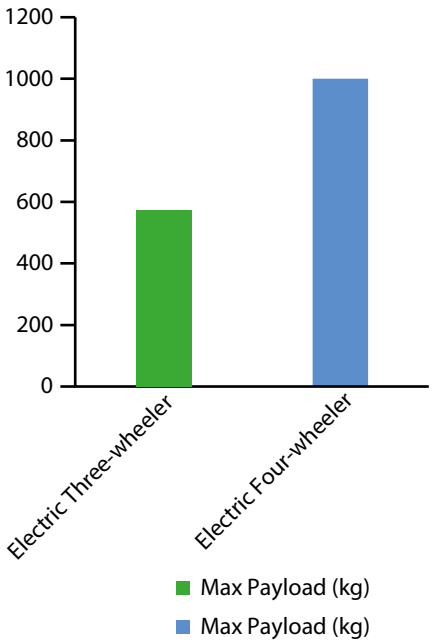


Figure 12 Maximum Payload of EV

Note: Vehicle payload includes battery weight

Vehicle Price

The three-wheeler LCVs mostly lie in the price range of Rs 1.5 to Rs 2.15 lakh. The cost varies with vehicle weight. In the four-wheeler category, the price ranges from Rs 3 to Rs 8.25 lakh, depending upon the vehicle carrying capacity.

Overview of Electric Freight Vehicle Market

With the Indian policy landscape supporting electrification, many small and large players have entered

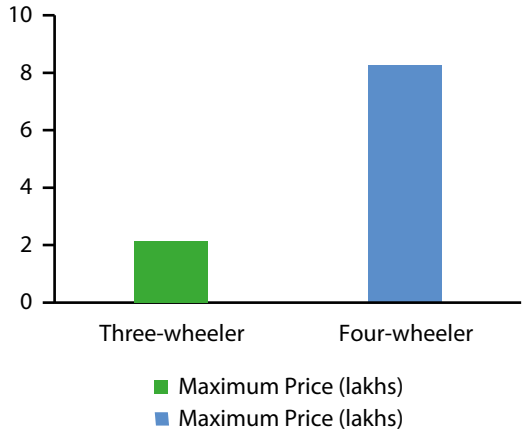


Figure 13 ICE Vehicle maximum price

the urban freight market. These players manufacture freight vehicles both in the three-wheeler and in the four-wheeler segments. Both the models are available with lead-acid and lithium-ion battery technology and their price vary as per the battery size and technology.

Among the key ICE players, M&M and Tata Motors are about to launch their four-wheeler electric variants Mahindra e-Supro cargo van and Tata ACE Electric, respectively. Apart from these, Croyance and Altigreen are the other two companies in the four-wheeler segment manufacturing electric cargo vehicles. Companies such as Inncrypto Technologies and e-Trio are investing in the retrofitting of electric four-wheeler cargo vehicles.

In the electric three-wheeler cargo vehicles, among the existing big ICE players Atul Auto became the pioneer by entering the market. Other smaller electric three-wheeler market players such as Kinetic, Lohia, Gayam Motors, Goenka Ecoyan, Adapt Motors manufacture both lead-acid and lithium-ion batteries. Players like Altigreen and Volta are involved in retrofitting of electric three-wheelers manufacturing.

Payload

Based on the TERI's compiled data payload of the vehicle in the four-wheeler models varies from 600 to 1000 kg. In the three-wheeler segment, the payload of electric freight vehicle ranges between 100 kg and 680 kg. In some electric three-wheelers, the battery weight is not included in the payload. Therefore, the payload capacity is assumed to be less than the stated.

Battery Capacity and Range

Based on the TERI's compiled data battery capacity of Mahindra's e-Supro cargo van is around 14.4 kWh and its range is 115 km. Mahindra electric vehicles use lithium-ion battery. The Croyance Automotive are installed with VRL battery packs in their electric cargo van and their range is around 120 km. As there are very few players in the four-wheeler segment, thus limited information is available. Among the four-wheeler retrofitted option segment, E-Trio is available on Tata Ace.

In the three-wheeler segment, both lead-acid and lithium-ion battery technologies are available. The battery capacity and the range vary with the payload. In the lithium-ion battery technology, the payload varies between 320 and 575 kg and accordingly the battery capacity ranges between 5 and 7.2 kWh. The Kinetic Safar medium e-delivery vehicle has 7.2 kWh battery capacity. The key players in the three-wheeler electric freight segment with lithium-ion battery are Kinetic Green Energy & Power Solutions Limited, Lohia Auto Industries, OK Play, Sarthi e-rickshaws, Speedways Electric. Altigreen and Volta are into retrofittment of vehicles; they use lithium-ion batteries. The range of all these vehicles is between 80 and 100 km.

The payload of lead-acid battery vehicles ranges between 320 and 600 kg. Most of the vehicles have a battery capacity of 4.8 kWh or 5.76 kWH as they use four batteries of 1.2 kWh each or 1.3 kWh each. The range of these vehicles is between 80 and 110 km.

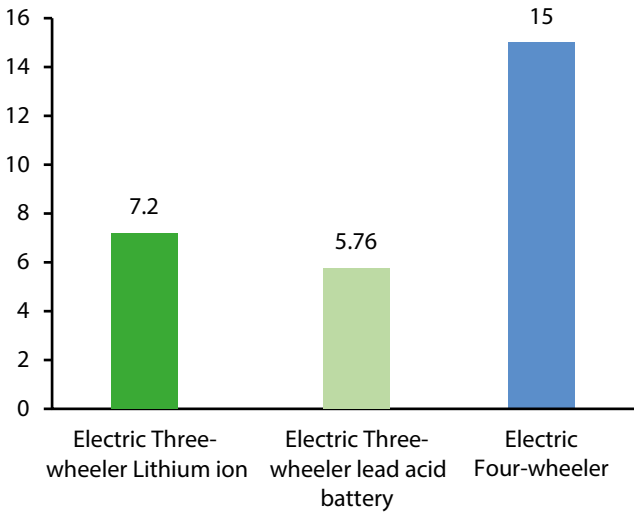


Figure 14 Battery capacity of commercially available electric vehicles in India

Motor Power and Maximum Speed

The speed of Mahindra Electric's e-Supro is 60 km per hour with a motor capacity of 25 kwh. Other electric four-wheelers also offer a similar speed range of 80-60 kmph. In the electric three-wheeler cargo vehicles, the motor power of lead-acid battery range between 750 W and 1500 W and speed between 23 kmph and 30 kmph. The lithium-ion battery vehicles also have similar range with the exception of Taskman Cargo from Gayam Motors, which offers a maximum speed of 55 km/h. The motor capacity of the vehicles varies between 900 W and 1500 W.

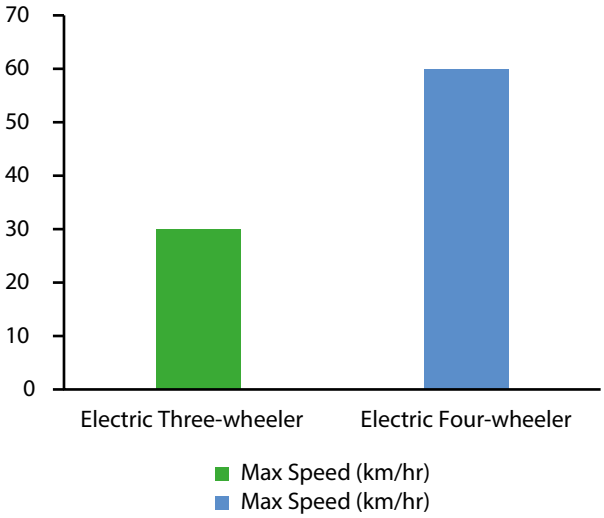


Figure 15 Maximum speed

Charging Hours and Price

The price depends on various factors such as fuel efficiency, payload, engine capacity. However, a tentative price range is captured.

Mahindra electric's e-Supro takes 8.5 h to charge and the vehicle costs around Rs 12 lakh (based on the stakeholder consultation as at present four-wheeler cargo vehicle is not available therefore its price range is not fixed).

In the electric three-wheelers, the charging time for lithium-ion battery vehicles range between 3 h and 5 h and the charging time of the lead-acid battery ranges between 6 h and 8 h. The price range also varies accordingly as the cost of vehicles with lithium-ion battery technology ranges between Rs 2 lakh and Rs 3.5 lakh whereas the cost of lead-acid battery vehicles lies between Rs 1 and Rs 1.5 lakh.

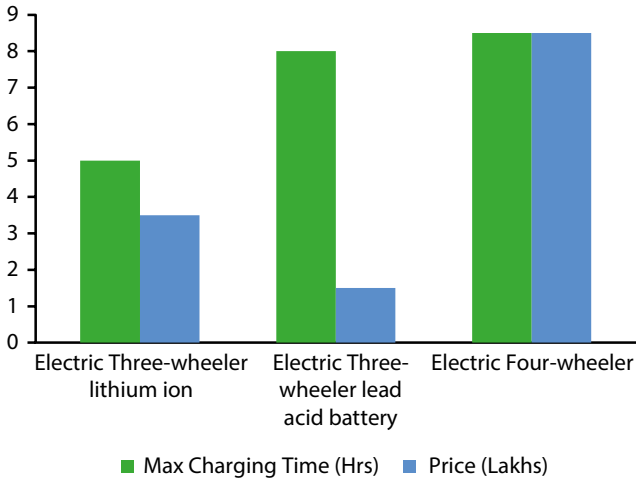


Figure 16 EV charging time and price

Table 1 Summary of ICE and EV vehicles

Vehicle Type	GVW (kg)	Payload (kg)	Price (lakh)	Charging Hours	Max Speed (kmph)	Battery Capacity (kWh)	Range (km)	Key Players
ICE 3W	975-995	425-525	1.5-2.15	-		-	-	M&M, Bajaj, Atul Auto
ICE 4W	2300-3425	500-1700	3-8.25	-		-	-	M&M, Tata Motors
E 3W- Lead Acid		320-600	1-1.5	6-8	23-30	4.8- 5.76	80-110	
E 3W- Li-ion		320-575	2-3.5	3-5	25-55	5-7.2	80-100	Kinetic, Lohia, OK Play, Sarthi, Speedways
E 4W - Li-ion		600-1000		8.5	60	14.4	115	Mahindra Electric's E- Supro, Croyance, Tata ACE Electric

Source: TERI

Conclusion

Based on market research, limited alternatives to ICE SCV four-wheelers could be found. The price range of the alternative electric four-wheelers is comparable to the premium range of ICE four-wheelers. However, the payload capacity and maximum speed are not at par with the ICE four-wheelers, and the charging time is very high. The range offered by the long charging is comparable to the average trip distance but may offer some limitations.

In the case of three-wheelers, the options are available both with lead-acid and lithium-ion battery technology. The price range of lead-acid battery is comparable with the ICE three-wheeler. The technology is nascent, and charging takes a long time. The lithium-ion battery three-wheelers take less charging time and offer almost similar range but their price range is higher than the conventional ICE vehicle. The maximum speed is another limitation for the electric three-wheelers, but the speed offered is as per the maximum speed required in the urban setting.

Overall, there is a high potential for replacement of conventional freight three-wheelers with electric three-wheelers. However, all present and upcoming government policies mention advance technology of batteries as one of the eligible criteria along with performance and safety. Robust technology with optimized cost is already available and OEMs are geared up for the freight four-wheeler segment.

5. Urban Freight: Impact on Energy and Emissions

Assessment of energy consumption and emissions plays a key role in analysing the sustainability of the transport systems. Considering the fact that the road transport system is one of the most energy and emission intensive sectors in India, there is a need to align our focus on decarbonizing the sector by specifically studying the characteristics of each of the sub-sectors. Up until now, the key focus of policymakers has been on reducing the fossil fuel dependency from the passenger road transport sector. In this direction, the government has taken several initiatives such as improving fuel efficiency, adopting advanced emission norms, and switching to alternative fuel technologies. However, the demand for diesel in the country has largely been driven by freight vehicles. As per IEA, oil demand for road freight vehicles has grown by more than a factor of three in India since 2000, which is the largest among all the countries (IEA, 2017). Hence, there is a need for policy focus on freight vehicle segment and identifying ways and technologies to reduce the oil demand from the sector.

In recent years, India has seen a rapid increase in demand for LCVs. The share of LCVs in the total freight vehicle segment has increased from 27% to 50% from 2002 to 2017.[1] As Indian cities rapidly urbanize, urban freight demand can be expected to increase too. A better understanding of the characteristics of this vehicle segment and its impact on overall energy security and emissions could help policymakers develop better measures to limit the environmental footprint of this segment. Additionally, SCVs such as three-wheelers, mini trucks and pick-up trucks, offer a higher potential of successfully adopting alternative fuel technologies. Many cities have already adopted CNG as an alternative fuel for freight vehicles in the three-wheelers and four-wheelers segment and different pilot projects are also being implemented to see the feasibility of electrification of commercial goods three-wheelers and four-wheelers. This indicates that adoption of alternative fuel technologies has been successful in the SCV segment as compared to M/HCVs. This offers conducive opportunity to Indian policymakers to step up transition towards cleaner fuels by introducing adoption of electric freight vehicles for SCV segment. Hence, by assessing benefits that can be realised by electrifying the SCV segment, this study will advance the case for electrification of the entire freight segment in the longer run.

Assessment of Impact on Energy Consumption and Emissions

This chapter aims to analyse the impact of growth in SCV segment on energy and emissions by 2030. For this purpose, a Business-As-Usual (BAU) scenario has been created to understand the environmental impact of current policy targets in the SCV segment. An alternative scenario is then created by considering high share of electric vehicles based on stakeholder consultations, government policies, and literature review. The two business cases are compared to understand the benefits of electrification across a broad range of assumptions.

Methodology

This analysis aims to estimate emissions from urban freight based on a bottom up activity-based approach. The analysis involves the following steps:

- **Estimating stock of three-wheeler and four-wheeler freight vehicles involved in urban freight up to year 2030**

[1] Based on SIAM sales data and TERI analysis

The total stock of motorized vehicles is the basic building blocks of bottom-up transport model. Considering that no published data is available on exact stock of SCVs in India, sales data from 1991 onwards was used to analyse the stock of three-wheeler and four-wheeler SCVs. This sales-based assessment has been made till 2016–17, post which forecast has been done till 2030.

❍ **Segregating vehicles by fuel type**

The available fuel technologies vary by type of freight vehicles. Currently, the three-wheeler segment in India has variants of diesel, petrol, CNG, LPG, and electric while the four-wheeler segment has the options of diesel, CNG, and electric. Going by the current policies and industry outlook (SIAM, 2019), the four-wheeler segment will be dominated by diesel-run vehicles with CNG accounting for only 5% in new sales by 2030. In the three-wheeler segment, as per the current growth trajectory, the share of diesel and petrol vehicles will decrease and that of CNG vehicles will increase by 2030. Due to continuous increase in prices of petrol and diesel, LPG is also likely to sustain for a long term in the three-wheeler segment. The overall market share of electric vehicle in this segment is likely to stay around 20% in a BAU scenario based on the global outlook (Bloomberg, 2019). Similar to the trends in the BAU scenario, electric three-wheeler are expected to dominate the market share in the alternative scenario as well (Figure 1).

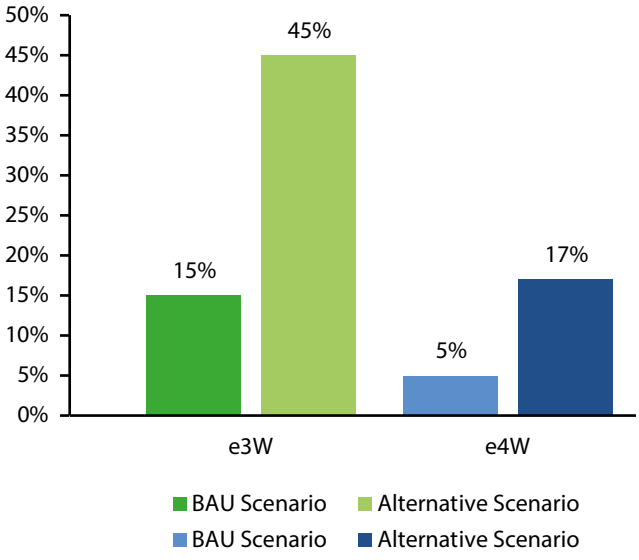


Figure 1 Market share of EV's in SCV segment by 2030–31 (based on TERI estimates)

❍ **Determining utilization rates, payloads, and fuel economy for three-wheelers and four-wheelers**

Different types of vehicles have different types of patterns in terms of use intensities. The activity data is estimated separately for three-wheelers and four-wheelers as well as by the technology used in a vehicle. Inputs are obtained from published literature, estimates from survey data, and assumptions based on stakeholder consultations.

❍ **Estimating the overall energy demand and emissions**

In order to estimate energy demand, we assess tonne-km (tkm) by different fuel types using factors such as vehicle utilization and payload. Once the tkm are calculated, fuel economy factors are taken into account to assess the total fuel consumption. The model allows for fuel efficiency to decrease with the age of vehicle using estimates from published literature (Malik, Tiwari, & Mohan, 2015). Emissions are estimated for both BAU and alternate clean energy scenarios. The two scenarios are compared to assess the potential emission benefits from electrification of urban freight vehicles in India. In the last step, energy and emission factors are utilized to calculate the total emissions from the segment (Box 1).

Impact of Electrification in SCV Segment

As per our analysis, the SCV segment is likely to grow at a CAGR of 9% between 2021 and 2031. Based on the trends in sales, it is expected that the share of four-wheelers in the total SCV segment is going to increase and will account for 76% of the total stock by 2031. In the coming decade, the three-wheeler SCV segment will grow at a CAGR of 6.5% while the four-wheeler will grow at a CAGR of 9.5% (Figure 2).

Based on the market shares for the BAU scenario, most of the vehicles in stock are diesel vehicles. For three-wheelers, petrol and CNG vehicle stocks are also high. Based on the number of vehicles with different fuel types and the utilization of these vehicles, the estimated tonne km up to 2030 is shown in Figure 3. By 2030, around 320 billion tkm (btkm) of freight movement is estimated to be moved by SCVs alone.

With the increase in market share of electric vehicles, the share of freight movement by electric vehicles is

Box 1: Emission factors

$$TKM_i = TA_i = V_i * FT_i * VU_i * P_i$$

$$Emissoions_i = FC_i * E_i * EF_i$$

Where:

TKM_i = Tonne Kilometre by Vehicle Type *i*
TA_i = Transport Activity by Vehicle Type *i*
V_i = On-road Stock of Vehicle *i*
FT_i = Share of Fuel Technologies
P_i = Payload
VU_i = Vehicle Utilization by Vehicle Type *i*
FC_i = Fuel Consumption by Vehicle *i*
FE_i = Fuel Efficiency of Vehicle *i* by Fuel Type
E_i = Energy Conservation Factors
EF_i = Emission Factors

Source: Pal et al, 2015

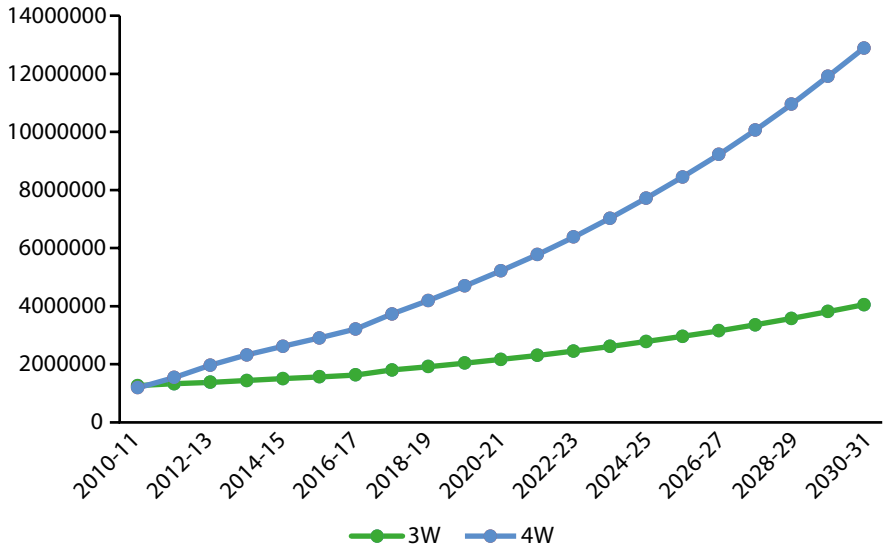


Figure 2 Estimated stock of SCVs till 2030 (based on TERI estimates)

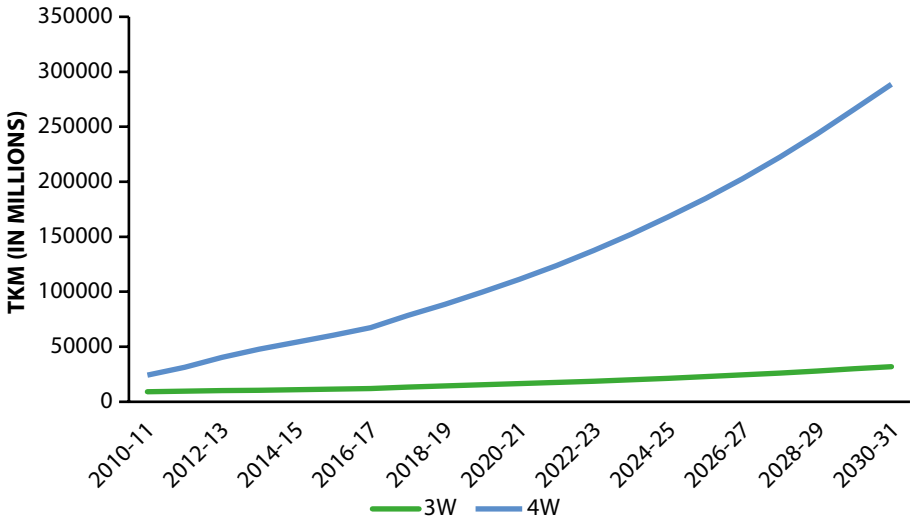


Figure 3 Estimated TKM by SCV segment (based on TERI estimates)

expected to more than double in the alternative scenario as compared to BAU. The share of electric three-wheelers in the total tkm will increase from 3% in BAU scenario to 11% in alternate energy scenario by 2031. Similarly, the share of tkm by electric four-wheelers is likely to go up from 1% to 4%.

The increase in freight demand and the resultant increase in tkm are going to increase the overall energy demand in the coming decades. The analysis suggests that the energy demand from SCV segment is going to grow at a CAGR of 8% by 2030–31. Due to lack of alternatives available in the four-wheeler segment, almost 80% of energy demand will come from this segment.

The increased freight movement and energy consumption are going to be associated with a significant increase in the amount of emissions. Figure 4 shows the estimated emissions from urban freight in million tonnes of carbon. The emissions has been increasing at an increasing rate. By 2030, around 45 million tonne of CO_2 is expected to be emitted annually by the SCV segment. The four-wheelers are expected to be the biggest contributors. Since most of the vehicles in this segment are diesel operated, the emissions in terms of local pollutants such as NOx, SOx and particulate matter are also going to be very high. Thus, it is clear that in the absence of any active policy measures to promote clean technologies, the urban freight segment is going to become one of the worst polluting segments in the country given the expected growth rates.

In order to reduce the environmental and economic impact of the ICE freight vehicles, there is a need to accelerate the adoption of alternative technologies in the freight segment. Our analysis shows that with the current market outlook for electric in the SCV segment, a slight reduction in the energy consumption and emissions can be achieved by 2030. As per the analysis with the increase in the share of electric vehicles in the alternate energy scenario, 8% and 2% reduction in energy consumption can be achieved in the three-wheeler and four-wheelers segments, respectively by 2031. Similarly, 10% and 4% reduction in CO_2 emissions is attainable in the freight the three-wheeler and four-wheelers segments, respectively (Figure 5).

Going by the current market scenario of ICE vehicles it is clear that the four-wheeler SCVs are going to dominate the market in the near future. While the three-wheeler freight vehicle segment is able to move away from petrol and diesel towards CNG, LPG and electric; the four-wheeler and other freight vehicle segments rely largely on diesel which is the most polluting fuel in the road transport segment. Given that this segment is largely dominated by diesel run vehicles and very limited

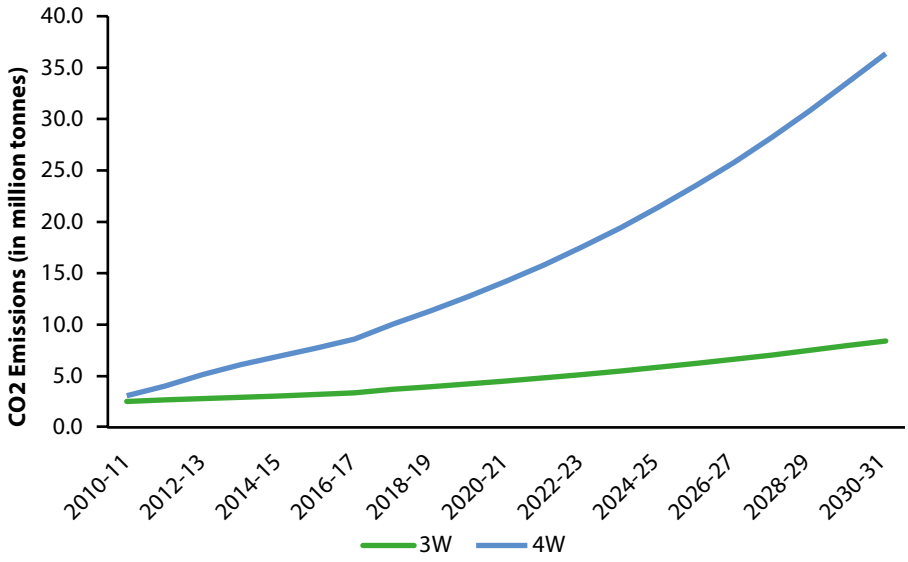


Figure 4 Estimated use-phase emissions till 2030–31 in BAU scenario (based on TERI estimates)

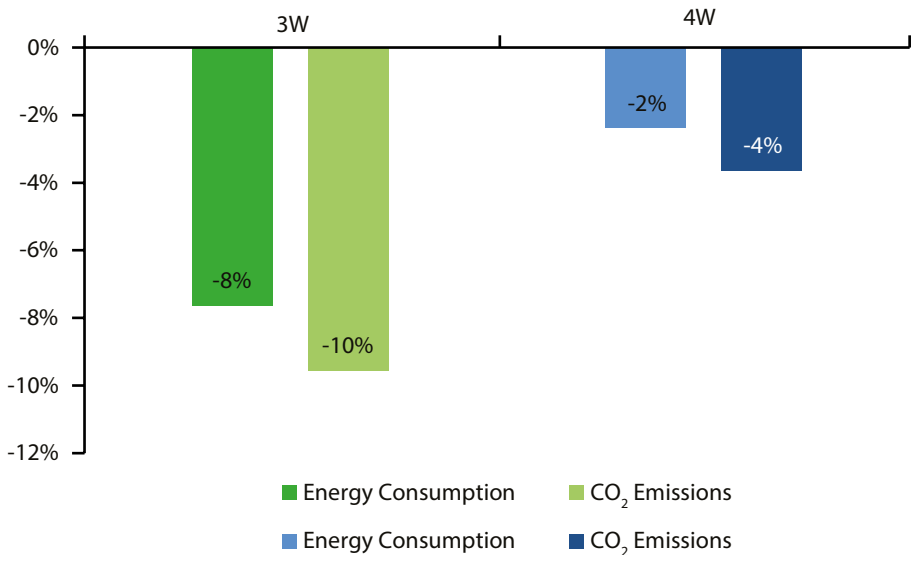


Figure 5 Impact of higher EV penetration (based on TERI estimates)

alternative technology options are available, there is a need to promote policies that favour the uptake of electric vehicles segment from both the supply and the demand perspective. The possibility of achieving a higher rate of reduction in emissions will increase significantly if in the four-wheeler segment a similar shift towards electric vehicles is made as was done in the three-wheeler segment.

Currently India is at an early stage of electric vehicle transition and the freight vehicle segment offers a front-runner advantage. The higher vehicle utilization rates in this segment makes the case for a viable business model given the technology becomes user friendly. Additionally, there is a need to continuously explore and invest in clean technologies that can be adopted in the high tonnage vehicle segment as well.

Summary: **Part I**

In this part of the report, we looked into the definition of urban freight and the types of vehicles that are deployed for the purpose. The urban freight sector is a major source of employment for vehicle owners, drivers, handlers, service segment, among others. It also contributes significantly to the city's economic activity and gross domestic product.

There are, however, negative externalities associated with the urban freight vehicular movement. Globally, GHG emissions from freight transportation have among the most severe environmental impacts in cities. As per the World Health Organization, Indian cities are among the top 15 most polluted cities in the world. As per TERI-ARAI's source apportionment study,[1] vehicular emissions, especially commercial vehicles, serve as a major contributor to air pollution. To overcome negative externalities of urban freight running on fossil fuel, switching to electric vehicles serves as an ideal solution.

Electrification of urban freight has been happening in different parts of the globe, including India, albeit at a very slow pace. Some of the leading countries in electric vehicles deployment include China, European nations, and North America. India is currently taking small steps towards electrification of urban freight. In fact, a number of electric vehicle-related policies of state governments, including Delhi and Telangana, focus on commercial application of electric vehicles. There have also been several initiatives at the enterprise level, with the deployment of electric vehicles by logistics service providers and commercial organizations.

The volume of freight traffic in India is projected to grow three times as compared to the current numbers by the NITI Aayog. It is, therefore, necessary to maintain an efficient flow of goods in and around the cities, which form a major share in the overall freight transportation. As part of this study, the focus is on the freight vehicles, light commercial vehicles (LCVs), which are less than 3.5 GVW. Within the LCVs segments, vehicles are classified as mini-trucks and pick-up trucks.

The Indian urban freight vehicle market is mostly dominated by ICE vehicles. These include both three- and four-wheeler segments available in different variants of petrol, diesel, liquefied natural gas (LPG), and compressed natural gas (CNG). The usage of these vehicles varies with the purpose of transportation, which is further determined by the payload or carrying capacity of the vehicles.

With the Indian policy landscape supporting electrification, many small and large players have entered the urban freight market. These players are producing freight vehicles both in three-wheeler and in four-wheeler variants. Both the models are available with lead-acid and lithium-ion battery technology and their price vary as per the battery size and technology.

Based on the market research, we have found that there are limited alternatives to ICE SCV four-wheelers. In the case of alternative three-wheelers, the options are available both with lead-acid and lithium-ion battery technology. The price range of the lead-acid battery is very well comparable with the ICE three-wheeler. The technology is nascent, and charging takes very long time. The lithium-ion battery three-wheelers take less charging time and offer almost similar range but their price range is higher than the conventional ICE vehicle. Overall, there is a high potential that in the very near future conventional freight three-wheeler s be replaced with electric three-

[1] Details available at https://www.teriin.org/sites/default/files/2018-08/Report_SA_AQM-Delhi-NCR_0.pdf

wheelers. As per TERI analysis, with the increase in share of electric vehicles in the alternate energy scenario, 8% and 2% reduction in energy consumption could be achieved in the three-wheeler and four-wheeler segments, respectively by 2031. Similarly, 10% and 4% reduction in CO_2 emissions is attainable in the three-wheeler and four-wheeler freight segments, respectively.

Among the electric three-wheeler cargo vehicles, Atul Auto is a pioneer in entering the three-wheeler freight market among the existing big ICE players. There are also other many smaller electric three-wheeler market players manufacturing in both lead-acid and lithium-ion batteries such as Gayam Motors, Kinetic Green, Lohia Auto, Goenka Ecoyan, Adapt Motors among others. Players such as Altigreen and Volta are also involved in retrofitting of electric three-wheelers.

Going by the current market scenario of ICE vehicles, it is clear that four-wheeler SCVs will continue to dominate the urban freight market in the near future. While the three-wheeler freight vehicle segment is able to move away from petrol and diesel towards CNG, LPG and electric, the four-wheeler and other freight vehicle segments continue to rely largely on diesel. The possibility of achieving a higher rate of reduction in emissions from the urban sector will increase significantly, when electric vehicle transition is fast tracked in the four-wheeler segment as well.

Through this study, TERI has sought to discuss the opportunity areas within the freight sector, which has a high potential of electric vehicle deployment resulting in significant benefits in terms of local air pollution. Despite significant economic benefits along with social and environmental costs associated with urban freight movement, it is neither researched extensively nor given adequate importance during the planning and city development processes. The study has sought to bridge the information gap, and to an extent data gap, with regard to urban freight movement in the Indian cities. Currently, there are limited data and satisfactory understanding of (a) urban freight (vehicle population, ODs, number of trips, trip lengths, load factor, fuel share, vehicle characteristics, etc.) and (b) rapidly increasing negative externalities.

Part II looks into the case cities – Delhi, Bengaluru and Surat, and sub-sectors in the urban freight sectors. The sub-sectors studied in this report are (i) delivery of posts and parcels by India Post in Bengaluru, (ii) organized service providers undertaking fleet level operations in Bengaluru, (iii) transport service providers for the textile industry in Surat, (iv) management and movement of solid waste in Surat, and (v) distribution of fruits and vegetables originating from the Azadpur and Okhla wholesale markets in Delhi.

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