



POLICY BRIEF

ELECTRIC-AUTOS

**Three wheeled transition to zero
emission mobility in Delhi**





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Authors: Anumita Roychowdhury, Sayan Roy and Shubham Srivastava

Cover: Ajit Bajaj

Layout: Surender Singh

Production: Rakesh Shrivastava and Gundhar Das



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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
E-mail: sales@cseinida.org
Website: www.cseindia.org

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Why this spotlight on electric three wheelers

While signing the global pledge for 100 per cent electrification target in the time frame of 2030-40 India had made a special mention that two- and three-wheelers are more than 70 per cent of global sales and more than 80 per cent in India and that all governments should support the transition of these light vehicles to zero emission vehicles. Within India, Niti Ayog expects 70-80 per cent electrification of this market by 2030, while the electric vehicle (EV) policies of 21 state governments have supportive provisions for these segments. Even though the overall electrification of new vehicle fleets nationally is still very small – just over five percent, - even this fleet is nearly almost dominated by these two segments.

This policy brief therefore puts a special spotlight on the electric three wheelers to understand what is working and what is not after several years of experience. One of the key reasons for this interest in three wheelers is their crucial role in meeting the needs of urban commuting, last mile connectivity as well as urban freight. Electrification of this fleet can help to decarbonise and achieve zero tailpipe emissions for a sizable commuting mass and substantial share of urban freight.

However, three wheelers are not one unified segment. This is stratified as electric rickshaws (e-rickshaws), and auto rickshaws that are classified as L3 and L5 respectively in the Central Motor Vehicle Act and Rules. Between them it is the e-rickshaw category that has boomed and propelled the original electrification trend nationally. But auto-rickshaws have remained a small part of this change.

It becomes necessary to understand why the progress in electric autos or the L5 category has remained slow and low. Both e-rickshaws and e-autos are important as intermediate public transport and goods carriers but there are differences.

E-rickshaws or L3 category have largely grown based on informal assembly outside the orbit of formal standards and certification systems though some minimum safety norms, and speed definition have been adopted for their registration. A small fraction of it is also manufactured in the organised sector with some original equipment manufacturers (OEM) stepping in.

The operations of the e-rickshaws are highly regulated and restricted in cities, especially in bigger cities. They are not allowed to operate in city centres and arterial roads. This limits their growth, people carrying capacity and earnings even though they continue to meet a sizable demand for travel in niche urban and suburban areas.

In contrast, the auto-rickshaws or L5 category are manufactured in the organised sector – both by conventional OEMs and start-ups, and are subject to relatively more demanding type approval and certification requirements, standardisation and norms. For electrification, this segment has a better opportunity for quality control and technology upgradation to improve range, safety, durability etc.

From an operational perspective this segment does not face restriction and are allowed to ply in most parts of the city and therefore can provide greater service coverage compared to the L3 category. This segment has a bigger opportunity to provide services over a larger area and population, connect more areas for multi-modal integration and provide last mile connectivity and also cater to a sizable part of local urban freight.

This L5 segment however, is finding it harder to penetrate the market in the face of entrenched internal combustion powered three wheelers fuelled by diesel, petrol and compressed natural gas (CNG). It is for this reason this study has focussed on the L5 electric auto segment to understand why the pace of electrification has remained low. This rapid assessment has been carried out in Delhi where the electrification programme is underway and has matured more than other cities to provide more insight from the ground.

Tapping the learning curve from the ongoing experience is important to inform the next phase of policy. The Government of the National Capital Territory of Delhi (NCTD) has proposed to revise its 2020 electric vehicle policy that had aimed for 25 per cent electrification of the fleet by 2024. This revision will require more insights into the enablers. This can also be useful for other state governments who are in the early stages of implementing electric vehicle policy.

This review is based on field assessment and interaction with a spectrum of stakeholders in the ecosystem including owners and drivers of passenger and goods e-autos, e-auto start-ups, financing agencies, charging providers, cargo operators and concerned officials. This rapid assessment has attempted to map out the emerging issues related to opportunities, barriers, and the way forward.

Key highlights and summary

Low penetration of e-autos or L5 category in Delhi: E-rickshaws and e-autos together constitute about 64 per cent of all EVs in Delhi. But e-rickshaws are 93 per cent of this fleet. Thus, e-autos or L5 category are a mere 7 per cent of this transition so far. Increasing this fleet is important as this segment meets a sizable share of travel demand and the need for last mile connectivity. An older study in Delhi has shown that almost 31–45 per cent metro commuters have shown their preference to use three-wheeler services.

Higher penetration of e-auto in urban freight than in passenger segment: The penetration of a-autos is small but there is an uneven trend between passenger and goods carrier segments. Comparatively higher penetration is noted in the goods carrier segment. Since January 2022, the electrification of goods or L5N segment has continuously crossed 40 percent of new sales or above on a monthly basis. But the passenger segment has seen a variable lower range of electrification level - between 0 to 35 per cent on a month-by-month basis. Growth in e-commerce post pandemic is considered to be the reason for spurt in demand for cargo vehicles.

Product range needs more diversification: Transport department of the Government of National Capital Territory of Delhi (GNCTD) has enlisted four electric L5 three-wheeler manufacturers with 11 e-L5 models to qualify for purchase incentives under Delhi EV policy. However, the models of Piaggio and Mahindra Ltd dominate at 91 per cent and the share of Piaggio alone is 83 per cent. Newer models are awaited.

The goods carrier segment is largely dominated by the new entrants. Among top five e-L5N three-wheeler manufacturers, three are entirely new to the business and do not have any variant in the internal combustion engine (ICE) segment. Three e-L5N manufacturers, Omega Seiki, Piaggio, and Mahindra, together make up for the 56 per cent of the total L5N market. Majority of these vehicle models have Lithium-ion batteries combined with plug-in chargers. However, some makers have swapping models.

Improve vehicle performance: Currently, electric passenger and goods three-wheelers have an operational range of 60–190 km per single charge. The actual range can be lower than the certified range. Passenger auto drivers point out that depending on the consumer demand, the required driving requirement can be 180 to 200 km a day. This requires top up charging during operational hours and therefore 2-3 hours of charging time can affect their earning.

It is however noted that in the goods carrier segment the majority are quite comfortable to operate between 80 to 150 kms that fully meets their fixed route delivery service requirements. This is encouraging online delivery services like Amazon, Flipkart and other players to move towards electrification. Post COVID-19 pandemic, the online product delivery services have increased several folds. In some cases where longer distances need to be traversed the operators are currently compensating the loss by operating the vehicle for longer hours. Therefore, further optimisation and development of technology to achieve higher cycles for the batteries can help to mitigate this concern.

Economics works in favour of e-autos: In Delhi, both capital cost and operational costs of passenger e-autos are lower. While in other cities the cost of e-autos are higher than the entrenched diesel or petrol/CNG autos, in Delhi its lower. This is due to the overall regulatory cap on registration and permits for three-wheelers. This has created a distorted artificial market that commands high premium pricing. Instead of the normal pricing range of Rs 3-4 lakhs for CNG autos, the actual cost goes up to Rs 7 lakh to Rs 7.5 lakhs per vehicle. In contrast, electric models cost about Rs 3.5 to 3.7 lakhs. Also the operating cost of electric vehicles is much cheaper -- for a distance of 180 km of daily average operations, - e-autos incur a cost of Rs. 250/- (including both night and top-up charging fee), the CNG auto costs around Rs. 350/-. Even for goods carrier owners it can be three times more profitable in specific use cases like fixed route service delivery.

Competitive and improved cost parity: With FAME 2 and GNCTD subsidies the up-front price difference between a CNG and electric goods carrier and passenger e-autos have reduced substantially. In some use cases, such as fixed route delivery for goods carrier, the total cost of ownership (TCO) is commercially viable. A Rocky Mountain Institute (RMI) estimate¹ of 2022 shows that the combined incentives of FAME 2 and GNCTD bring the TCO of electric vehicles to INR 1.94/km, which is below the cost of CNG vehicles at INR 2.25/km. It is expected that even without subsidies the goods carriers can achieve cost parity with their ICE counterparts by 2023.

Despite the favourable cost differential there is resistance among CNG auto-owners to make a cross over – though interest is growing: This is largely because of uncertainties around daily driving range possible without compromising on their earnings, charging requirements especially home charging, and lack of safe parking and fear of theft. Yet, there is a considerable demonstration effect of the current e-auto fleet on the road that is drawing attention. But quite a large number of CNG auto owners are still servicing their loan and would need to wait before taking the

decision to change over to the electric model. Therefore, a policy intervention to mandate only sales of e-autos can prevent lock-in of capital in new ICE vehicles.

Concerns around home and night time charging and top up charging: These vehicles rely greatly on night time home charging for full charge and top up charging in public charging stations during operational hours. But adequate and reliable access to electricity, facilities to park for charging near homes, fear of theft are serious discouraging factors. Most live in small rented places without adequate parking facilities. This has led to mushrooming of informal parking cum charging facilities that are operated informally on payment basis.

Public charging network for top up charging: For top up charging during the day the operators consider that the current network is accessible even on a long drive. There are around 2452 public charging and 234 battery swapping facilities in Delhi. There is a plan to add another 896 charging and 103 swapping facilities over the next 1-2 years. Majority of the chargers are slow and moderate types that are quite compatible with e-three wheelers. However, only a few areas have dense charging facilities. More distributed development is needed.

It also emerged that e-auto drivers find it difficult to use automated charging stations as any problem faced while operating the system they cannot seek assistance. Sometimes the advance payment process gets stuck and they cannot retrieve the money which is deducted in advance in the public chargers. A lot more skill building and on spot assistance is needed for them.

Highly variable charging cost: Unit cost of charging has been provided by SWITCH DELHI portal of the Delhi EV Cell. Currently, due to lack of regulation and standardisation, charging costs vary from location to location. It shows that depending on the charging provider and type of charging the unit cost varies quite widely between Rs. 12/- to 40/- (inter quartile range). In some areas the cost of charging goes up to Rs. 200/- to 350/-. High variability of charging cost despite the unit cost of electricity at Rs 6, is a major concern area for mass adoption. It is important to assess the contributory factors to high charging cost and find a more standardised practice. Several factors contributing to this including locational attributes, type and quality of charger, energy supply, security and operational assistance offered etc. Even strategies of market capture with a pricing strategy also contributes. This is a concern.

Financing challenges: It is well known that electric autos find it very difficult to arrange finances from conventional sources, need to pay high interest rates and

have shorter payback period compared to ICE models. Poor creditworthiness, uncertainty around cost recovery due to lack of second-hand market etc complicate the challenge. They need to depend on high cost loans. While the formal banking sector shies away, private financiers are stepping in with varying repayment schedules – monthly, daily. They are also innovating in finance. It is interesting to see that the carbon trading market is also beginning to show interest in the sector and may begin to have instruments of trading carbon for larger fleet owners.

Battery swapping: Delinking battery from the vehicle has found a lot of support especially in the commercial segments. A quick replacement of a discharged battery with a charged one in a swapping station helps to reduce the top up charging time. Delhi has also extended the coverage of purchase subsidies to include swapping models. This reduces the vehicle cost. There are several players in the battery swapping domain, which includes Sun Mobility, Battery smart, Lithium Power, ChargeUp etc. Almost all of them are providing swapping options for two- and three wheeler models. In Delhi, SUN mobility is the key and sole provider to cater to the L5 passenger and goods carrier segments. They are providing battery-as-a-service (BAAS) for this segment and rental models. Therefore, vehicle owners do not need to worry about the durability and end of life of the battery. They have tied up with key OEMs including Bajaj, Piaggio, Mahindra, EV electric for both passenger and goods carrier segments. Other swapping players like Battery smart among others are also developing swapping models for retrofitment vehicles.

Swapping is attractive for certain use cases where fleet owners can use their vehicles for double shift operations or long extended operations which are generally not possible with plug-in vehicles. However, individual owner-cum drivers have shown stronger preference for vehicles with longer range preferably 180-200 km in single charge over swapping. Lack of availability of swapping models, limited swapping stations, concerns related to battery theft etc. influence such decisions. (See *Box: Battery swapping can be a game changer for the commercial L5M/N segment, to understand the potential of swapping to transform the commercial vehicle segment.*)

Strong interest in the aggregator and delivery fleet: Draft motor vehicle aggregator scheme 2023 of the government of NCT Delhi aims for rapid electrification of the three-wheeler segment for all the vehicles belonging to app-based aggregator services including Amazon, Flipkart, Zomato, Denzo etc. in phased manner. It provides for targets of 50 per cent electrification of the fleet in two years and 100 per cent in four years. The aggregator scheme has not mentioned the L5M/N segment directly but these as part of the aggregator and delivery fleet will be impacted. Battery swapping can be an enabler for this segment.

Perception of the electric three wheeler manufacturers: The OEM representative feels that the immediate opportunity is bigger in the goods carrier segment due to rapid growth in e-commerce activity after the pandemic. Their small service delivery areas and fixed route operations offer a better opportunity for electrification. At the same time there is a concern that this segment may also plateau soon after the initial spurt as the market may get saturated soon. It is necessary to bring in the cargo fleet of the larger warehouse based urban freight into the fold. That market is still hesitant given the nature of their business and payload requirements.

They agree more product innovation is needed but that would be more in the framework of value engineering rather than introduction of high end technology. The cost sensitive market precludes such options. However, through value engineering, range, battery performance, safety among others need to be addressed. The manufacturers are also considering strategies like battery as a service that allows vehicle operators to pay as they go and batteries are available on rent. Manufacturers feel a good charging network will matter for the passenger segment for faster adoption.

There are also worries that sales of electric three wheelers may slow down after the tightening of the safety norms -- the Automotive Indian Standard (AIS) 156, to prevent overheating of lithium batteries and fire incidents. The industry expects challenges with respect to the new tests that are required for thermal propagation and other related issues. They fear that this may push up the cost of compliance and the price of the product. This requires value engineering that is also affordable.

Retro-fitting of vehicles: There is a growing interest in retrofitting of existing older autos with battery technology. This is expected to reduce the capital cost as retrofitting costs half of the new vehicle. Technically and principally retrofitting is possible. But this will require stringent quality control and quality assurance and proper oversight of the retrofitting agencies. Legally, Automotive Indian Standards (AIS 123) allow post 1990 vehicles to be retrofitted. But retrofitters inform that usually the target segment is 5 to 15 years. A lot of engineering judgement needs to be applied to very older vehicles to assess their structural strength, quality of the suspension, strength of the chassis, body design, wiring harness, among others. If the auto owners agree to do proper refurbishing of the vehicles that may add further to the costs. The retrofitter claims that they are being able to provide comparable torque, top speed, average speed, etc vis a vis the OEM products. Retrofitting helps to extend the life of the vehicle and would work as long as the batteries last. Usually, a three-year warranty and a five-year guarantee on the performance are given.

Retrofitters are allowed to retrofit only those models for which they have obtained certification from ARAI under the Automotive Indian Standards related to safety norms like AIS156 and retrofitment rules of AIS 123. In case they seek to use those systems in other models they need to take type extension approval under specific AIS norms. Cost of retro fitment is high and capacity to retrofitment is limited. Retrofitters are now bringing in lithium ion batteries. They need to innovate to address safety aspects and thermal management of batteries.

The Policy for Clean Air in Delhi, National Capital Region and beyond issued by the Air Commission states that based on the central government rules, the state governments need to further define and notify the implementation mechanism for retro-fitment. It is necessary to register retrofitters for quality control and safe installation. Some NBFCs are more confident to fund retro-fitted vehicles, in case vehicles are certified by the appropriate certified authority like ARAI, ICAT etc.

The next steps

Implement the mandate for new three wheelers to be electric: The GNCTD has stated that all the new or renewed permits should be issued for electric passenger three wheelers only and this will be like a lifetime permit till the vehicle is fit to ply on the roads of Delhi. In addition to this, the draft motor vehicle aggregator scheme 2023 is incorporating phase-wise targets to electrify the aggregator fleet to meet 100 per cent electrification in four years. This will have a bearing on the three wheeler delivery fleet as well. There is an opportunity in this segment. In other vehicle segments sales mandate may be required.

Strengthen both fiscal and non-fiscal incentives: Delhi has already exempted the electric vehicles from the motor vehicle tax and registration fees and is providing purchase and scrappage incentives for EVs. Even though the incentives are available to both electric rickshaws (L3) and electric autos (L5) the uptake of L5 segment has been minimal. Therefore, the GNCTD needs to make support for this segment stronger. Also consider additional non-fiscal benefits to electric three wheeler owners, such as discounted or free parking facilities especially in multi-modal locations such as metro stations, bus terminals, major commercial places, earmarking of areas for safe parking with charging facilities, creating low emission zones to incentivise entry of electric or zero emission vehicles while curtailing ICE etc.

Need stronger industry participation for product development to support mandate for e-only registration: As the GNCTD has stated that all new three wheeler registration needs to be battery operated, this has – by default – become a

sales mandate for the industry. This should catalyse the market and encourage the manufacturers to diversify the product range and innovate.

Support charging ecosystem: As these vehicles rely largely on night-time home charging supported by top-up charging in public charging networks, steps may be taken to set up parking cum charging facilities at the community parking locations at subsidized fees. To enable this, the Parking Management Area Plan (PMAP) may be implemented in each municipal ward to comply with the Delhi Parking Rules 2019 that has provided for parking based charging facilities. Develop battery swapping market for this segment to help achieve scale while addressing the issues around standardisation, interoperability, rationalised rates etc.

Standardise and rationalise charging rates: It is necessary to address the widely varied charging rates across the city. Regulate, standardise and rationalise the rates of charging across charging providers considering the varied input costs. Fix the electricity price for electric vehicles. Charging rates need to be within the affordable range of the masses.

Support financing mechanism: Delhi has already created a dedicated Delhi Finance Corporation (DFC) for disbursement of easy loans to the applicant. GNCTD may also explore the possibilities beyond traditional lending and act as a credit guarantor for providing easy loans to individual E-L5M/N drivers or owners. The government or notified agencies can provide partial guarantee against default.

Enable second-hand market for used product: Not having any second-hand sale of L5 vehicles, is a barrier to financing and bankability. Need a strategy to develop a second hand market for electric vehicles, batteries etc. Involve aggregators, recyclers, delivery agencies and manufacturers to address this issue.

Retrofitment market requires stringent oversight for quality control and assurance and strong process of certification and standard setting.

Create awareness to build public support for electric passenger and good carrier services: Majority of the L5 operators have limited knowledge about electric vehicle technology, operational aspects, market access, government policy, and are also victims of misinformation. Currently, they are going more by the demonstration effect of their fellow drivers/owners who currently use e-autos. Field assessment indicates sizable dormant demand. Well-designed outreach programme can sensitize them about the technology, financial instruments, operational aspects, availability of incentives, charging needs and safety requirements among others. It is possible to catalyse this into active demand.

1. Three-wheelers in EV transition

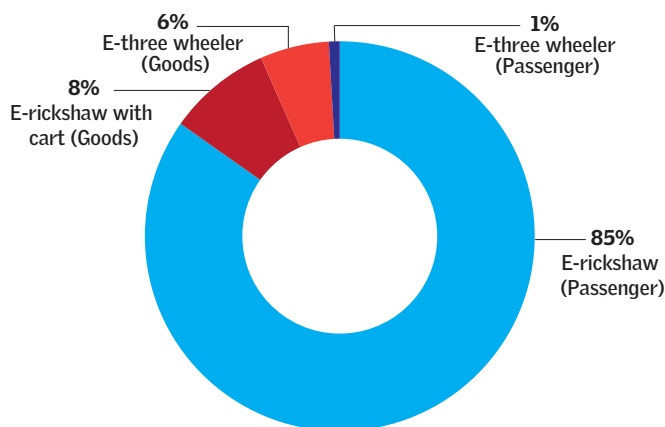
Since the notification of the electric vehicle policy of the Government of the National Capital Territory of Delhi (NCTD) in August 2020, the annual electric vehicle (EV) penetration has increased from 3.87 per cent in FY 2019-20 to 10.52 per cent in FY 2022-23. As of May 2023, out of 2.23 lakhs registered electric vehicles, 1.43 lakhs are three wheelers that constitutes about 64 per cent of the total EVs in Delhi. Predictably, three and two wheelers together are about 93 per cent of the total registered EVs.

The quicker uptake in these segments show that there is considerable scope of accelerating electrification of these segments to address the polluting internal combustion engine (ICE) powered vehicles.

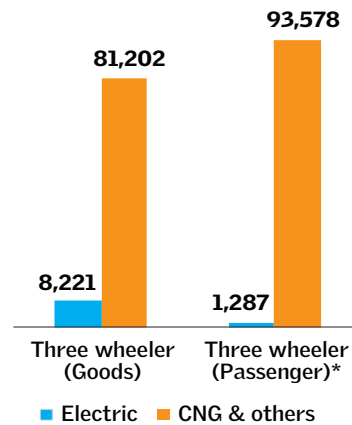
However, 93 per cent of total e-three wheelers in Delhi are in the L3 or e-rickshaw category, and only 7 per cent are in the L5 category that includes LM5 passenger e-auto segment and L5N the goods carrier segment. (See *Graph 1: Status of three-wheeler segment in Delhi*, for details). The L3 e-rickshaws and carts differ from e-autos (passenger and good) and have lower power and speed, lower range, cheaper costs, higher usage of lead acid batteries (though lithium ion battery is also available) and have smaller operational range as their movement is restricted and confined to specific zones. (See *box: Difference between E-rickshaws (L3) and Electric autos (L5 three wheelers)*).

Graph 1: Status of three-wheeler segment in Delhi

A. Percentage distribution of e-three wheelers in Delhi (till 14th June 2023)



B. Number of registered L5 three-wheelers in Delhi (till 14th June 2023)



Source: Vahan Database [*L5 three-wheeler (Passenger) number is updated according to Economic Survey of Delhi 2022-23 report]

DIFFERENCE BETWEEN E-RICKSHAWS (L3) AND ELECTRIC AUTOS (L5 THREE WHEELERS)

- Largely locally assembled and also produced on a limited scale in the organised sector such as by the Mahindra's. There are minimal safety norms and others that are met in the organised sector but not in the unorganised sector.
- Net power of the motor is not more than 2,000 kW, with maximum speed of not more than 25 km per hour.
- E-carts are designed to carry a maximum weight of 310 kg with nearly the same net power and speed of vehicles.
- They can have both lithium and lead-acid based battery versions. But lithium ion batteries can be nearly double that of the lead acid battery.
- The range of the small Li-ion battery vehicles is a little higher (i.e., 90–130 km per single charge) than of lead-acid battery (i.e., 75–110 km per single charge) based vehicles.
- The cost of Li-ion vehicles is higher (i.e., Rs 1.1–1.95 lakh) than lead-acid models (i.e., 0.95 to 1.4 lakhs).
- Normally use conductive charging (plug-in) facilities. Charging takes around three to eight hours to fully charge depending upon the battery type.
- Rapid conversion of manual rickshaws to EVs, cheaper costs and government incentives for them in some states has further helped.
- Depend on informal financing in the market. But were eligible for Delhi Government incentive scheme. These are also exempt from payment of motor vehicle registration fee etc
- Like the L5 auto category this segment also has both single and multiple ownership and rental system
- They have restricted operations and are not allowed on the arterial roads and operations are restricted. This reduces their daily mileage, earning and passenger loading.

Electric autos or L5 three wheelers:

- These are produced in the organised sector by the established original equipment manufacturers (OEMs)
- Under the current norms their maximum speed can exceed 25 km per hour. Gross vehicle weight is limited to 1,500 kg.
- Both passenger and goods e-autos are mainly lithium based and have a higher range. The e-autos (especially the top three brands) can operate at a range of 120–180 km per single charge, with a maximum speed up to 40–45 kmph.
- Most models have Li-ion batteries, with conduction charging (plug-in) facilities requiring full charging time of three to four hours.
- The cost of the passenger e-autos range between Rs 2.5–3.4 lakh, and goods e-autos cost around 2.8– 3.8 lakhs.
- These have unrestricted access in the city and there is no restriction on their operations. Therefore, they have higher per day mileage, are capable of taking on more passengers and earn more.
- Delhi has a special scenario in which their numbers have been capped since 1998 with time to time limited expansion and modernisation of the fleet is based on fleet renewal strategy.
- Delhi government has allowed a new lot of fixed numbers to be added to the fleet.
- They qualify for Delhi government and FAME subsidy.
- Formal financing is expensive and difficult in this segment and relies largely on local commercial finances.

The Government of Delhi is already providing a purchase incentive of Rs. 30,000/- per vehicle for both passenger and goods carriers. In the goods carrier segment the incentive is for the first 10,000 vehicles. Both electric passenger autos and goods carriers are eligible for interest subvention of 5 per cent on loan and/ or hire purchase and scrappage incentive of Rs. 7,500/- for scrapping and de-registering old ICE vehicles.

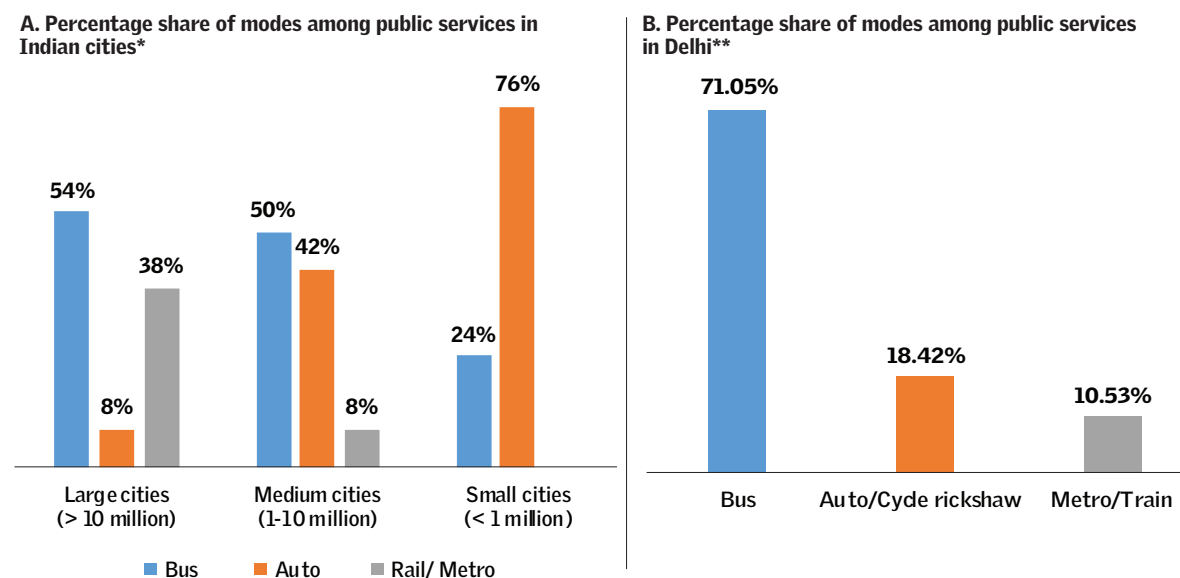
2. Why rapid electrification of three wheelers is necessary?

Meet sizable mobility needs: Nationally, autos-rickshaws are part of the intermediate public transport or para-transit system and play a very vital role in urban commuting, particularly for medium and smaller cities in India. Three-wheelers account for 42–76 per cent of public mode share in medium to smaller cities (See *Graph 2-A: Percentage share of modes among public services in Indian cities*).

Cities with inadequate public bus services or limited bus services are largely dependent on three-wheeler services. It may be noted that presently, only around 60 cities out of 4000 towns and cities listed in the Census have organised bus services. Rest are dependent on Intermediate public transport modes for daily commuting.

In Delhi, three wheelers are the second most used public transport service after buses. As per the High-Powered Committee report on how to decongest Delhi, three-wheeler mode share is higher than metro and rail services. (See *Graph 2-B: Percentage share of modes among public services in Delhi*). This is also comparable with bus service but there are several pockets that are outside the orbit of good bus

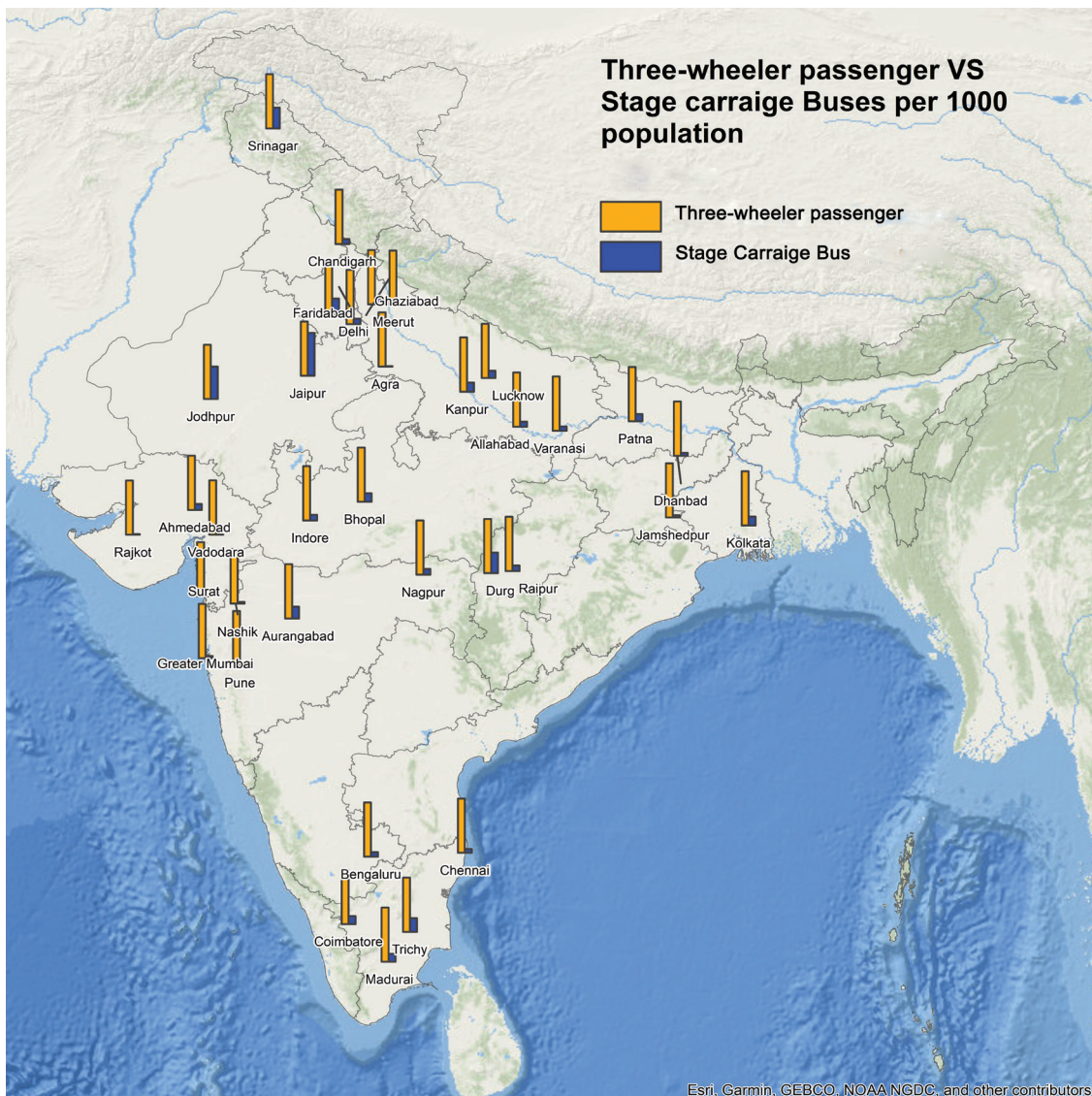
Graph 2: Three-wheeler mode share in India and Delhi



Source: *Ravi Gadepalli 2016, Role of Intermediate Public Transport in Indian Cities, Vol. 9, Economic and Political Weekly.²
 **Report of High-Powered Committee on how to decongest Delhi³

service and are largely served by three-wheelers or/and gramin seva services. Nationally, irrespective of city sizes, including Delhi, the number of three-wheeler availability per lakh population is much higher than the bus population of cities. Typically per capita number of three-wheelers are quite large compared to buses (*Map 1: Comparative assessment of number of stage carriage buses and 3Ws registered per lakh of population (as on March 31, 2018)*). These are low occupancy and high frequency services that cater to the specific needs of the commuters.

Map 1: Comparative assessment of number of stage carriage buses and three-wheelers registered per lakh of population (as on March 31, 2018)



Role in last mile connectivity: In bigger cities like Delhi that have longer travel distances compared to smaller towns, three-wheeler services may not be the prime mode of service over a mid to long route ranges. But they act as the dominant second mode of services and especially for providing last mile connectivity and feeder services for mass transportation including buses and metro. An older study by the researchers of School of Planning and Architecture, Delhi in 2010, found that almost 31–45 per cent metro commuters had shown their preference to use three-wheeler services, including cycle-rickshaws (available on certain locations at that time).⁴ Currently, the GNCTD has also deployed around 50 electric L5M or passenger three wheelers for last mile connectivity in Dwarka area.

Internal combustion powered three wheelers are high emitters: L5 three wheelers powered by the ICE engines and fuelled by conventional fuels always draw restrictive action due to their pollution potential. Due to this reason Delhi has made a massive transition from petrol and diesel fuel three wheelers to compressed natural gas engines (CNG) more than a decade ago. Other cities are still struggling with this transition especially those who are still using diesel autos rampantly.

Nationally, the market share of L5 three-wheelers is almost equally divided between diesel and petrol. Even after meeting the current Bharat Stage VI (BSVI) emissions standards, a diesel three-wheeler emits close to six times higher particulate matter and two times more nitrogen oxide compared to a BSVI diesel car causing enormous exposure. Older vehicles emit more. Conventional ICE vehicles have small, single-cylinder diesel engines of less than 500 cc displacement (higher engine size will attract rules for four-wheelers under the Central Motor Vehicle Rules). These have unstable emissions and high exhaust temperatures that limit the scope of application of advanced after-treatment systems. They meet emission standards mostly through improved calibration, optimization of combustion, automatic ignition timing, friction reduction, improved air filters and lubricating oil.

While CNG was the first step to side step the dirty conventional fuels, given the continued challenge of air quality in cities, even this transition is not adequate. With battery technology there is an opportunity to leapfrog to zero emissions for mass commuting. There is a limit to how much the testing parameters including driving cycle can be improved significantly and cost effectively for ICE vehicles. The key strategies that Delhi has adopted for this segment includes the mandate for registration of only CNG or electric autos and there is already a legacy policy of capping the number of three wheelers.

3. Towards electrification of passenger three wheelers in Delhi

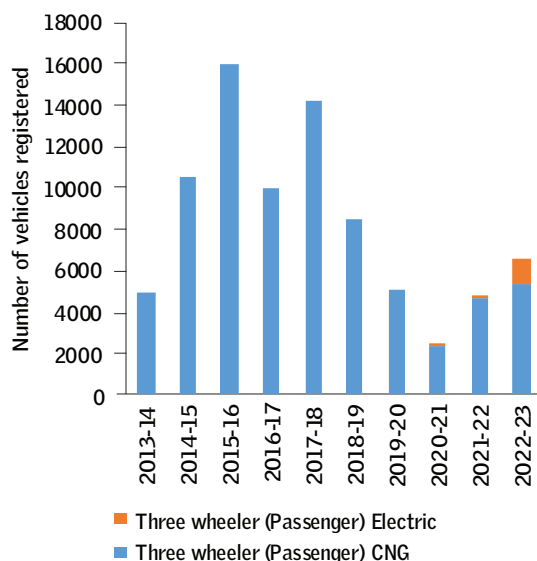
Three-wheeled passenger autos (L5M) are the most amenable candidate for leapfrogging to zero-emissions electric mobility. It is possible to set the mandate for 100 per cent electrification of this low volume segment. Yet the current pace of electrification in this segment is very slow and there is divergence in trends between passenger and goods three wheelers.

Comparative analysis of the passenger and goods carriers show that the penetration of e-autos in the passenger segment is much smaller than the goods carriers. The cargo segment is responding better to electrification. The dominant fuel however is still CNG (See *Graph 3: Annual registration of L5M/N three wheelers in Delhi*, for details).

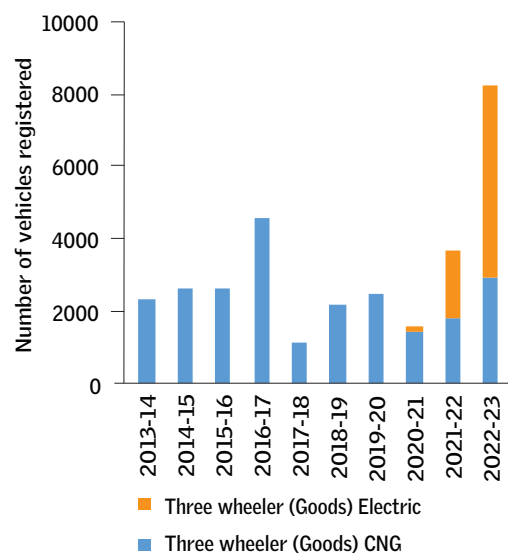
In FY 2022-23 alone, Delhi had registered around 6455 electric L5 three wheelers, including both passenger and goods with an EV penetration ratio of 44 per cent. Since January 2022, the goods carriers (L5N) segment has continuously crossed

Graph 3: Annual registration of L5M/N three wheelers in Delhi

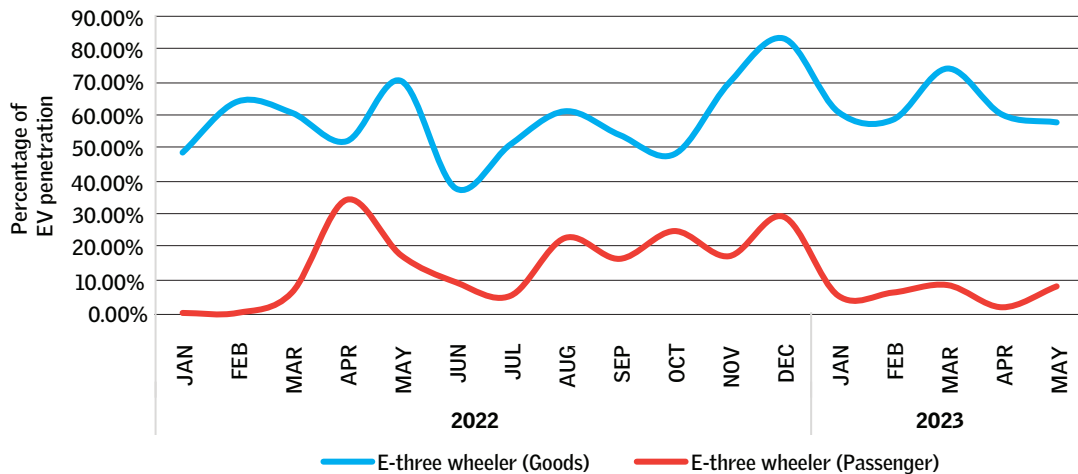
A. Annual registration trend of L5M three wheelers (Passenger) in Delhi



B. Annual registration trend of L5N three wheelers (Goods) in Delhi



Source: Vahan database

Graph 4: Month-wise electrification level of L5 three wheeler segment in Delhi

Source: Vahan database

40 percent or above electrification level on a monthly basis. (See *Graph 4: Month-wise electrification level of L5 three-wheeler segment in Delhi* for details). Generally constant EV penetration level of 10 to 12 per cent for a year or more is a sign that the segment can transform with support and market dynamics.

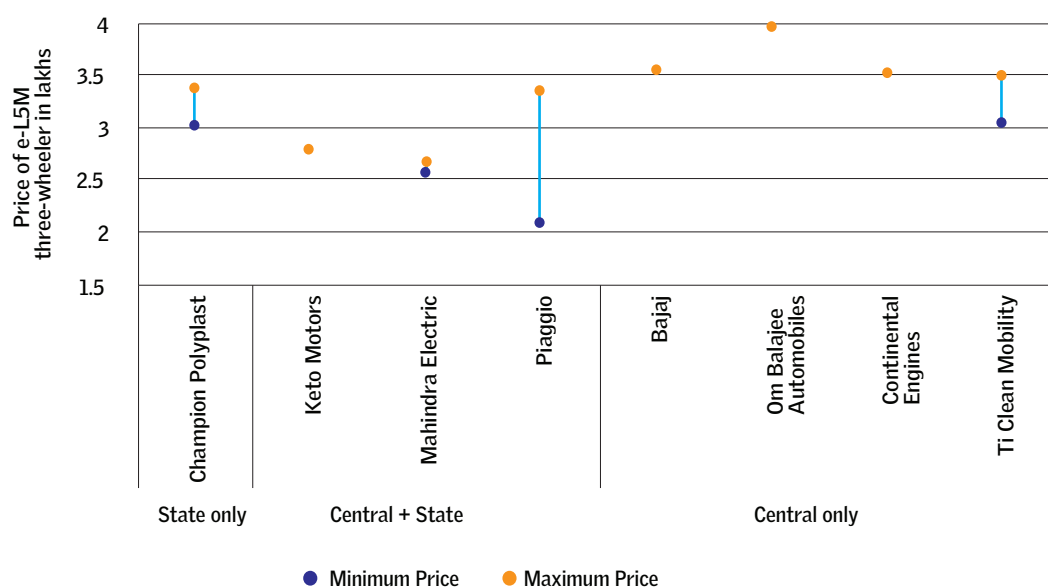
The passenger segment however has not been able to reach that level as its electrification level ranges drastically between 0 to 35 per cent on a month-by-month basis. Its trend is also not consistent. While the consistency in the EV penetration trend in the passenger segment is yet to be achieved, in the last 15 months, the penetration level has gone below 5 percent thrice. This indicates that this segment will require a bigger push to attain a more stable and growing trend. But it is expected to transform.

4. Making of a good programme

Need a diverse product mix: Transport department of GNCTD has enlisted four electric L5 three-wheeler manufacturers with 11 e-L5 models to qualify for purchase incentive of Rs. 30,000/- under Delhi EV policy. Four OEMs including Keto Motors, Mahindra Electric and Piaggio and except 'Champion Polyplast', are receiving incentives under both state policy and FAME 2 scheme of the central government. Bajaj Ltd, Om Balajee Automobiles, Continental Engines and Ti Clean Mobility are receiving only FAME 2 subsidies. (See *Graph 5: On-road price of e-L5M three-wheelers after Incentive and tax exemption in Delhi*). Subsidies are helping these vehicle models to become more competitive vis a vis IC counterparts and are available at a range of 3 to 4 lakhs.

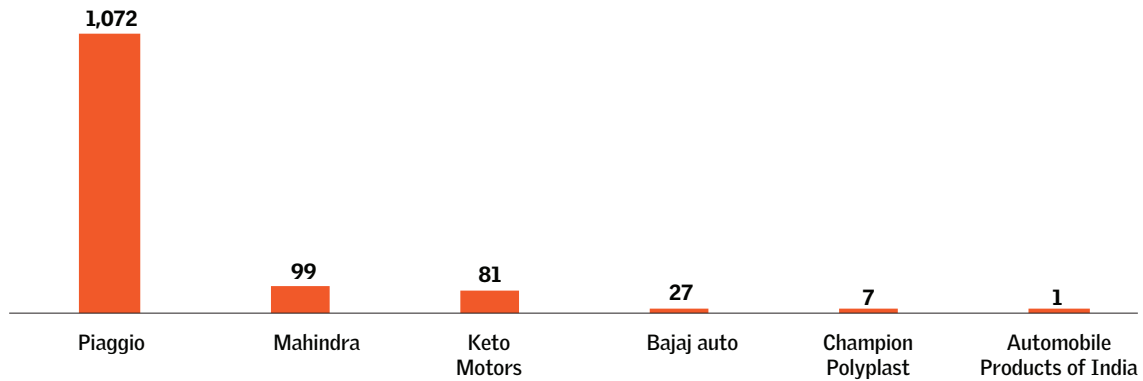
Piaggio and Mahindra together cover around 91 per cent of the total e-L5 three-wheeler market. About 83 per cent of the electric passenger three-wheeler market in Delhi is dominated by Piaggio vehicles. (See *Graph 6: OEM-wise number of registered L5M three-wheelers in Delhi (till 14th Jun 2023)*). In this segment, all manufacturers use Li-ion batteries with conduction charging (plug-in) facilities that require four to five hours of charging. A few including Piaggio have come up with variants that can swap batteries. This is to address the charging anxiety related to long charging time.

Graph 5: On-road price of e-L5M three-wheelers after Incentive and tax exemption in Delhi



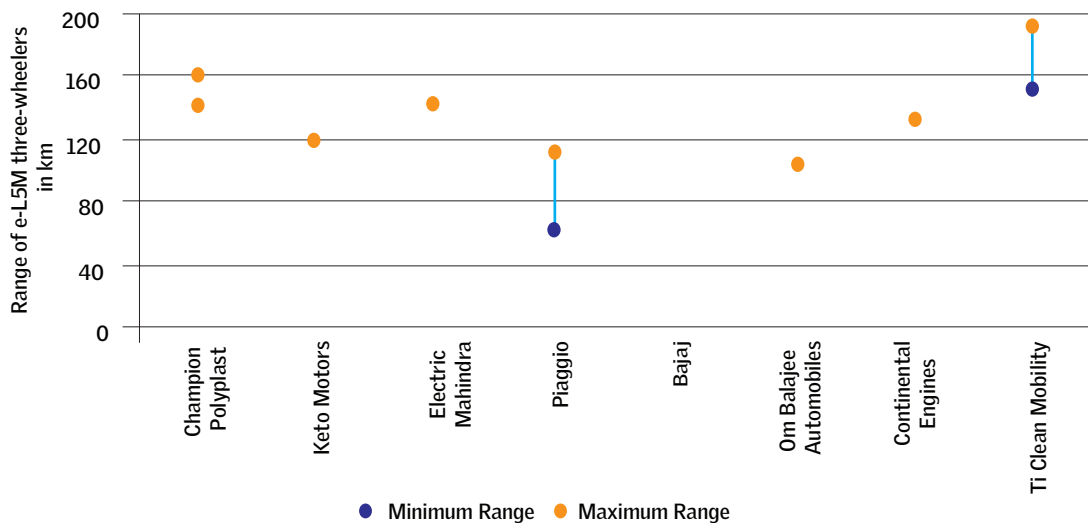
Source: CSE – compiled from various sources

Graph 6: OEM-wise number of registered electric L5M three-wheelers in Delhi (till 14th Jun 2023)



Source: Vahan database

Graph 7: OEM-wise available range of e-L5M three-wheelers



Source: CSE – compiled from various sources

Vehicle performance plays a defining role: The electric passenger and goods three-wheelers can operate for a range of 60–190 km in a single charge with a maximum speed up to 40–45 kmph. Although these are all certified ranges, actual range can be lower than claimed. This speed range need not be a constraint as the average traffic speed in Delhi is quite comparable.

Average operators – operating for 180 to 200 km a day, need top up charging during their operational hours. They need to charge for 3 hours between 2 to 5 pm to resume operation for another 50 to 60 kms before retiring for the day. This has a bearing on their business and earnings. Some of them have observed that sometimes they had to give up certain high revenue generating trips (long distance) due to low battery range. This needs to inform product development that needs to optimise battery capacities and optimise efficiencies to meet the requirement of longer driving ranges.

Similarly, in the goods segment, some operators are currently compensating the loss by operating the vehicle for long hours as there is no time restriction on electric models as there is for CNG vehicles. (*see Table 1: Comparative analysis between CNG and electric L5M three-wheelers in Delhi*).

Table 1: Comparative analysis between CNG and electric L5M three-wheelers in Delhi

Key parameters	CNG L5M three-wheeler	E-L5M three-wheeler
1. Range (in km)	120 - 180 km (Fuel tank: 4-5.6 kg)	60-150 km in single charge
2. Speed (in kmph)	65-70	40-45
3. Seating capacity	D + 3	D + 3
4. Fuel consumption per unit	30-35 km/kg.	4.6-5.8 kWh/100 km
5. Refuelling time/Charging time	5 minutes (maximum)	4-5 hrs.
6. Gradeability (in percentage)	18-22	7-20
7. Capital cost (in Rs lakh)	2.2-2.8	2-3.5
8. Operating cost (in Rs)	2-3/km	0.2-0.3/km

Source: CSE – compiled from various sources

Quicker product development needed to improve performance. The conventional OEMs have limited product range. Bajaj Ltd, the dominant player in the CNG L5M segment with a market share of 53 percent in the ICE market has only one e-L5M model so far. Battery technology development will be critical to improve performance. But batteries are 40 per cent of the vehicle cost. Therefore, innovation would need to keep the cost within the affordable range. A study by RMI for the Delhi government shows that the battery life expressed as the number of cycles a battery lasts before needing to be replaced is currently about 2,000 cycles⁵.

If this can be further improved, lesser battery replacement would be needed over the lifetime of the vehicle. This will also reduce total cost of ownership. Optimising such improvement within an affordable price range will be critical.

Distorted pricing of CNG autos making e-autos more cost effective in Delhi: Delhi has a unique situation where it is easier for e-autos to achieve price parity compared to the CNG passenger three-wheelers primarily because of artificially inflated pricing of the CNG autos because of the cap on the number of vehicles.

This situation has occurred due to permit restrictions. As limited permits restrict the number of vehicles that can be sold in the city, this has led to premium and inflated pricing that is also driven by the auctioneers and dealers. The overall cost of procuring a CNG passenger autos that should normally be around Rs 3-4 lakhs, the actual cost of e-autos add up to Rs 7 lakh to 7.5 lakhs per vehicle inclusive of registration, permit fees among others. In contrast, electric models cost only Rs 3.5 to 3.7 lakhs. It can be half the cost of the CNG three wheelers. The higher and inflated cost of CNG autos also indicate that there is an appetite to absorb higher margins in the market.

According to operators, operational cost of e-autos is also cheaper compared to CNG autos. For a distance of 180 km average daily cost Rs. 250/- for e-autos (including both night and top-up charging fee). But for CNG autos they need to spend around Rs. 350/-. At least a Rs. 100/- saving per day is possible. Similarly, owners of e-goods carriers find specific use cases like fixed route service delivery of white goods, milk, bread etc more profitable—in some cases an increase of 3 times. If with policy mandate the market picks up and there is a longer term policy visibility, higher product diversification is expected.

Despite the favourable cost differential CNG auto-owners hesitating to cross over: Even though the indications are that e-autos are cheaper to own and operate in Delhi market, the larger body of CNG auto owners are still uncertain. The usual concerns are range anxiety, home charging constraints, lack of safe parking and fear of theft. There is a considerable demonstration effect of the current e-auto fleet on the road that is drawing attention from others. Also quite a large number of CNG auto owners are still servicing their loan and would need to wait before they can take the decision to change over to the electric model.

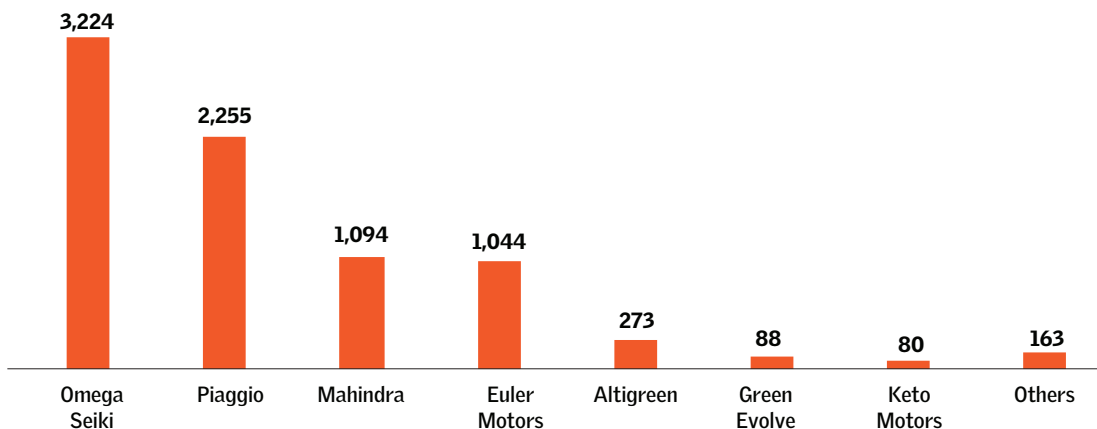
Preferences for electric models are growing. Despite the challenges, auto owners and drivers are beginning to prefer electric models. On ground rapid assessment has brought out that the cost of operation and maintenance are much lower compared to IC-CNG vehicles. This effectively lowers the total cost of ownership (TCO) of these vehicles compared to CNG counterparts. Owners and drivers have commented on the ease of driving, lower stress as there is no gear and clutch in these vehicles and the overall operational and maintenance costs. This indicates that if the challenges related to limited products, inadequate performance, and charging infrastructure are expanded, there will be considerable uptake in the market.

5. Electric goods-carrier

Need more models: Electric goods carrier segment (L5N) is largely dominated by the new entrants. Among the top five e-L5N three-wheeler manufacturers, three are entirely new to the business and do not have any variant in the ICE segment. Three e-L5N manufacturers (Omega Seiki, Piaggio, and Mahindra), together make up for 56 per cent of the total L5N market. (See *Graph 8: Top seven OEMs with registered electric L5M three-wheelers in Delhi (till 14th Jun 2023)*). Majority of these vehicle models have Lithium-ion batteries combined with plug-in chargers. However, some makers have swapping models.

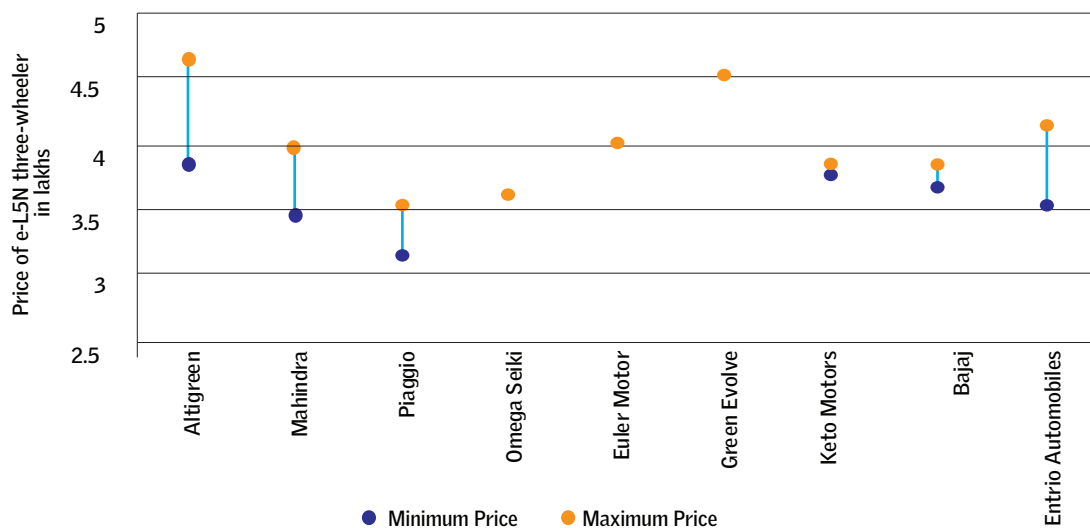
Improved price parity: The FAME 2 incentives for L5N segment are available for 12 OEMs with 43 e-L5N three-wheeler models. Of these, the transport department of GNCTD, has enlisted three manufacturers with nine models for qualifying for additional state incentive of Rs. 3500/- to 4000/- per vehicle under the Delhi EV policy. As a result, the up-front price difference between a CNG and e-L5N three-wheeler has gone down drastically. And lower total cost of ownership of these vehicles for certain used cases has made these vehicles commercially viable as well. This has led to higher electrification rate on a monthly basis compared to passenger three wheelers.

Graph 8: Top seven OEMs with registered electric L5M three-wheelers in Delhi (till 14th Jun 2023)



Source: Vahan database

Graph 9: On-road price of e-L5N three-wheelers after Incentive and tax exemption in Delhi

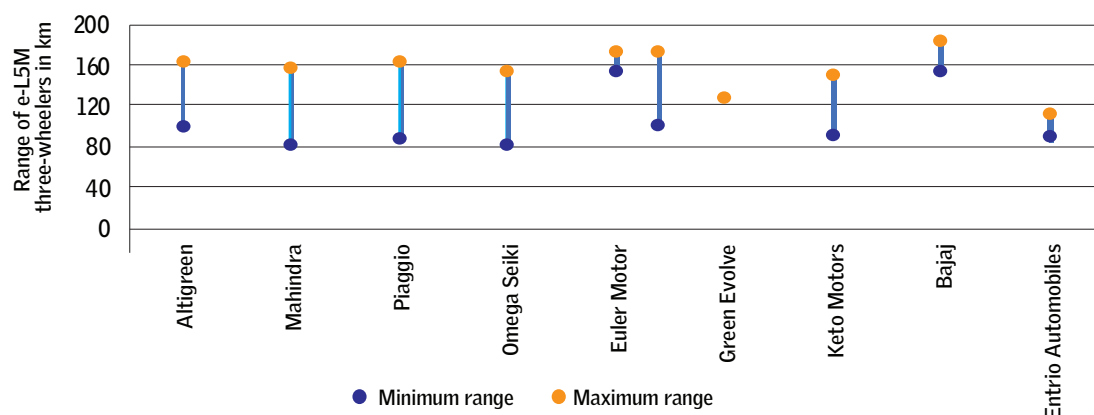


Source: CSE – compiled from various sources.

A 2022 study by RMI estimates⁶ that the combined incentives of FAME 2 and GNCTD bring the TCO of these electric vehicles to INR 1.94/km, which is below the cost of CNG vehicles at INR 2.25/km. It is expected that even without subsidies the goods carriers can achieve parity with their ICE counterparts by 2023. It is evident that the present price range of e-L5N vehicles are quite competitive with the CNG ones (See *Graph 9: On-road price of e-L5N three-wheelers after Incentive and tax exemption in Delhi*).

Vehicle range more aligned to local requirements: Majority of the L5N goods carriers models are quite comfortable to operate between 80 to 150 kms that fully cover the requirement of certain use cases or fixed route delivery service operations like last-mile delivery of milk, bread and other FMCG products. Thus, big online delivery services like Amazon, Flipkart and other players are rapidly converting their delivery vehicles into electric. This kind of product delivery requires a limited and pre-defined service kms per day which can be served by these models comfortably with single change. Since 2020 and post COVID-19 pandemic, the online product delivery services have increased several folds and have strong potential for electrification. (Graph 10: OEM-wise available range of e-L5N three-wheelers and *Table 2: Comparative analysis between CNG and electric L5N three-wheelers in Delhi*)

Graph 10: OEM-wise available range of e-L5N three-wheelers



Source: CSE – compiled from various sources

Table 2: Comparative analysis between CNG and electric L5N three-wheelers in Delhi

Key parameters	CNG L5N three-wheeler	E-L5N three-wheeler
1. Range (in km)	120-170 km (Fuel tank: 4 kg)	80-150 km in single charge
2. Speed (in kmph)	50-60	45-55
3. Payload capacity (in kg)	600-700	400-688
4. Fuel consumption per unit	30-35 km/kg.	6.4-8.6 kWh/100 km
5. Refuelling time/charging time	5 minutes (maximum)	4-5 hours
6. Gradeability (in percentage)	18-22	16-20
6. Capital cost (in Rs)	2.4-2.8	2.4-3.8
7. Operating cost (in Rs)	2-3/km	0.4-0.6/km

Source: CSE – compiled from various sources

Cost effective operations e-goods carriers: The cargo operators have indicated that operating electric L5N goods carriers is quite a profitable proposition for the local/ hyper local delivery partner or operator themselves. Illustratively, a delivery service provider generally gets Rs. 35,000/- from large conglomerates like Amazon/ Flipkart for goods delivery within a range of 35 km of daily operation on a monthly basis. If they use CNG models the overall cost including EMI's for vehicle, fuel, maintenance and driver cost is around Rs. 30000/- to Rs. 31000/-.

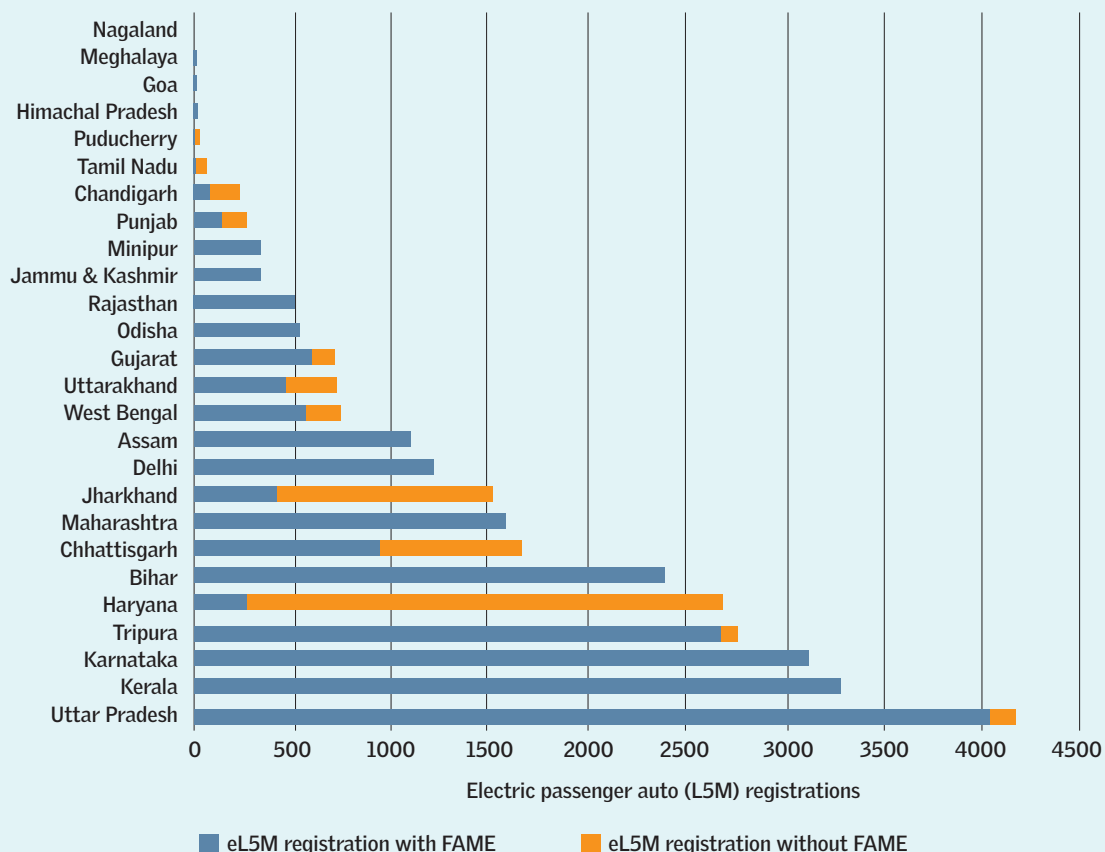
ROLE OF SUBSIDY TO PUSH ELECTRIC L5M/N THREE-WHEELERS

Unlike L3 segment, which is much cheaper and already viable economically even without subsidies. The L5 segment is still slightly costly compared to its IC counterpart. The requirement of subsidy, particularly for the L5 segment is clearly visible from the following two graphs (11 and 12). Till date, except for one or two areas, the registration of both L5M and L5N segments is largely influenced by the FAME subsidy.

Uttar Pradesh, Kerala and Karnataka, top three states with the highest number of electric L5M three-wheelers and all have one thing in common, majority of the electric L5M vehicles have received FAME subsidy. Same is also true for the L5N segment.

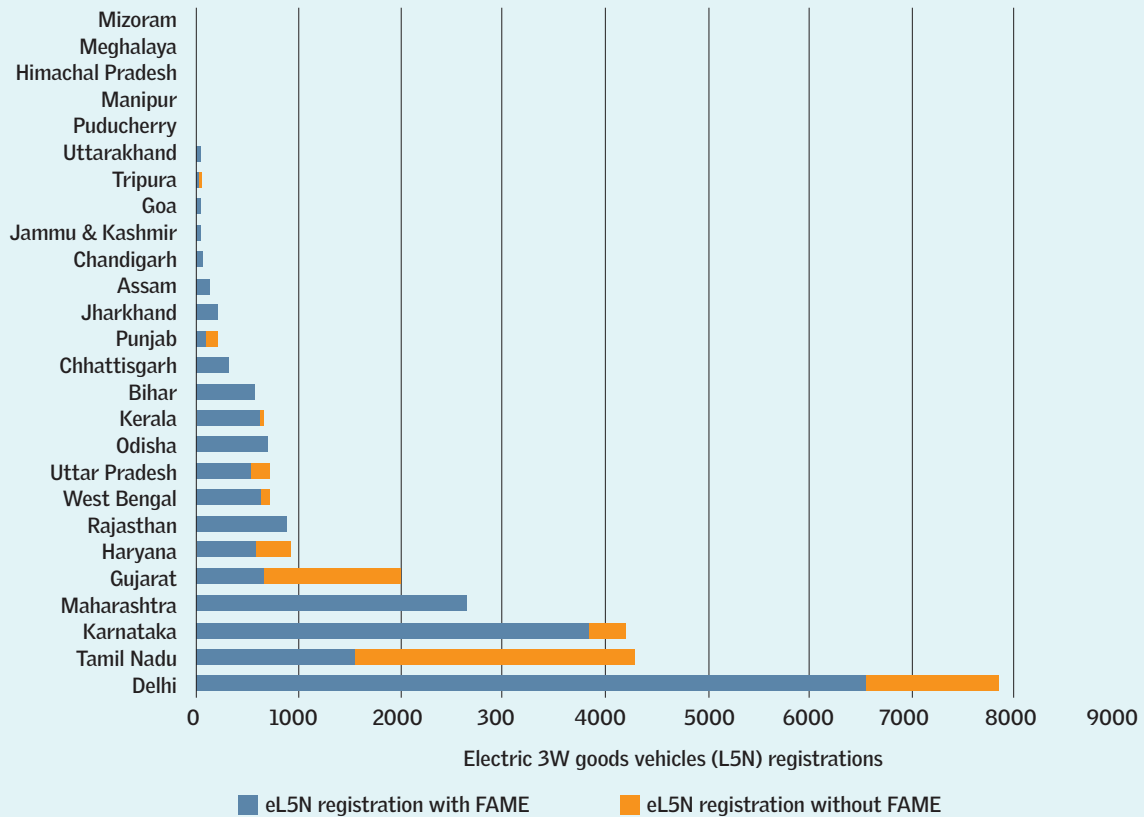
A combination of central and state subsidy can push the segment further – Delhi is the prime example. Delhi has the most electric L5N three-wheeler registered among Indian states, but if we look at the growth trend then it clearly shows that majority of these vehicles were registered after State subsidy is applied from 2020, which helps the price drop to a range where it looks profitable to have an electric vehicle. See *Graph 13: Annual registration of electric L5M/N three-wheelers in Delhi, for details.*

Graph 11: Electric L5M three-wheeler registrations in Indian states - with and without FAME subsidy (Apr' 2023)



Source: FAME Dashboard, Vahan Dashboard (Apr' 2023)

Graph 12: Electric L5N three-wheeler registrations in Indian states - with and without FAME subsidy (2023)

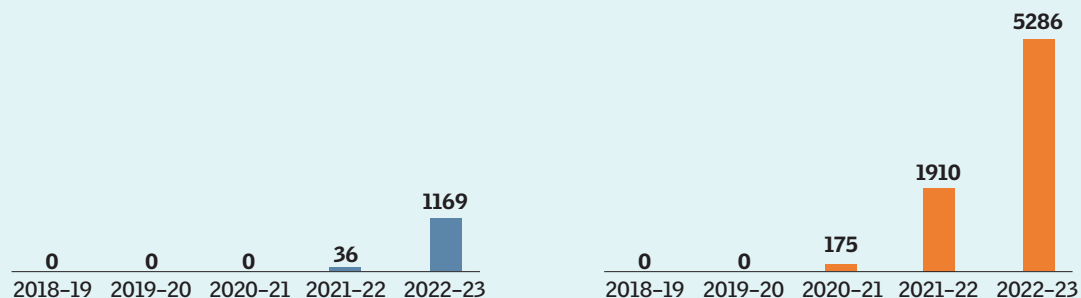


Source: FAME Database, Vahan database (2023)

Graph 13: Annual registration of electric L5M/N three-wheelers in Delhi

A. Annual registration of electric L5M three-wheelers in Delhi

B. Annual registration of electric L5N three-wheelers in Delhi



Source: Vahan database

But for electric models that cost would come down to Rs. 20,000/- to Rs. 21,000/. Effectively it is possible to save around Rs. 14,000/- to Rs. 15,000/- per month and monthly earning can increase by 3 times or more.

Despite the improved profitability and comparatively higher penetration of electric models, goods carriers need to compete with the existing CNG vehicles in every use case. This requires more innovations to improve range, and payload capacity of the e-variants. It is evident that currently for the last mile delivery there is not much difference in payload between the electric models and the ICE CNG models. Therefore fleet replacement is possible.

Need operational discipline: Typically, the goods carriers (L5N) are subjected to overloading. Field visits to Okhla mandi and other commercial areas showed regular overloading. Nearly all the vehicle operators admitted that they usually resort to overloading to maintain profit margin. One operator claimed that he was carrying 1.7 tons of goods whereas his vehicle is technically permitted to carry only 500 kg. Majority of the L5N operators have agreed that they usually carry 800-900 kg goods per trip. Consumer awareness about the impact of overloading on the vehicles and quickening of battery degradation is limited. Battery is the most expensive part of an e-vehicle. Its replacement before time can increase total cost of ownership and make services unviable.

Strong interest in the aggregator and delivery fleet: Draft motor vehicle aggregator scheme 2023 of the government of NCT Delhi aims for rapid electrification of the three-wheeler segment for all the vehicles belonging to app-based aggregator services including Amazon, Flipkart, Zomato, Denzo etc. in phased manner. (See Table 3: Target for adoption of three-wheeler in new fleet in Delhi). It provides for targets of 50 per cent electrification of the fleet in two years and 100 per cent in four years. The aggregator scheme has not mentioned the L5M/N segment separately. But these as part of the aggregators and delivery fleet can also be impacted.

Table 3: Target for adoption of three-wheeler in new fleet in Delhi

Timeline	6 months	1 year	2 year	3 year	4 year
Adoption target	10%	25%	50%	75%	100%

Source: Draft motor vehicle aggregator scheme 2023, Delhi.

6. Electric three wheelers and charging infrastructure

Concerns around home and night time charging: This category of vehicles depend largely on night time home charging and in some cases charging in parking places for full charge and on public charging networks for the top up charging during the operational hours during the day. Night parking-cum-charging is a big concern as many of them do not have adequate parking spaces near their homes or have access to reliable electricity.

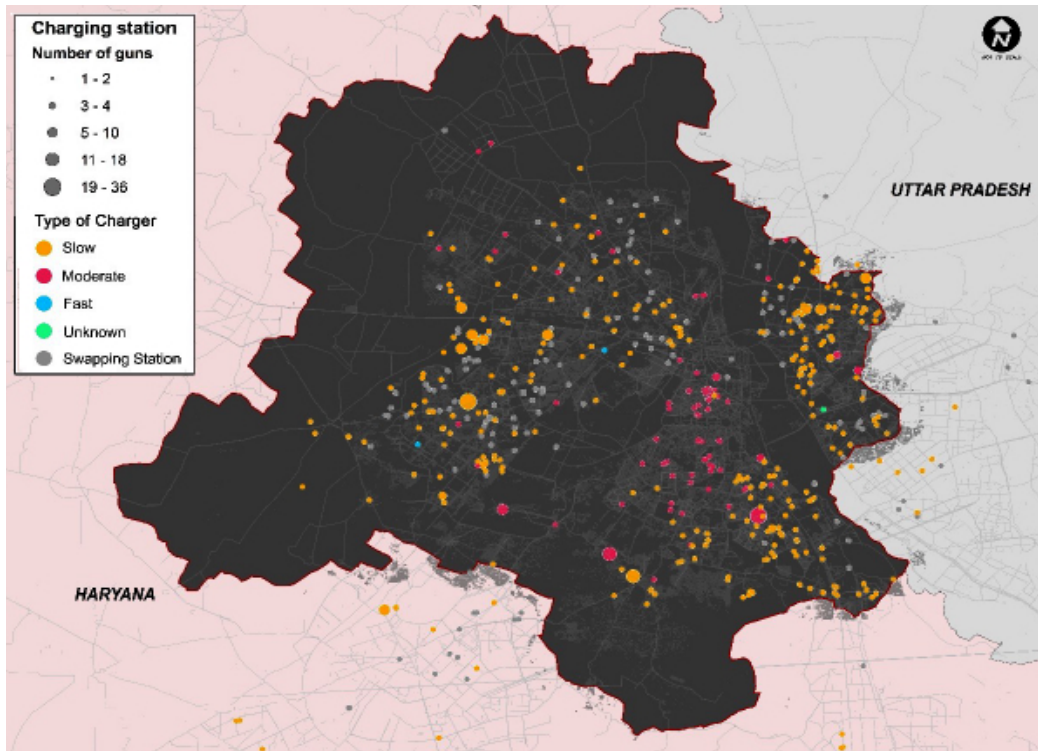
In fact, several CNG vehicle operators have expressed their hesitation to cross over to electric models for this purpose. Majority of the passenger and goods three wheeler owners and drivers live in small rented places at the outskirts of the city or low income settlements. Parking is usually done on road-side or nearby open spaces. But that also increases the chances of vandalism and theft. Several incidents of battery theft have impacted them negatively. This requires a strategy for organising safe parking cum charging facilities targeted at these segments in the city.

Public charging network: Delhi has created quite a large charging network compared to other cities. There are around 2452 public charging and 234 battery swapping facilities. There is a plan to add another 896 charging and 103 swapping facilities over the next 1-2 years. It may be noted that as per the Delhi EV policy at least one charging station should be made available in a 3*3 km grid. According to an expression of interest issued by the Department of Heavy Industry (DHI), on 15th Sep 2019, a slow charging station should be designed in such a way that at least 10 vehicles can be charged in that station simultaneously.

Majority of the chargers are slow and moderate type which is quite compatible to charge passenger and goods e-three wheelers (L5M and N categories). (See *Map 2: Distribution of Charging infrastructure according to charger types in Delhi*). Currently, given the battery technology level of the three wheelers, fast charging option for three wheelers is not available.

Even though the charging stations are quite numerous, only a few areas have dense charging facilities. Other areas need adequate and equitable distribution of charging infrastructure. (See *Map 3: Concentration of chargers in 3*3 km grid in Delhi*). This can be further expanded and rationalised.

Map 2: Distribution of charging infrastructure according to charger types in Delhi

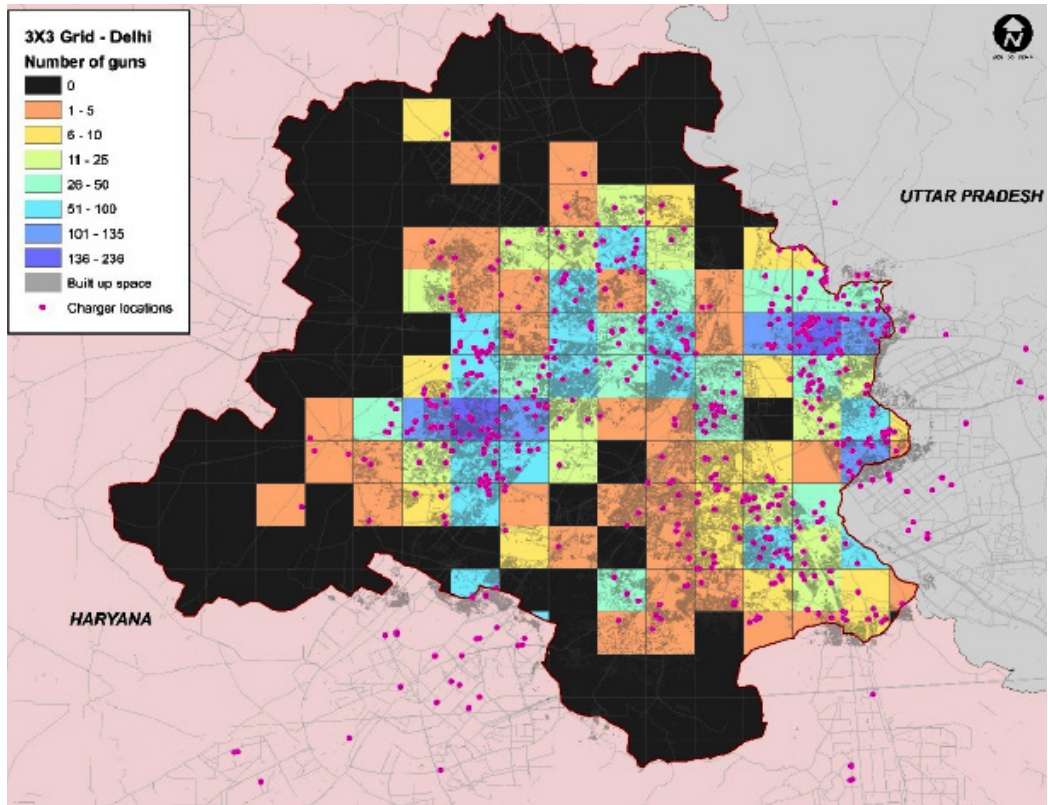


Source: SWITCH DELHI portal (ev.delhi.gov.in)

The feedback from the e-auto drivers in South Delhi show that access to charging stations is not a constraint even on a long drive. This needs to be evaluated for all zones of Delhi.

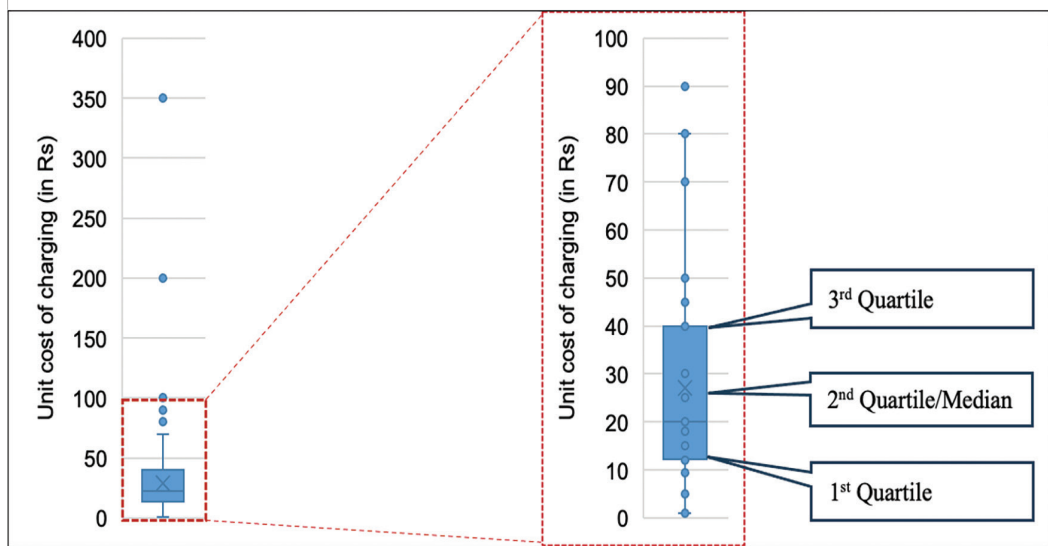
Charging cost: Currently, due to lack of regulation and standardisation, charging costs vary from location to location. It shows that depending on the charging provider and type of charging the unit cost varies quite widely between Rs. 12/- to 40/- (inter quartile range). In some areas the cost of charging goes up to Rs. 200/- to 350/-. (See Graph 14: Unit cost of charging in Delhi). High variability of charging cost despite the unit cost of electricity at Rs 6, is a major concern area for mass adoption. It is important to assess the contributory factors to high charging cost and find a more standardised practice. Several factors contributing to this including locational attributes, type and quality of charger, energy supply, security and operational assistance offered etc. Even strategies of market capture with a pricing strategy also contributes. This is a concern.

Map 3: Concentration of chargers in 3*3 km grid in Delhi



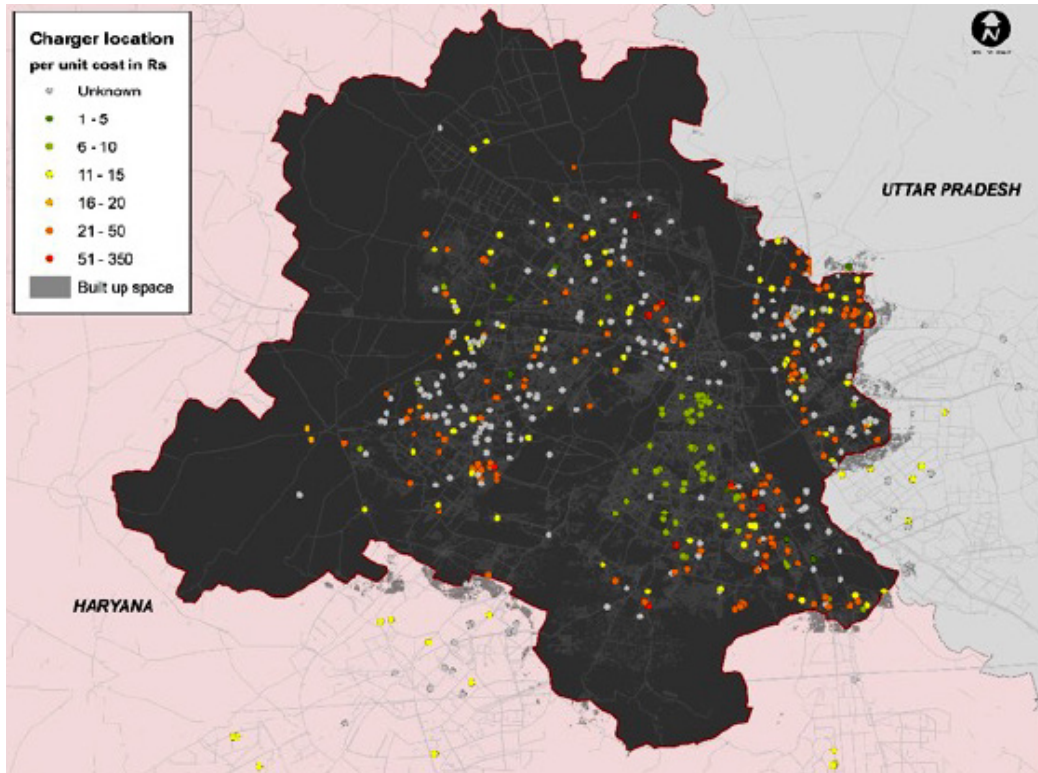
Source: SWITCH DELHI portal (ev.delhi.gov.in)

Graph 14: Unit cost of charging in Delhi



Source: SWITCH DELHI portal (ev.delhi.gov.in)

Map 4: Charger locations with unit cost difference in Delhi



Source: SWITCH DELHI portal (ev.delhi.gov.in)

Informal charging stations: To cater to the requirements of this segment that is hugely price sensitive, requires affordable electricity and also security for their vehicles, informal parking cum charging places have emerged in different parts of the city. These are informal set ups in open but enclosed areas where e-rickshaws and e-autos pay for parking and charging and can park and charge during the night and day as needed. Field visits in South Delhi showed shift charging wires in a row capable of charging at least 25 to 30 vehicles. The operators of these places collect the money for charging. The users of this facility claim that the cost works out to be cheaper for them and that their vehicles are also secure.

It is interesting to note that even though the cost of home charging is lower, some auto drivers prefer to take the service of informal charging facilities and pay higher rates because of reliable charging service, availability of parking and security. Illustratively, if home charging costs about Rs 30-35 per day, overnight charging and parking in the informal facilities cost -as was observed - is around Rs 100 per night.

Operational hassles in public charging stations: Several operators have expressed concern over top-up charging facilities. Majority of the charging points are automated. In case of difficulty in operating them they not know where to go for assistance. Nearly in all public chargers money is deducted in advance. There are several instances where users have not been able to charge their vehicles due to technical glitches and could not get their money back.

Battery swapping for three wheeler segments – an opportunity: Battery swapping works on the principle of replacing the spent battery with a fully charged one in swapping stations and avoiding the long plug-in charging time. This is becoming a popular choice for the commercial segments. Delhi has extended the purchase subsidies to swapping models as well. This helps to reduce the vehicle cost and also creates more options for drivers/ owners.

Delinking battery from the vehicle has found a lot of support especially in the commercial segments. This reduces the vehicle cost. There are several players in the battery swapping domain, which includes Sun Mobility, Battery smart, Lithium Power, ChargeUp etc. Almost all of them are providing swapping options for two- and three wheeler models. In Delhi, SUN mobility is the key and sole provider to cater to the L5 passenger and goods carrier segments. They are providing battery-as-a-service (BAAS) for this segment and rental models. Therefore, vehicle owners do not need to worry about the durability and end of life of the battery.

They have tied up with key OEMs including Bajaj, Piaggio, Mahindra, EV electric for both passenger and goods carrier segments. Fr the goods carriers they are providing batteries to Omega Seiki and Greaves Electric for the swapping variants. The existing swapping stations of SUN mobility include 15 battery systems. They are also planning to install their “SwapX” stations (3 battery systems) at every grocery store or neighbourhood locations in Delhi to make swapping easier and more accessible. Other swapping players like Battery smart among others are also developing swapping models for retrofitment vehicles.

Swapping is very useful for certain use cases where fleet owners can use their vehicles for double shift operations or long extended operations which are generally not possible with plug-in vehicles. However, individual owner-cum drivers have shown interest in vehicles with longer range preferably 180-200 km in single charge over swapping. Lack of availability of swapping models, limited swapping stations, concerns related to battery theft etc. influence such decisions. (See *Box: Battery swapping can be a game changer for the commercial L5M/N segment*, to understand the potential of swapping to transform the commercial vehicle segment.)

BATTERY SWAPPING CAN BE A GAME CHANGER FOR THE COMMERCIAL L5M/N SEGMENT:

Electric vehicle makers need to balance high cost of vehicles and low range of vehicles to make them competitive vis-à-vis conventional vehicles. Increasing the vehicle range by increasing the battery size increases the cost as well. About 40–50 per cent of the overall cost is actually battery cost. Also, larger batteries increase the vehicle weight and substantially reduce the loading/ payload capacity of the vehicle. It also affects the energy consumption of the vehicle and increases the charging time. Fast charging (high c-rate) also deteriorates the batteries more quickly unless battery composition allows it and batteries with such composition costs even more.

Currently, the majority of electric vehicle makers are offering plug-in charging models with comfortable travel range for personal usage, where one can travel a maximum 50–70 km but for commercial usage it becomes a challenge. Average commercial vehicles (including 3W, cars and buses) travel at 180–220 km per day depending upon the type of vehicle and city size. For additional km of travel, they either have to go for larger batteries or have to compromise their operational efficiency by charging the batteries during the operational hours—in both their earnings are impacted. Cities also need to develop entire ecosystems with dense public charging networks to support it. This requires huge investment.

In this situation, battery swapping can emerge as a viable alternative solution which can take care of concerns related to cost and range. In swapping technology, vehicles don't have to have large batteries to begin with. This substantially reduces the upfront cost. Additionally, innovative business models are also developing in-around battery swapping where companies are providing batteries as-a-service (BAAS), as a result vehicle owners don't need to worry about the durability and life of a battery, rather they can use battery as rental service. Furthermore, in swapping, batteries can be charged in a controlled environment with required charging rate which will help in increasing battery life.

Additionally, plug-in charging requires long charging-cum-parking space, which is very scarce in big cities particularly during day-time operation. Still many L5M/N three-wheeler operators stay in small rented rooms where they find it difficult to park their vehicle and thus the majority of time, they park it in open grounds or places or road side by illegally encroaching the public spaces.

In the beginning government policies and incentive structures based on battery sizes have indirectly favoured plug-in technology over swapping. To make swapping successful some short of standardization in terms of battery casing, a common communication gateway is required.

Although battery swapping in the case of large vehicles like cars and buses is technically possible, it is still challenging given the heavy weight of the batteries, requirement of robotic arms for battery replacement etc. But in small commercial vehicles including commercial 2Ws and 3Ws, swapping is easier. However, for this initiative to take off it is necessary to have some form of standardization, in terms of battery size - interoperability, communication protocols, connectors and safety protocols of the batteries.

7. Electric three wheeler manufacturers: perception

As the vehicle manufacturers are an important partner in this transition, it is necessary to understand their perception of the market dynamics. It is possible to identify key issues conveyed by the industry players who have spoken under the conditions of anonymity. The OEM representatives feel that the current trend is an evidence that the cargo segment or L5N has a greater chance of quicker electrification than passenger ones. After the COVID-19 pandemic, e-commerce activity has increased many folds. Their small service delivery areas and fixed route operations offer a better opportunity for electrification.

They agree that for higher levels of penetration, industry needs to upgrade the product portfolio in terms of range, battery performance, safety among others. But this will be an incremental and optimisation approach instead of a big leap in technology to keep the vehicles affordable for the majority. They also believe that given the cost sensitivity of the segment, subsidy needs to continue for some time to build the market. An average electric L5N goods auto costs around Rs. 3.5 to Rs 4.2 lakhs without subsidy and after subsidy the cost reduces to Rs. 2.8 to Rs 3.5 lakhs. Subsidy can make a difference in the early stages of growth.

Companies are also working on several strategies like battery as a service (BAAS) that allows vehicle operators to pay as they go and batteries are available on rent. The batteries are being separated out from the vehicles. They are also moving towards a business model that allows second life of vehicles.

Manufacturers feel that a good charging network can enable faster adoption, particularly for the passenger segment. At the same time some of the companies are also coming up with swapping models to reduce range anxiety.

Industry representatives emphasize the need for value engineering. Research and product development is oriented in this direction. This requires reducing battery load, optimization of motor power for better performance, extract more energy from the battery and transfer the energy smoothly to drive the motor more efficiently. Several companies are working on new generation batteries for this segment including solid state batteries for a longer life of at least 5000-10000 cycles. The key thrust is on value engineering that can improve quality and performance incrementally instead of opting for high end technology solutions in a quicker timeframe.

There are also worries that sales of electric three wheelers may slow down after the tightening of the safety norms – the Automotive Indian Standard (AIS) 156, to prevent overheating of lithium batteries and fire incidents. The industry expects challenges with respect to the new tests that are required for thermal propagation and other related issues. They fear that this may push up the cost of compliance and the price of the product. This requires value engineering that is also affordable.

8. Financing challenges

The electric autos find it very difficult to arrange finances from conventional sources at the same level of interest rate and payback period as that of CNG autos. Bankability is affected because of uncertainty over resale value of the vehicles that makes cost recovery in the case of default difficult. Additionally, low income of these vehicle owners and lack of proper documentation complicate the challenge more. Financiers are not comfortable about providing loans to first time buyers and migrants and without local guarantors.

Therefore, they resort to high cost loans with higher interest rates and shorter repayment period that imposes economic constraints. This is one of the leading reasons behind the low adoption rate in this segment. (See *Box: Why financing electric passenger and goods three wheelers remain a challenge*).

Private financiers who have come forward are ready to provide financial support in a way that the beneficiary do not need to pay their instalments more than Rs. 8000/- a monthly or Rs 250/- to 300/- a day. Financiers have also started providing loans for three wheeler batteries as well, where repayment instalments equals to around Rs. 150 a day.

According to the financiers, there is interest in supporting models with tracking devices installed inside the battery pack and battery swapping market. According to them transformation in the L5N segment is more certain as applications like local/ hyper local deliveries are quite defined in terms of operating area and kms.

On the other hand L5M passenger segment is suffering due to lack of appropriate charging infrastructure for this group of users. In addition, global companies like Amazon, Flipkart among others are also backing the L5N segment to transition to electric, specifically for first/ last mile. Electric L5M/N segment also saves lots of carbon, which can further be traded. There are companies which buy carbon credits – which opens up an additional revenue source for large fleet owners. This also gives confidence to financiers to finance such individuals or companies.

WHY FINANCING ELECTRIC PASSENGER AND GOODS THREE WHEELERS REMAIN A CHALLENGE

In contrast to the ICE passenger and goods three-wheelers which are being financed by almost all conventional banks and non-banking financial corporations (NBFCs), electric three wheelers have limited options of financing. Although the number of institutes providing financial support for procuring electric vehicles are increasing, it is limited for e-three wheelers.

Several NBFCs and fintech companies have come forward to fill the gap of EV financing but their interest rates are much higher than that of conventional banks—around 20–25 per cent.

Similarly, the loan payback period for electric versions is much shorter than the ICE counterpart. The payback period for an ICE model ranges between four to five years for bank loans and up to three years for NBFCs. But for electric vehicles, it is usually two years.

Low payback period discourages vehicle operators to buy an electric variant. The emerging evidence from the ground shows that the EMI amount can increase from Rs 8,000–8,500 (purchased with subsidy) to Rs 11,000–12,000 (purchased without subsidy). This is an almost 40–100 per cent increase in EMIs compared to Rs 4,300–6,200 for diesel and/or CNG ones. Thus, a major chunk of the monthly profit (i.e., around Rs 15,000) actually is consumed for loan repayment.

Similarly, for goods three-wheelers EMI increases from Rs 9,000–12,000 (purchased with subsidy) to Rs 12,000–16,000 (purchased without subsidy).

Conversation with the financing institutions have highlighted several challenges that impact the financing of electric passenger and goods three wheelers:

- **Uncertainty around vehicle technology:** There are several new market players in this segment without proven track records. The financial institutes are unsure about the quality of the product. Financiers claim that small start-ups/dealers are customising the product according to the requirements stated by the customers (largely related to battery type and size etc.) which have bearing on the performance of the product.
- **Underdeveloped market for second hand e-autos:** Given the uncertainty around the technology, the resale value of e-vehicles have not been established yet. There is no second-hand market for e-autos. Thus, financial institutes are unsure about the cost of recovery and payback in case there is default payment.
- **Differences in warranty period:** In the case of diesel or CNG three-wheelers, the original equipment manufacturers (OEMs) generally provide a minimum of three years or 100,000 km warranty (whichever is earlier) on the whole vehicle. Extension of warranty period is also possible. In the case of electric ones, differentiated warranty is offered for different vehicle components. Battery warranty is for three to five years, motor and controller for one year and charging system for six months. Extended warranty scheme is not available for e-autos. This creates uncertainty in the market.
- **Difficulty in dispute resolution:** E-battery performance and warranty depends on the usage pattern of the vehicle. For example, if a certain good e-auto battery is designed to operate for five years with a 500 kg load, then it has to be used in the same way to sustain it for five years. Overloading can affect the battery durability. In such a situation it becomes difficult to resolve the dispute between manufacturers and vehicle owners/operators.
- **Lack of credit worthiness:** Majority of the vehicle owners-cum-operators are new and there are concerns around their credit worthiness. Often, they do not have experience in banking transactions. Thus, creditors are apprehensive of providing credit to them.
- **Fragmented and small markets reduce access to financial services:** As the market is new and demand is low, fragmented and dispersed, financial institutions or lenders find it difficult to widen the scope of services and serve across geographies.

9. Retro-fitment of vehicles

There is considerable interest in converting ICE three wheelers to battery operated vehicles. This is primarily due to the prevalence of a large fleet of old and ageing vehicles that are often the priority target for phasing out strategy for pollution control. To avoid the high cost of replacement with new vehicles, retrofitment with electric motor systems and battery is preferred. Retrofitment cost can be half of the new vehicle. Several state governments including Kerala, Tamil Nadu, have started to provide support for retrofitment.

Technically and principally retrofitment is possible. But this will require stringent quality control and quality assurance and proper oversight of the retrofitting agencies.

Legally, Automotive Indian Standards (AIS 123) allows post 1990 vehicles to be retrofitted. But retrofitters inform that usually the target segment is 5 to 15 years. A lot of engineering judgement needs to be applied to very old vehicles to consider their structural strength, quality of the suspension and shocks impacting the electronics, strength of the chassis, body design, wiring harness, among others. If the auto owners agree to do proper refurbishing of the vehicles that may add further to the costs. Retrofitment would typically require batteries, motors, controllers, batteries, gearbox, wiring harness, thermal management, dashboard, IOT unit, chargers, charging ports, etc. The retrofitter claims that they are able to provide torque, top speed, average speed, etc comparable to that of the products of the OEMs.

Retrofitment helps to extend the life of the vehicle and would work as long as the batteries can go. Usually, a three-year warranty and a five-year guarantee on the performance are given.

Under the current Automotive Indian Standard (AIS) rules, retro-fitment strategy needs certification of retro-fitment kits of specified make and model of vehicles by the Automotive Research Association of India (ARAI) and as per the standards and provisions being notified under Central Motor Vehicle Rules (CMVR). This needs to be performance linked. Currently, safety aspects are covered by AIS 156 while certification for retrofitment is under AIS 123. Compliance is adding to the costs.

Retrofitters are allowed to retrofit only those models for which they have obtained certification from ARAI. In case they seek to use those systems in other models they

need to take type extension approval under specific AIS norms. In this case only limited additional tests are done and all the tests are not repeated. Certification for retrofitment is expensive and testing capacity in the testing agencies are also inadequate. This is a bottleneck for the start-ups. There seems to be a trend towards taking support of third party facilities. But this is not usually encouraged.

Several retrofitthers are now bringing in lithium ion batteries. There is a limit to how much the battery size can be increased as its weight cannot exceed the gross vehicle weight by 25 per cent. They need to remain within the weight range and still be able to pack more energy. They cannot also opt for high cost battery management systems. Retrofitthers are moving towards lithium chemistries. They need to innovate to address safety aspects and thermal management of batteries.

The Policy for Clean Air in Delhi, National Capital Region and beyond issued by the Air Commission Based on the central government rules, the state governments need to further define and notify the implementation mechanism for retro-fitment. It is necessary to register retrofitthers for quality control and safe installation.

Some NBFCs are now willing to fund retro-fitted vehicles, in case vehicles are certified from the appropriate certified authority like ARAI, ICAT etc. According to them, retro-fitment also has a huge potential to electrify a large portion of the L5M/N segment. There are retrofitthers which are coming with battery rental models as well to provide battering on rent (i.e., around Rs. 150/- per day).

10. The next steps

Implement the mandate for new three wheelers to be electric: The GNCTD has stated that all the new or renewed permits should be issued for electric passenger three wheelers only and this will be like a lifetime permit till the vehicle is fit to ply on the roads of Delhi. In addition to this, the draft motor vehicle aggregator scheme 2023 is incorporating phase-wise targets to electrify the aggregator fleet to meet 100 per cent electrification in four years. This will have a bearing on the three wheeler delivery fleet as well. There is an opportunity in this segment. In other vehicle segments sales mandate may be required.

Strengthen both fiscal and non-fiscal incentives: Delhi has already exempted the electric vehicles from the motor vehicle tax and registration fees and is providing purchase and scrappage incentives for EVs. Even though the incentives are available to both electric rickshaws (L3) and electric autos (L5) the uptake of L5 segment has been minimal. Therefore, the GNCTD needs to make support for this segment stronger. Also consider additional non-fiscal benefits to electric three wheeler owners, such as discounted or free parking facilities especially in multi-modal locations such as metro stations, bus terminals, major commercial places, earmarking of areas for safe parking with charging facilities, creating low emission zones to incentivise entry of electric or zero emission vehicles while curtailing ICE etc.

Need stronger industry participation for product development to support mandate for e-only registration: As the GNCTD has stated that all new three wheeler registration needs to be battery operated, this has – by default – become a sales mandate for the industry. This should catalyse the market and encourage the manufacturers to diversify the product range and innovate.

Support charging ecosystem: As these vehicles rely largely on night-time home charging supported by top-up charging in public charging networks, steps may be taken to set up parking cum charging facilities at the community parking locations at subsidized fees. To enable this, the Parking Management Area Plan (PMAP) may be implemented in each municipal ward to comply with the Delhi Parking Rules 2019 that has provided for parking based charging facilities. Develop battery swapping market for this segment to help achieve scale while addressing the issues around standardisation, interoperability, rationalised rates etc.

Standardise and rationalise charging rates: It is necessary to address the widely varied charging rates across the city. Regulate, standardise and rationalise the rates of charging across charging providers considering the varied input costs. Fix the electricity price for electric vehicles. Charging rates need to be within the affordable range of the masses.

Support financing mechanism: Delhi has already created a dedicated Delhi Finance Corporation (DFC) for disbursement of easy loans to the applicant. GNCTD may also explore the possibilities beyond traditional lending and act as a credit guarantor for providing easy loans to individual E-L5M/N drivers or owners. The government or notified agencies can provide partial guarantee against default.

Enable second-hand market for used product: Not having any second-hand sale of L5 vehicles, is a barrier to financing and bankability. Need a strategy to develop a second hand market for electric vehicles, batteries etc. Involve aggregators, recyclers, delivery agencies and manufacturers to address this issue.

Retrofitment market requires stringent oversight for quality control and assurance and strong process of certification and standard setting.

Create awareness to build public support for electric passenger and good carrier services: Majority of the L5 operators have limited knowledge about electric vehicle technology, operational aspects, market access, government policy, and are also victims of misinformation. Currently, they are going more by the demonstration effect of their fellow drivers/owners who currently use e-autos. Field assessment indicates sizable dormant demand. Well-designed outreach programme can sensitize them about the technology, financial instruments, operational aspects, availability of incentives, charging needs and safety requirements among others. It is possible to catalyse this into active demand.

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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

E-mail: subhasish.parida@cseindia.org Website: www.cseindia.org