International Copper Association India
Copper Alliance

Alliance for an Energy Efficient Economy

Catalysing the Market Transformation of

ELECTRIC 3-WHEELERS IN INDIA

2023

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Jointly prepared by: International Copper Association India Limited (ICA India) and Alliance for an Energy Efficient Economy (AEEE).

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Executive Summary

Three-wheelers (3Ws) play a significant role in providing the last-mile connectivity. Electrification of three-wheelers has emerged as a necessity to provide a green and clean last-mile ride. The electrification of three-wheelers poses various key challenges. Alliance for an Energy Efficient Economy (AEEE) and International Copper Association India (ICA) collaborated on this study to identify the key barriers to facilitating the adoption of electric three-wheelers (E3Ws) on the market. The proposed whitepaper aims to identify pathways for a market transformation for electric three-wheelers in India.

The whitepaper facilitates the increased adoption of E3Ws in India by examining the perspectives of consumers and different stakeholders involved in the E3W ecosystem – fleet operators, financial institutions, dealerships, and service centres. The study was carried out in three cities – Delhi, Lucknow, and Bangalore, with the majority of the survey (70%) conducted in Delhi. The driver survey was broadly divided into three vehicle segments across the three cities: e-rickshaw, e-auto, and internal combustion engine (ICE). Each vehicle type was further divided into goods and passenger transport, and the findings are presented in this report accordingly. The entire report covers various key aspects related to E3Ws, including purchase, charging, performance, aftersales, safety, retrofitting, etc. Chapter 2 provides an overview of the E3W ecosystem, which includes the classification of E3Ws in India, charging and battery swapping infrastructure, and role of E3Ws in last-mile connectivity, with application in different areas. Chapter 3 discusses the findings and key insights from the consumer survey. It examines the key challenges, concerns, and expectations from the consumer perspective. Chapter 4 presents the key insights from the stakeholder consultation and discusses the various challenges, such as manufacturing concerns, financial challenges, the battery swapping ecosystem, and state policies' role in E3W adoption. Chapter 5 provides recommendations to address the barriers to E3W adoption in India.

The recommendations presented in the whitepaper focus on topics ranging from consumer perceptions and demand incentives to addressing product issues such as awareness, servicing, safety, and other related topics. The recommendations comprise important aspects of the E3W ecosystem, such as installing more and regularly maintaining charging points, providing investment support to charging and swapping players, and conducting regular EV awareness forums to educate people about the benefits of EVs. Additionally, providing better training to service center technicians, improving the build quality of EVs through customer feedback, and partnering with financial institutions to provide cheaper loans, will be crucial in overcoming the challenges faced by EV drivers. The market transformation for E3Ws in India will require the stakeholders in the electric vehicle (EV) ecosystem to further deliberate and implement strategies in line with the recommendations presented in the whitepaper.

Acronyms

3W - Three-Wheeler

4W - Four-Wheeler

AC - Alternating Current

AEEE - Alliance for an Energy Efficient Economy

Ah - Ampere-Hour

ARAI - Automotive Research Association of India

BAAS - Battery-As-A-Service

BIS - Bureau of Indian Standards

BMS - Battery Management System

BSS - Battery Swapping Stations

CAPEX - Capital Expenditure

CC - Cubic Centimetre

CESL – Convergence Energy Services Limited

CIRT - Central Institute of Road Transport

CMVR - Central Motor Vehicles Rules

CNG - Compressed Natural Gas

COVID-19 - Coronavirus Disease of 2019

DC - Direct Current

DISCOM - Electricity Distribution Company

DST- Department of Science and Technology

E3W - Electric Three-Wheeler

E4W - Electric Four-Wheeler

EMI - Equated Monthly Installment

EOI - Expression of Interest

EV - Electric Vehicle

FADA - Federation of Automobile Dealers Associations

FAME - Faster Adoption and Manufacturing of Electric and Hybrid Vehicles

FY - Fiscal Year

GPS - Global Positioning System

GST - Goods & Services Tax

GVW - Gross Vehicle Weight

ICA - International Copper Association India Limited

ICE - Internal Combustion Engine

ICAT - International Centre for Automotive Technology

IEA - India Energy Outlook

INR - Indian Rupee

IPT - Intermediate Public Transport

JMI - Jamia Millia Islamia

kg - Kilogramme

km - Kilometre

kW - Kilowatt

LCO - Lithium-Cobalt-Oxide

LEV - Light Electric Vehicle

LFP - Lithium-Iron-Phosphate

Li-ion - Lithium-Ion

LTO - Lithium-Titanium Oxide

LTV - Loan-to-Value Ratio

MoP - Ministry of Power

MoRTH - Ministry of Road Transport and Highways

MSW - Municipal Solid Waste

NBFC - Non-Banking Financial Company

NCA - Nickel-Cobalt-Aluminium

NGO - Non-Governmental Organisation

NMC - Nickel-Manganese-Cobalt

NPA - Non-Performing Asset

NREDCAP - New & Renewable Energy Development Corporation of Andhra Pradesh Limited

OEM - Original Equipment Manufacturer

PCS - Public Charging Station

PwC - PricewaterhouseCoopers

QIS - Quick Interchange Station

R&D - Research & Development

RFID - Radio-Frequency Identification

SNA - State Nodal Agency

SOC - State of Charge

STEPS - Stated Policies Scenario

ULB - Urban Local Body

USD – United States Dollar

UT - Union Territory

V - Volt

01 Introduction

1.1 Overview of the three-wheeler market

In India, three-wheelers (3Ws) are the most dominant mode of transport for last-mile connectivity. In fiscal year (FY) 2021, the market value of 3Ws was United States Dollar (USD) 754.5 million (Imarc, 2022), and this is expected to further increase due to the growth in population, increased travel demand, ease of booking through apps, etc.

Many companies, such as e-commerce, pharma, textile, retail, poultry, dairy, etc., prefer 3Ws for last-mile connectivity due to their excellent maneuverability and low operating cost. **Figure 1** depicts three-wheeler sales in previous years.

In FY21-22, electric vehicle (EV) 3Ws dominated the market, with a 47% market share (EVreporter, 2022). Due to growing environmental concerns & government restrictions, alternative fuel-driven three wheelers are gaining traction, and this trend is likely to continue until FY2026.

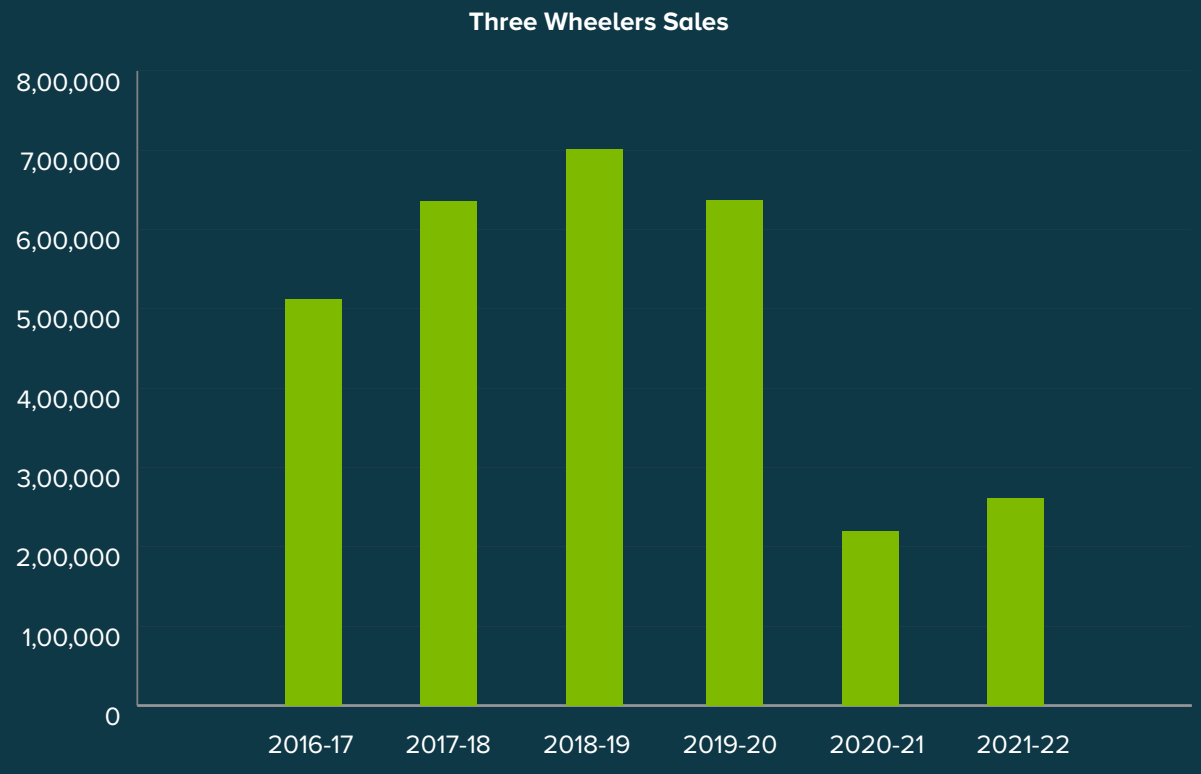


Figure 1: Three-wheeler sales in India

Source: SIAM

1.2 Overview of the electric three-wheeler market in India

According to the September 2022 Vehicle Retail Data released by Federation of Automobile Dealers Associations (FADA) (FADA 2022), the 3W segment has continued to witness a structural shift from internal combustion engine (ICE) vehicles to EVs, which is also seen in the significant increase in e-rickshaws. Electric three-wheelers (E3Ws) make up a significant share of the EV market in India; the E3W passenger segment accounts for 59.4% of the cumulative market share through FY2022, with the E3W cargo segment accounting for an additional 4 percent (JMK Research & Analytics 2022).

Figure 2 depicts the number of E3W registrations in India from 2013-14 to 2022-23. The number of registrations has steadily increased from 2015-16 to 2019-20. However, E3W registrations decreased significantly in 2020-21, due to the coronavirus disease of 2019 (COVID-19) pandemic, which affected the Indian economy across various sectors. However, recent years show a recovery in terms of the number of E3Ws registered, as it doubled from 88,477 registrations in 2020-21 to 1,78,079 registrations in 2021-22.

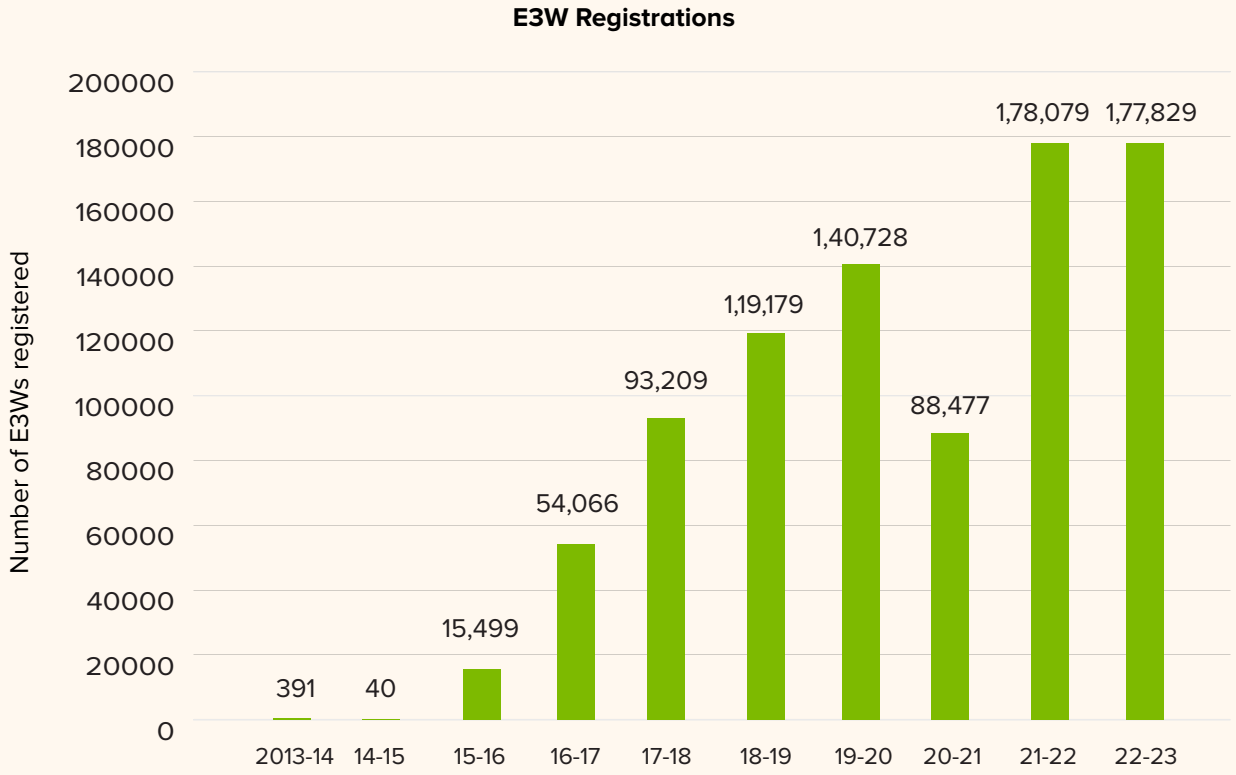


Figure 2: E3W registrations in India

Source – Vahan Dashboard (MoRTH 2022). Accessed on 10.10.2022.

According to the India Energy Outlook 2021 (IEA 2021), in the Stated Policies Scenario (STEPS), there will be 55 million electric two-and three wheelers on the road in 2030, comprising 19% of the total stock. This will increase to 160 million in 2040, accounting for over 50% of the stock of such vehicles.

E3Ws play a critical role in last-mile connectivity and goods transport in India. However, 3W electrification is facing various financial, operational, manufacturing, and safety-related challenges. Therefore, Alliance for an Energy Efficient Economy (AEEE), in collaboration with International Copper Association India Limited (ICA), is undertaking research on the E3W market transformation. This research paper aims to highlight the pervasive challenges in the ecosystem and offer recommendations to address these issues.

02 Electric three-wheeler ecosystem

2.1 Classification of electric three-wheelers

This section provides an overview of E3Ws available on the Indian market. As per the Central Motor Vehicles Rules (CMVR 1989) and its amendments, 3Ws are categorised into different categories, including L5M (Auto), L5N (Cargo), E-Rickshaw, and E-Cart. Specifications include motor power, seating capacity, maximum speed, engine power, and gross vehicle weight. Vehicle engine power above 25 cubic centimetres (CC) is used for both L5M and L5N ICE vehicles. Gross vehicle weight is considered 1500 kilogrammes (kg) (max) (Vivek Jain, 2021).

#Vehicle Category: L5M (Auto)

- Engine Power > 25 CC (ICE)
- Motor Power > 0.25 KW (BOV)

- Max. Capacity > 25 Km/hr
- Seating Capacity = Driver + 3

#Vehicle Category: E-Rickshaw

- Only Electric (Battery Operated)
- Motor Power < 2 KW

- Max. Speed < 25 Km/hr
- Seating Capacity = Driver + 4

#Vehicle Category: L5N (Cargo)

- Engine Power > 25 CC (ICE)
- Motor Power > 0.25 KW (BOV)

- Max. Speed > 25 km/hr
- Seating Capacity = Driver

#Vehicle Category: E - Cart

- Only Electric (Battery Operated)
- Motor Power < 2 KW

- Max Speed < 25 Km/hr
- Seating Capacity = Driver

Figure 3: Three wheeler classification

Table 1: E3W classification

Vehicle category	Maximum speed	Motor power	Seating capacity	Examples
L5M	More than 25 km/h	0.25 kW	Driver+3	Auto-rickshaws, electric autos
L5N	More than 25 km/h	0.25 kW	Driver	Loading tempos, electric cargo
e-Rickshaw	Less than 25 km/h	2 kW	Driver+4	e-rickshaws
e-Cart	Less than 25 km/h	2 kW	Driver	e-carts

The E3W segment in India is experiencing significant growth due to the impact of various government initiatives. As per the EV Reporter (2022), this segment has captured a 47% share of the total 3Ws sold in FY21-22 (EV Reporter, 2022). Despite its potential, the Indian E3W market remains largely unorganized, with many players being start-ups or new entrants to the 3W industry. This has sparked a race among EV manufacturers to establish a dominant position in the Indian E3W market.

The Government of India is providing various incentives such as the Faster Adoption and Manufacturing of Electric and Hybrid Vehicles (FAME I & II) scheme in the E3W segment. Table 2 provides the list of E3W manufacturers registered under the FAME II scheme.

Table 2: Active FAME II approved E3W models

	e-cart	e-rickshaw	L5M	L5N
Piaggio Vehicles Private Limited			2	14
Omega Seiki Pvt Ltd				5
Mahindra Electric Mobility Limited	6	2	2	3
Mahindra & Mahindra Ltd				3
Altigreen Propulsion Labs Pvt Ltd				3
Etrio Automobiles Private Ltd.				3
Euler Motors Pvt Ltd				2
Kinetic Green Energy & Power Solutions Ltd	1	3		1
Keto Motors Private Limited			2	1
Om Balajee Automobile India Pvt Ltd			1	1
MLR Auto Ltd				1
Continental Engines Private Limited				1
Green Evolve Private Limited				1
champion polyplast		1		
Y C Electric Vehicle		2		
Avon Cycles Ltd		1		
Goenka Electric Motor Vehicles Pvt. Ltd.		1		
Saera Electric Auto Pvt. Ltd.	1	3		
U P Telelinks Ltd		1		
Khalsa Agencies		1		
Atul Auto Limited	1	1		
Dilli Electric Auto Pvt Ltd	1	1		
Shigan Evoltz Limited	1	1		
Lohia Auto Industries		4		
G.R.D. Motors		1		
SKS Trade India Pvt Ltd	1			

	e-cart	e-rickshaw	L5M	L5N
J.S. Auto Pvt Ltd.		1		
Balan Engineering Private Limited	2	1		
Smartomatic Vehicles Private Limited	1	1		
Efev Charging Solutions Pvt Ltd	1	1		
Fitwel Mobility Private Limited	1	1		

(*As on December 2022)

2.2 Overview of existing policies and schemes related to electric three-wheelers

India is emphasising and promoting EVs in order to take a leap towards cleaner transport. The government has introduced several policies and plans to increase the pace of EV adoption among consumers. The central government has introduced schemes such as FAME I and FAME II that provide different types of financial incentives, like purchase incentives, interest subventions, road tax exemption, registration fee exemption, income tax benefits, etc. (Dixit Aasheesh, 2020).

Along with the central government, state governments are also working to accelerate EV adoption. This section analyses the EV policies of 23 states/union territories (UTs), as mentioned in Figure 4.

The policies have been assessed based on the following criteria:

- EV adoption targets
- Consumer incentives for EV adoption such as capital subsidies, road and registration tax exemptions, scrappage, financing, priority registration, and free permits
- Operational incentives, including green zones, reserved parking slots, and toll fee waivers
- Charging infrastructure incentives such as capital subsidies for charging equipment, land subsidies, special EV tariffs, renewable energy use, charging station setup, and battery swapping incentives
- Manufacturing incentives, comprising capital subsidies, tax exemptions/reimbursements, interest subsidies, land purchase and registration incentives, retrofitting incentives, battery recycling and reuse incentives, and battery warranty and buyback agreements
- Skill development
- Research & development (R&D).

The states are scored from 0 to 1 on each of the above parameters, i.e. a score of 0 if the parameters are not addressed in the policy and a score of 1 if they are addressed. The scores for each state are then summed up, and the total score ranges from 0 to 25. ***Figure 4*** depict the state ranking based on the overall scores of their EV policy documents.

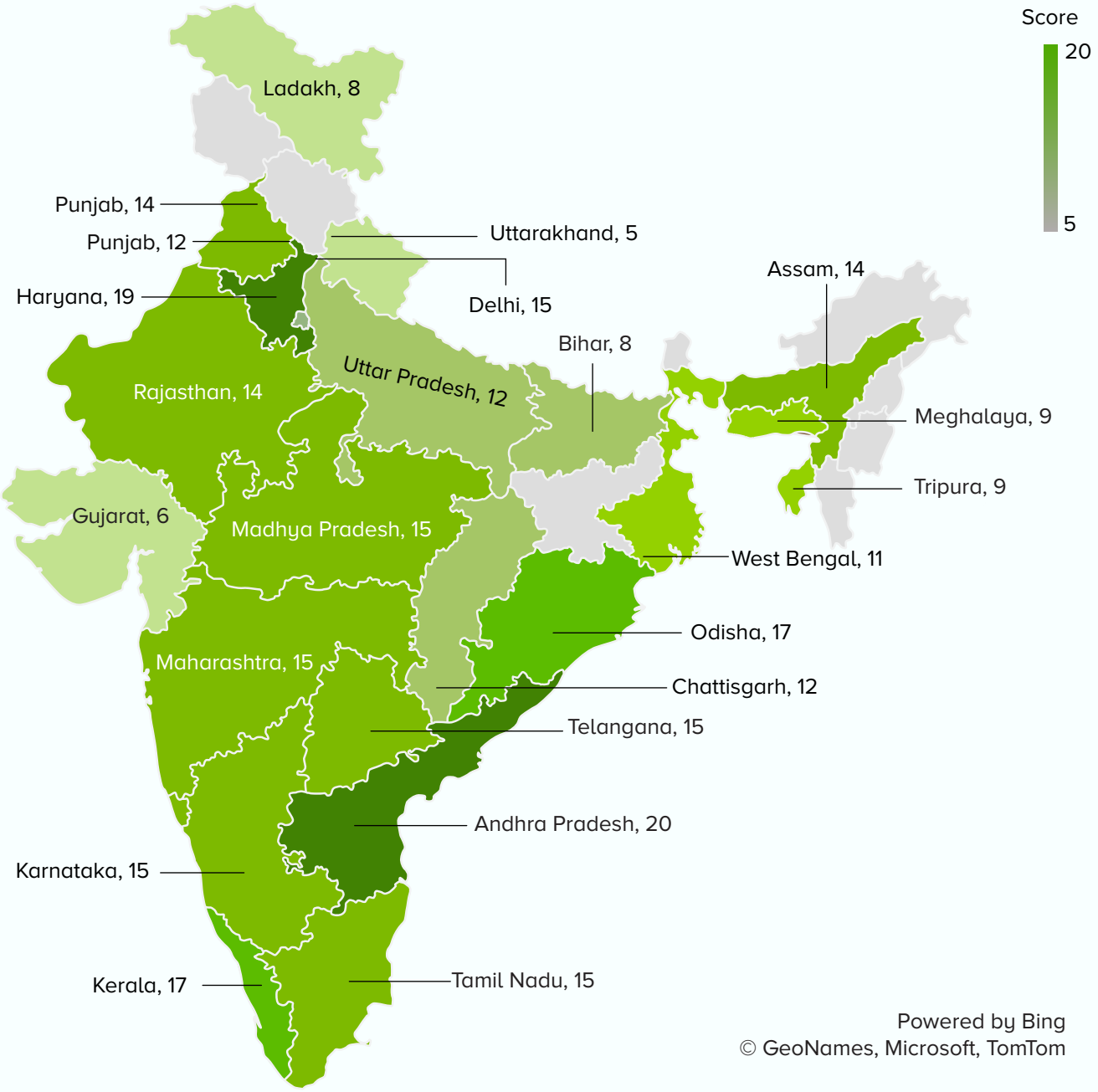


Figure 4: State EV policy scoring

The EV policies of low-scoring states have limited provisions related to scrappage policies, priority registration/free permits, toll fee waivers, integration & management of EV charging infrastructure networks, retrofitting, and battery warranty and buyback agreements. Furthermore, the policies also lack provisions for access to financing, green zones, land subsidies (charging infrastructure), and battery swapping incentives. Overall, the following critical policy gaps have been identified from the analysis of the state EV policies. The subsidy's timely disbursement would be a motivating factor for consumers. The states can also offer incentives to retrofit kit manufacturers to establish their businesses, bringing more players into the market, increasing the competition, and leading to better product quality and price. This will help convert the existing conventional fleet to electric more quickly.

2.3 Electric three-wheeler charging ecosystem

- The charging and battery swapping requirements for E3Ws depend on various parameters such as battery configuration (fixed or detachable) and their application (passenger or goods transport), which impacts their operating parameters, e.g. travel pattern, range required, load type, etc.
- E3Ws have fixed or detachable batteries that can be charged with onboard and portable chargers. However, onboard chargers are not commonly used in E3Ws; portable charging is more prevalent in this segment (AEEE 2020). Normal alternating current (AC) power charging is adequate for E3Ws, as they have small, low voltage batteries. Most of the E3W models on the Indian market are designed for slow charging (KPMG, 2020).

In addition, battery swapping has emerged as another option, particularly for use cases that require fast charging and less vehicle downtime. Battery swapping entails removing the discharged battery from the E3W and replacing it with a charged battery. This can reduce the vehicle's downtime. Furthermore, in the case of E3Ws, battery swapping can be done manually and is more cost-effective than for electric four-wheelers (E4Ws) or electric buses (AEEE 2020).

- Figure 5 presents the vehicle segment-wise charging requirements in India for FY2030. 7.66 lakh charging stations will be required for the E3W vehicle segment in 2030(JMK Research, 2022).

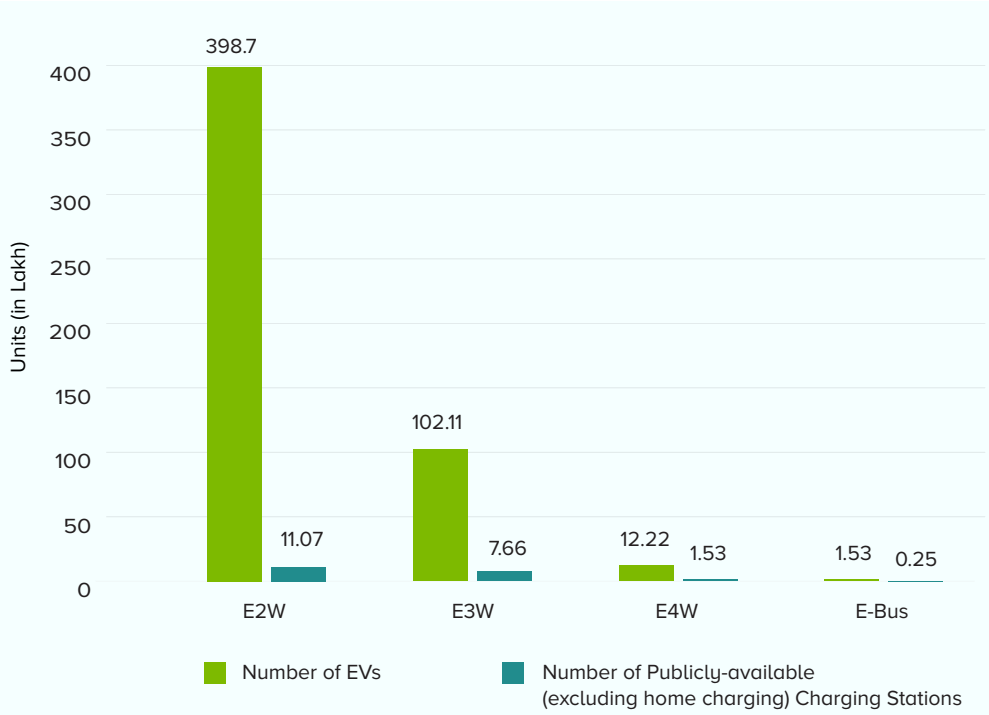


Figure 5: Public and semi-public charging station (excluding home charging) requirements in India (FY2030)

Source – (JMK Research & Analytics 2022)

2.4 Electric three-wheeler use cases

2.4.1 Role of electric three-wheelers in last-mile connectivity

The E3W industry is bracing for an intense race, with new players coming into play on the back of robust demand from last-mile connectivity segments. The E3W market, which includes the cargo and passenger segments, has seen significant growth, as logistics companies use e-autos for last-mile delivery. Another major driving factor is the fact that E3Ws' total operating cost per kilometre (km) is lower than that of conventional ICE autos. **Figure 6** shows the number of registered passengers E3Ws in India over the period 2013-2022.

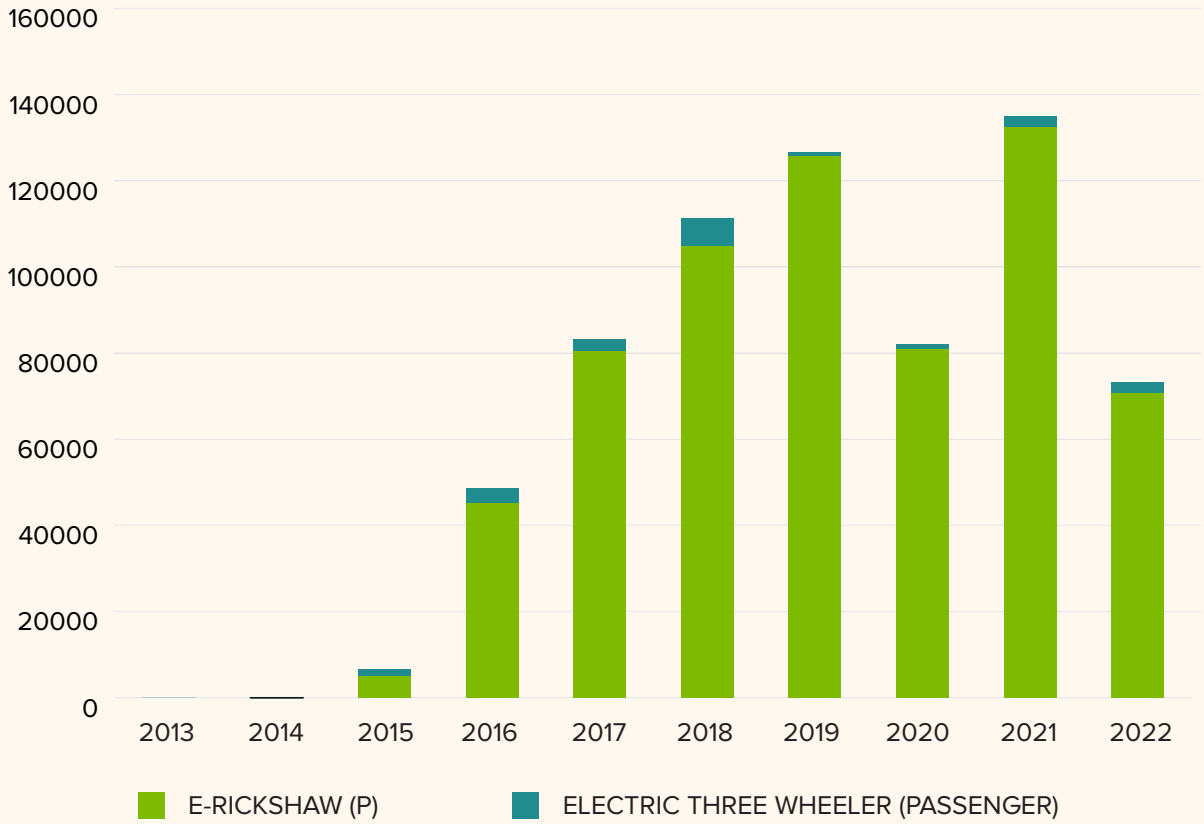


Figure 6: Passenger E3W registration in India (2013-2022)

Source: Vaahan Dashboard

Similar to the total number of registrations, as analysed above, the number of passenger vehicle registrations increased from 2016 to 2019 and then fell in 2020 due to the COVID-19 pandemic (VAHAN Dashboard, 2022). For every year following 2014, e-rickshaw registration has had a much greater share than E3W registration. (Rohira, 2022). The registration number peaked in 2021, followed by a fall in 2022 due to result of many reasons with a major of recent fires and safety concerns (*Electric Vehicles: EV Growth May Slow down as Safety Norms Are Tightened - The Economic Times*, 2022).

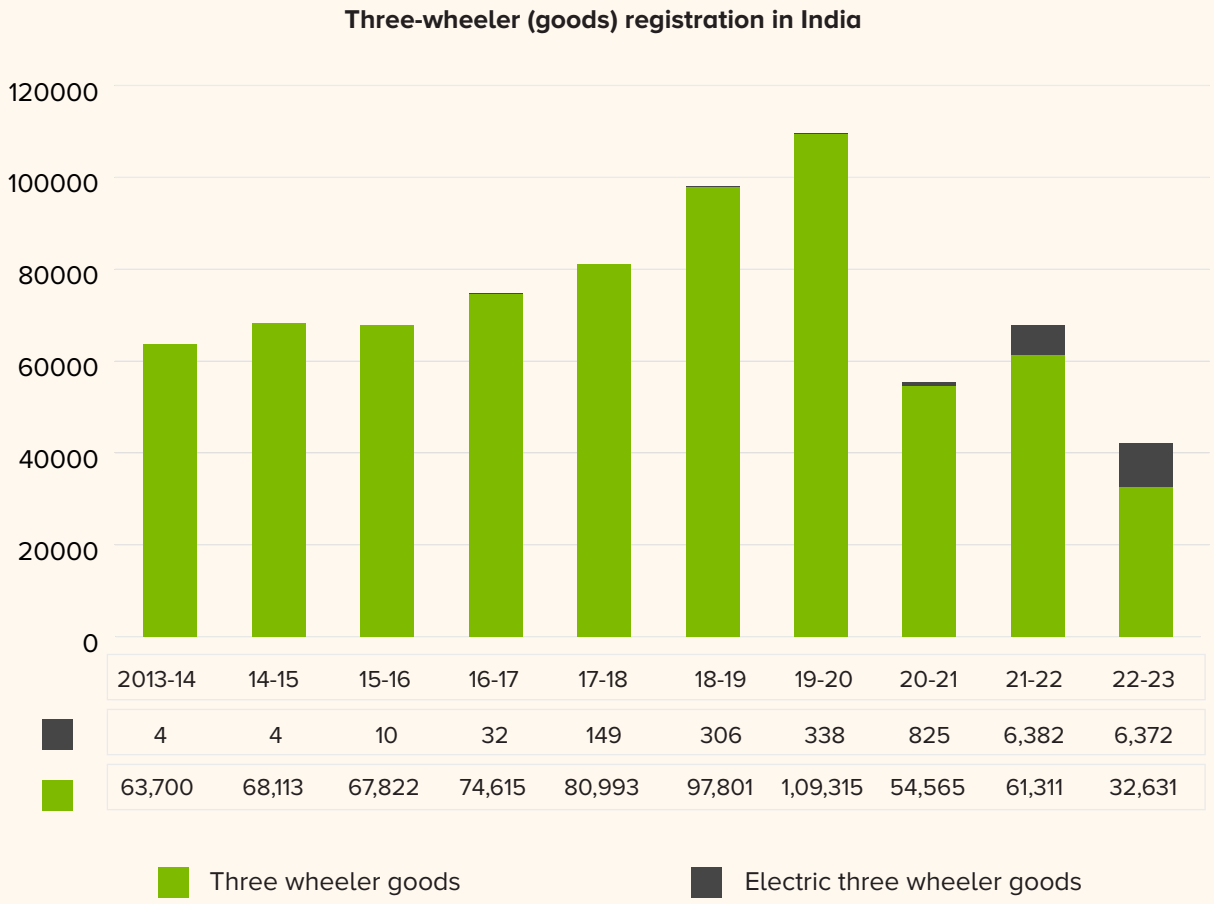


Figure 7: 3W (goods) and E3W (goods) registration in India

Source – Vahan Dashboard (MoRTH 2022)

As shown in ***Figure 7***, E3W goods vehicles have been increasingly used in the last three years for last-mile delivery due to their good feasibility for small loads and doorstep reach. The operational cost of an E3W is 50-60 paisa per km, much lower than the operating cost of the diesel 3Ws and small delivery four-wheelers (4Ws), at about Indian Rupee (INR) 3 and 7 per km, respectively. Therefore, a commercial E3W operates at approximately 16% of an ICE equivalent's running cost and approximately 10% of an ICE 4W. An additional feature of E3Ws that makes them suitable as delivery vehicles is the use of advanced telematics. This enables the delivery fleet operator to have a better overview of the operations in real time and prevent vehicle misuse, rash driving behaviour, and so on (Saran 2021).

Furthermore, the Convergence Energy Services Limited (CESL) tender for E3Ws included delivery vans for e-commerce players as one of the use cases for demand aggregation (*Electric Three Wheelers: CESL Floats Tender to Procure 1 Lakh Electric Three-Wheelers - The Economic Times*, 2021). This use case refers to on-demand delivery of goods by sellers or service providers in the hyper-local e-commerce market. The expression of interest (EOI) gives the following specifications for the delivery vehicle:

- The vehicle should be technically in compliance with the FAME II Guidelines.
- All vehicles offered should have Automotive Research Association of India (ARAI)/International Centre for Automotive Technology (ICAT) certification.
- OEM E3W chargers should be capable of charging in any mode (i.e. slow/fast) any number of times.
- All wiring within the vehicle interior, including boot space, shall be concealed properly.
- Charging ports/points should be on the exterior body of the three-wheeler with a designated flap.
- An easily accessible telematics gateway unit should be optional in the E3W.
- The charger as per ARAI standards should be supplied along with the vehicle at no additional cost.

2.4.2 E-autos as intermediate public transport

Intermediate public transport (IPT) plays many roles in providing its services and could benefit our current transport system, if well-organised. IPT comprises auto-rickshaws, shared autos, cycle rickshaws, and 4W passenger vehicles. These feeder services complement the existing transport systems and also act as an alternative when needed. In general, IPT provides the following services:

- First- and last-mile connectivity: IPT provides connectivity to passengers to and from the major public transport systems like buses, metros, railways, ferries, etc. by ensuring that all parts of the city have easy access to public transport stations.
- Door-to-door service: IPT offers on-demand door-to-door services to passengers, such as occasional trips to the airport or emergency trips for healthcare, meaning these passengers do not have to rely on private vehicles or public transport.
- Flexibility: IPT serves the mobility needs of the lower and middle classes and allows passengers to board and alight anywhere during the journey.

2.4.3 Applications in waste management and other urban utility vehicles

Diesel 3Ws, used extensively for point-to-point shuttle services in India, emit more toxic pollution and particulate matter than the majority of other vehicles on the road. Going electric helps 3Ws save money on their operating costs, from freight loaders to waste disposal vans. Compared to diesel and compressed natural gas (CNG) 3Ws, E3W fuel costs are significantly lower (TechSci Research, 2021). Examples of E3W applications in waste management and other urban utility vehicles are discussed in this section.

CESL floated a tender in July 2021 for the procurement of 1 lakh E3Ws. The tender aimed to empanel OEMs to supply E3Ws for different use cases to end-consumers on a pilot basis. The various use cases included the electrification of 3Ws used for the collection of municipal solid waste (MSW) by urban local bodies (ULBs) or private contractors deployed by local authorities for door-to-door garbage collection.

The EOI stated the vehicle should be technically in compliance with the FAME II Guidelines. All vehicles offered should have ARAI certification (CESL 2021) Table 3 presents the technical specifications of E3Ws for municipal solid waste collection.

Table 3: E3W MSW container specifications

Parameter	Unit of Measurement	Remarks
Volume requirement (e.g. 1 CuM/1.1CuM)	CuM	1.1-1.2 CuM
Capacity	kg	Min. 500
Automatic hydraulic tipper mechanism	Yes/No	Yes
Partition required for dry and wet waste	Yes/No	Yes
Partition split	Ratio	60:40
Partition required along length or width	Along length or width	Along length
Top cover required	Yes/No	Yes
Top cover type	Metal or soft tarpaulin	Metal
Tipping angle	Degrees	45 degrees
GPS tracking system	Yes/No	Yes

Source - (CESL 2021)

New & Renewable Energy Development Corporation of Andhra Pradesh Limited (NREDCAP), the state nodal agency for implementation of electric mobility in Andhra Pradesh, opened a bid in March 2022 for the supply and maintenance (for a period of 3 years) of seven electric waste collection autos in NP Kunta (NREDCAP, 2022). The bid document specified the following requirements for the E3W waste collection autos:

- Comply with the applicable standards and specifications of ARAI/ICAT/CIRT and CMVR.
- The battery must be 80 ampere-hours (Ah)/48 volt (V) capacity and above.
- Gross vehicle weight is minimum 750 kg and above.
- Load carrying capacity is 300-350 kg.
- Range per full charge shall be 80 km.
- Wireless mike set of reputed brand.
- Separate bins for wet and dry waste.
- Hydraulic lifting facility with button type.
- Charger to charge the vehicle as per the standards and specifications of Ministry of Power (MoP)/ electricity distribution companies (DISCOMs)/ARAI.

The following requirements were also included in the bid:

- The successful bidder shall impart training to the auto drivers after delivering the vehicles to NP Kunta on driving and operation and maintenance of electric autos and generate awareness about the benefits and charging of e-autos.
- The e-auto batteries shall be insured for a minimum period of 3 years, covering all risks.
- All relevant documents and related certificates for vehicle registration shall be provided and vehicle registration arranged with the road transport authority.
- The user manual and warranty/guarantee cards shall be provided.

2.5 Battery swapping ecosystem for electric three-wheelers

An alternative battery recharging method that is receiving global attention is battery swapping. A depleted EV battery is removed from the vehicle and replaced with a fully charged one. The technology is being tested in various EV segments, including electric two-wheelers, E3Ws, E4Ws, and even e-buses. The use of battery

swapping stations (BSS) instead of traditional charging stations can mitigate the disadvantages of conductive charging, such as longer charging time and battery degradation. Furthermore, EV adoption is hindered by the high cost of ownership. By taking the battery out of the equation, the cost can be reduced. A third party can own the battery and be liable for replacing the drained batteries with fresh, charged, standardised ones.

The Indian government has shared a draft battery swapping policy and soon it will release the final draft of the policy (*India's Proposed Battery Swap Scheme* | *IBEF*, 2022). The policy will initially focus on battery swapping services for electric scooters, motorcycles, and auto-rickshaws in a boost for sectors like last-mile delivery and ridesharing. The government is likely to offer EV owners an incentive of up to 20% of the total subscription or lease cost of the battery, in addition to what they already get for buying EVs (*Electric Vehicle: Govt to Soon Announce Incentives under New Battery Swap Scheme* | *Mint*, 2023). The policy, announced by finance minister Nirmala Sitharaman in her budget, will focus on creating a comprehensive framework, including regulatory, operational, and technical elements, on incentivising battery swapping. NITI Aayog is expected to work with the Bureau of Indian Standards (BIS) and the Department of Science and Technology (DST) to develop technical standards for batteries, including interoperability. The policy is likely to outline range requirements, safety standards, performance assessment, and battery life.

Battery swapping stations act as a battery aggregator and are established enough to participate in power and reserve markets. BSS can maximise their profits by providing services to the system, such as voltage support, regulation reserves, and energy arbitrage. In India, battery swapping with a leasing/pay-per-use model has the potential to significantly lower the EV acquisition cost. Swapping may prove beneficial to fleet operators, low-speed EVs (e.g. taxi aggregators, e-autos, e-rickshaws, etc.), and buses with intercity point-to-point travel (<30 km per trip, 8-10 trips per day) (Parag Diwan, 2018). A well-established network of smart swappable batteries could be instrumental in the rapid adoption of EVs for public transport. However, the battery swapping model has not fully succeeded globally due to its techno-commercial dynamics. The main issues with the model are standardisation, commercial viability, and reliability.

Conductive charging faces several issues that may negatively influence potential EV buyers, as summarised in Figure 8.

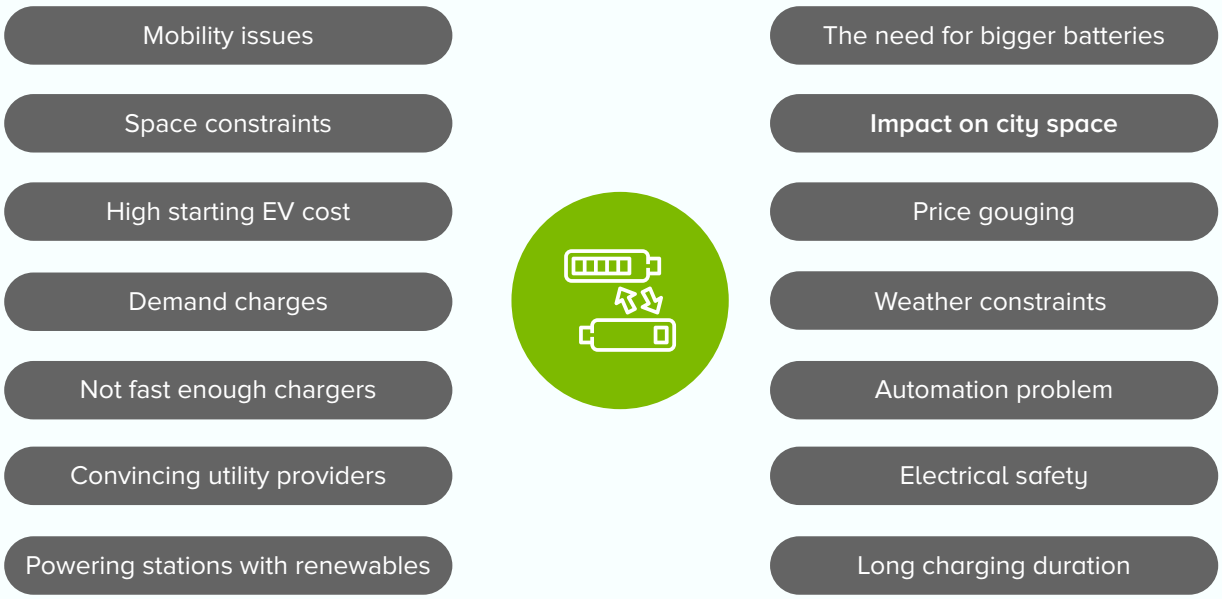


Figure 8: Conductive charging issues

BSS effectively supply power to EVs while cutting down waiting times. Considering these stations could act as a link between EV owners and power systems, they can provide huge benefits to power systems. The various benefits of battery swapping over conductive and wireless charging include:

- Batteries can be charged away from swapping points, allowing more freedom in setting up swapping points.
- Reduction in the upfront EV cost, as the battery ownership cost is replaced by battery leasing
- Increased predictability of battery life due to controlled charging conditions
- Charging of batteries can be postponed to night or off-peak hours.
- By controlling the battery charging and discharging time, the potential peak demand or overloading caused by increasing EV penetration can be flattened.
- Allows longer trip distances for the owners thanks to fast battery swapping
- Decreases the cost of upgrading a household to high power chargers.

To fully exploit the potential of BSS, EV batteries should be easily replaceable and accessible to everyone. To ensure this, consistent standardisation of EV batteries is needed. Therefore, the best EV model is one where the owner leases batteries from the company. In such a model, the EV price is drastically reduced, as the battery cost is deducted from the total vehicle cost.

Battery swapping challenges in India

There are numerous advantages of battery swapping over traditional conductive and inductive charging; however, the model's implementation is complicated in the Indian context. To make battery swapping work in a diverse range of scenarios, a strong government mandate and subsidy is required. Significant barriers to successful large-scale implementation of battery swapping in India include:

- Standardisation of EV lithium-ion battery packs – This has not yet happened globally, and the probability of this happening in India is questionable, as most auto OEMs prefer to control their design strategies for battery packs as part of their core technology.
- Inadequate battery pack design to enable ease of swapping (weight, dimensions, and ergonomics) – Apart from being standardised, battery pack design should also enable easy swapping. Making different battery specifications and chargers compatible with each other is crucial to scaling up the swapping infrastructure.
- Greater number of batteries needed to power the same number of EVs
- The shorter commercial life of battery packs due to customer preference for new batteries with higher range – With rapid technological advancements in battery engineering, with every upgrade, the existing battery pack will become redundant, as customers will prefer to lease higher-range batteries.
- Higher costs of battery leasing over the life of the EV
- Higher goods and services tax (GST) on separate battery (18%) vs. battery sold with EV (5%) – There is a need to extend FAME II subsidies to battery swapping operators and also bring the GST rate on swapping services (18%) down to compete with EVs with plug-in charging models (5%).
- Lack of financing and incentives to set up BSS - Banks are reluctant to provide loans for this activity, as they are unsure about the new technology and the resale value of batteries in the event of default. The cost of setting up BSS can also vary depending on the total capacity of batteries, swapping station location, and complexity of the replacement process.

- Difficult interoperability, as major car companies do not share the technology around batteries (or any technology) - There are very few products in the automobile that are consistent across brands. The cigarette lighter power supply (plug for global positioning system (GPS)) and the valve stem for tires are the only components that can be mixed and matched across brands. Getting all car companies to voluntarily use the same battery design and technology would have to be government-mandated.
- Opportunity cost of battery packs and limited supply of lithium and cobalt sitting in gas stations across the country
- Reliability of leased/rented battery packs – In an attempt to maximise profitability, if battery providers short-change the customer, therefore causing a potential breach, this could lead to a serious disaster in the swapping business and create a larger controversy around battery swapping.

At present, battery swapping is considered a feasible solution for commercial EV fleets, especially in the electric 2W and E3W segments. The Ministry of Road Transport and Highways (MoRTH) has allowed the sale and registration of EVs without batteries, giving a huge boost to battery swapping solutions. Furthermore, industry stakeholders are making large investments in developing the battery swapping ecosystem. This indicates that battery swapping will emerge as a distinct part of EV charging networks in India in the coming years.

Separate projects have been initiated for battery swapping standards for light electric vehicles (LEVs) and buses. There will be two series of standards documents, covering the form factor of the battery pack, interoperable connection systems, communication between the battery management system (BMS) and the EV and charging station, and network management. Any EV may utilise a battery pack conforming to these standards. The removable battery packs can be charged using AC or DC charging systems. The BIS is yet to develop Indian standards for EV roaming and grid-related management functions.

Under the MoP's direction, states have nominated state nodal agencies (SNAs) to govern the implementation of public charging. SNAs are mandated to select implementing agencies to install, operate, and maintain public charging stations and battery swapping/charging facilities in the state. Unless otherwise specified by the state, state DISCOMs are the SNAs by default.

03 Insights from consumer survey - Analysis of consumer perceptions

This section presents the findings from the consumer survey conducted by ICA and PricewaterhouseCoopers (PwC) India. The study was carried out in three cities—Delhi, Lucknow, and Bangalore—and captured the perspectives of stakeholders involved in the entire E3W ecosystem – consumers, fleet operators, financial institutions, dealerships, and service centres. The driver survey was broadly divided into three vehicle segments—e-rickshaw, e-auto, and ICE 3W—across the three cities, and each of the vehicle types was further divided into goods and passenger vehicles.

3.1 Driver experience with e-rickshaws

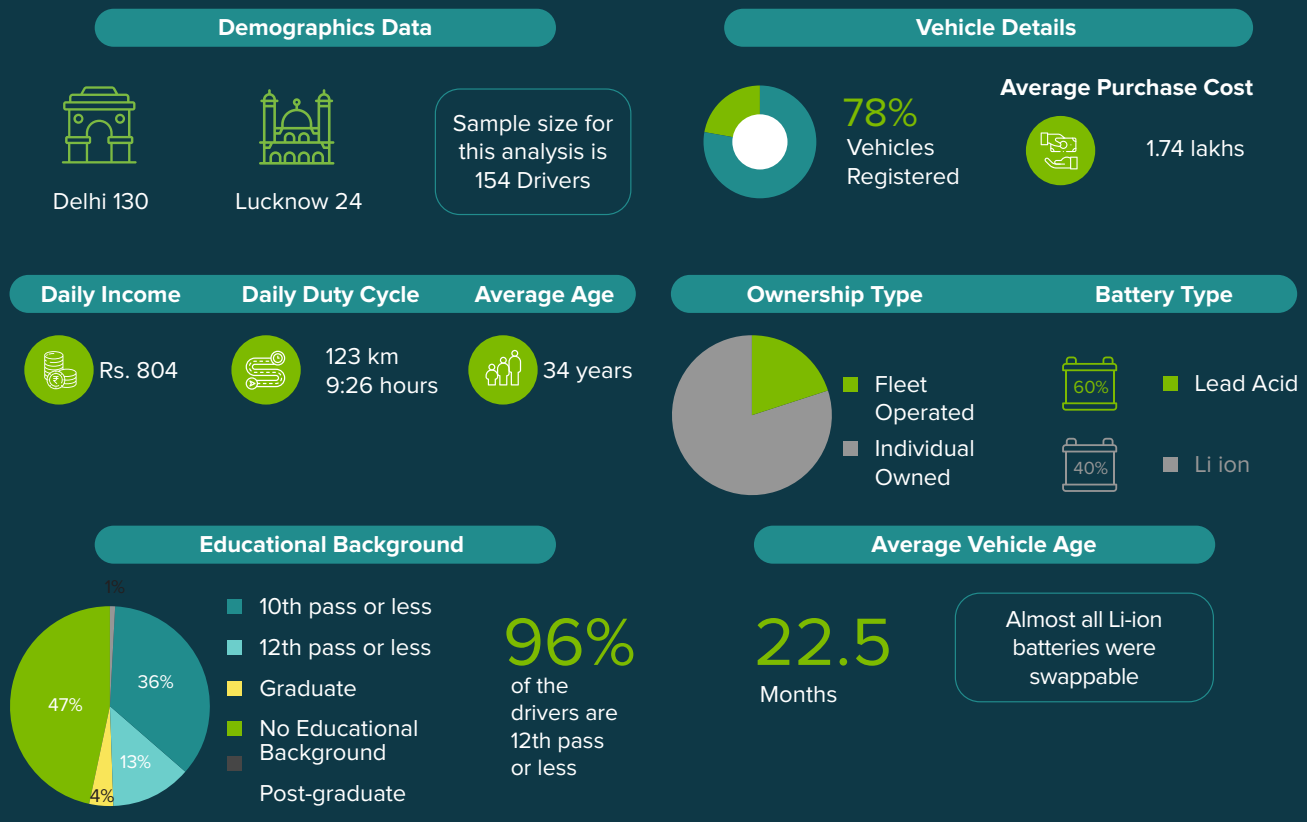


Figure 9: Surveyed e-rickshaw owner demographic profile and vehicle data

The e-rickshaw driver experience survey was conducted in the cities of Delhi and Lucknow. Around 154 drivers participated in the survey. Eighty percent of the e-rickshaws were owned by individuals, with the remainder operated through fleet owners. An e-rickshaw can be purchased at an average cost of 1.74 lakhs, and most of the e-rickshaws on the road were over two years old. They covered an average of 123 km as their duty cycle over 9 hours daily, through which they earned an average amount of Rs. 804 per day. 96% of the drivers who participated in the survey had completed their secondary education or had a lower level of education. 78% of the surveyed e-rickshaws were registered. The battery type most preferred by the respondents was lead-acid batteries (60%); the rest of the rickshaws had lithium-ion (Li-ion) batteries that could be swapped as per the requirement.

Experience with the purchase of e-rickshaws: Almost **three-fourths** of the total surveyed drivers purchased an e-rickshaw primarily because of the lower upfront vehicle cost, with cost effectiveness being the second most common reason.

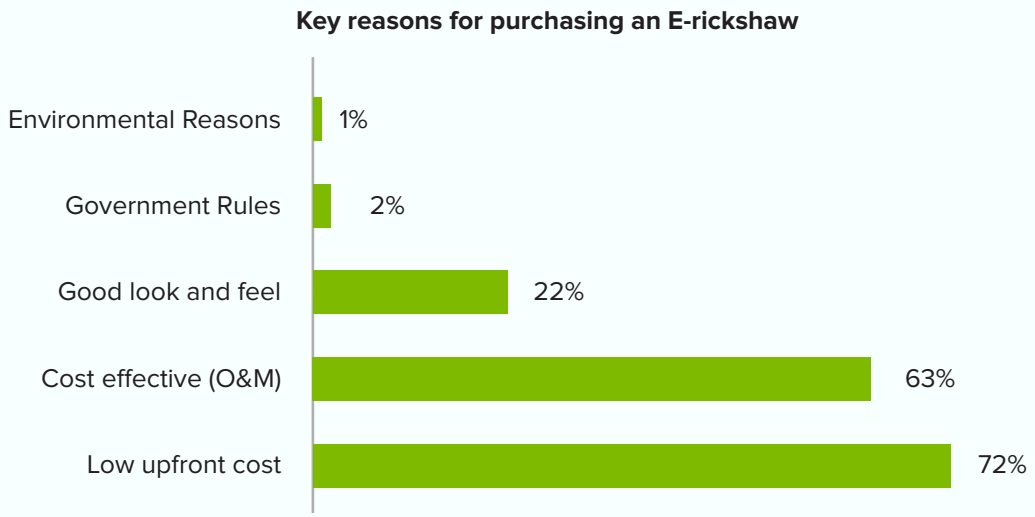


Figure 10: Key reasons for purchasing an e-rickshaw

A total of **63%** of the respondents cited low operations and maintenance cost as the primary reason for buying an e-rickshaw. Very few respondents mentioned the unique e-rickshaw design or relevant government policies. Similarly, environmental concerns did not matter much to the respondents.

Experience with the charging infrastructure: The most preferred battery type was lead-acid batteries when it comes to fixed battery type. Fixed batteries gave them the benefits of low upfront cost and greater ease of handling. Removable Li-ion batteries were preferred by 91% of drivers over removable lead-acid batteries. Around 80% of respondents preferred removable batteries, as they helped them save time required for battery charging. This saved time was used to increase their earnings by completing more trips. The only reason respondents preferred a fixed battery, whether lead-acid or Li-ion, was its affordability and the convenience of handling it at home all by themselves.

Figure 11: Removable vs. fixed lead-acid & Li-ion batteries

The average amount of time it took for captive charging was 5.23 hours, and domestic charging took 7.5 hours. For drivers who park in captive spaces, there was an average monthly parking fee of around Rs. 1,000 per e-rickshaw. Specifically, in the Delhi context, average non-peak swap time was 7 minutes, and peak swap time was 67 minutes, due to high demand and insufficient battery availability. In other words, there is a 60-minute difference between the average session swap times during peak and off-peak hours. Moreover, swapping has the highest average fuel cost, followed by captive charging and then domestic charging.

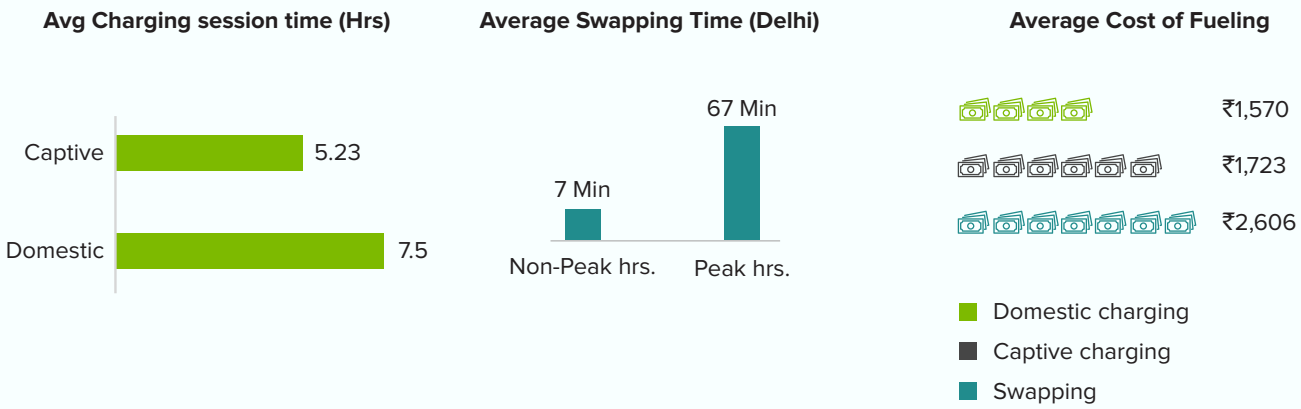


Figure 12: Battery swapping & charging preferences

When it comes to charging preferences, there is nearly a 50-50 split for full charging versus top-up charging in the lead-acid captive charging segment. In contrast, in domestic charging, 86% prefer full charging, and the rest prefer top-up charging. On average, starting state of charge (SOC) for batteries is around 25%, and ending SOC is around 80 percent. E-rickshaw drivers in Delhi and Lucknow expressed an average satisfaction index of 3.57 out of 5 with the charging and swapping infrastructure in their respective localities.

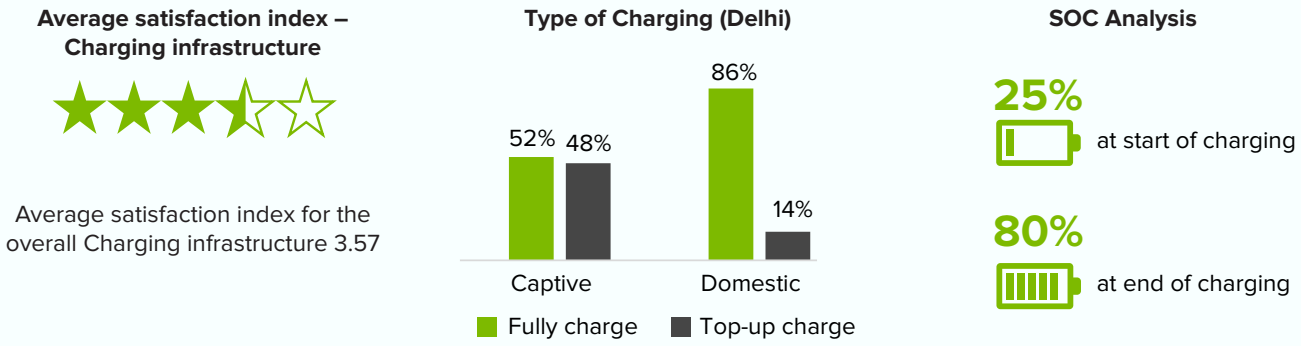


Figure 13: Charging infrastructure data

Experience with e-rickshaw performance: e-rickshaw drivers expressed an average satisfaction index of 3.57 with the performance of their e-rickshaws. The difference in terms of km between the committed and actual range for Li-ion batteries is 5.2%, while for lead-acid, it is 14.4 percent. Hence, it can be concluded that the difference between the committed and actual range in lead-acid batteries is greater than that of Li-ion batteries.

The average warranty period for the e-rickshaw motor, controller, and battery is **1 year**, and the servicing time reported for e-rickshaws was **2 hrs.16 min.**

According to the survey, the average annual servicing cost for e-rickshaws is approximately Rs. 5,000. Unfortunately, there are no authorised service centres available for e-rickshaws near the drivers' areas of operation. Hence, they have to rely on local shops for repairs.

Experience with resale and finance: Drivers had an average satisfaction index of 3.7 for the whole financing process. The average down payment was 14.74%, and they received a return on investment of 18 percent. The average resale value was Rs. 61,166, which was primarily dependent on the e-rickshaw battery's condition.

Experience with safety: Delhi and Lucknow e-rickshaw drivers gave a 3.8 rating for security satisfaction index. Safety features in e-rickshaws included fire extinguishers, system activation warning, SOS button, and battery overheat warning. E-rickshaw drivers near Jamia Millia Islamia (JMI) expressed their concerns regarding the safety of Li-ion batteries, citing the recent JMI metro fire accident at ETO Motors's charging hub. 68% of respondents stated that they received no security briefing at the time of purchase or thereafter. 26% claimed that there were no safety features, and 55% of drivers were unaware of safety features.

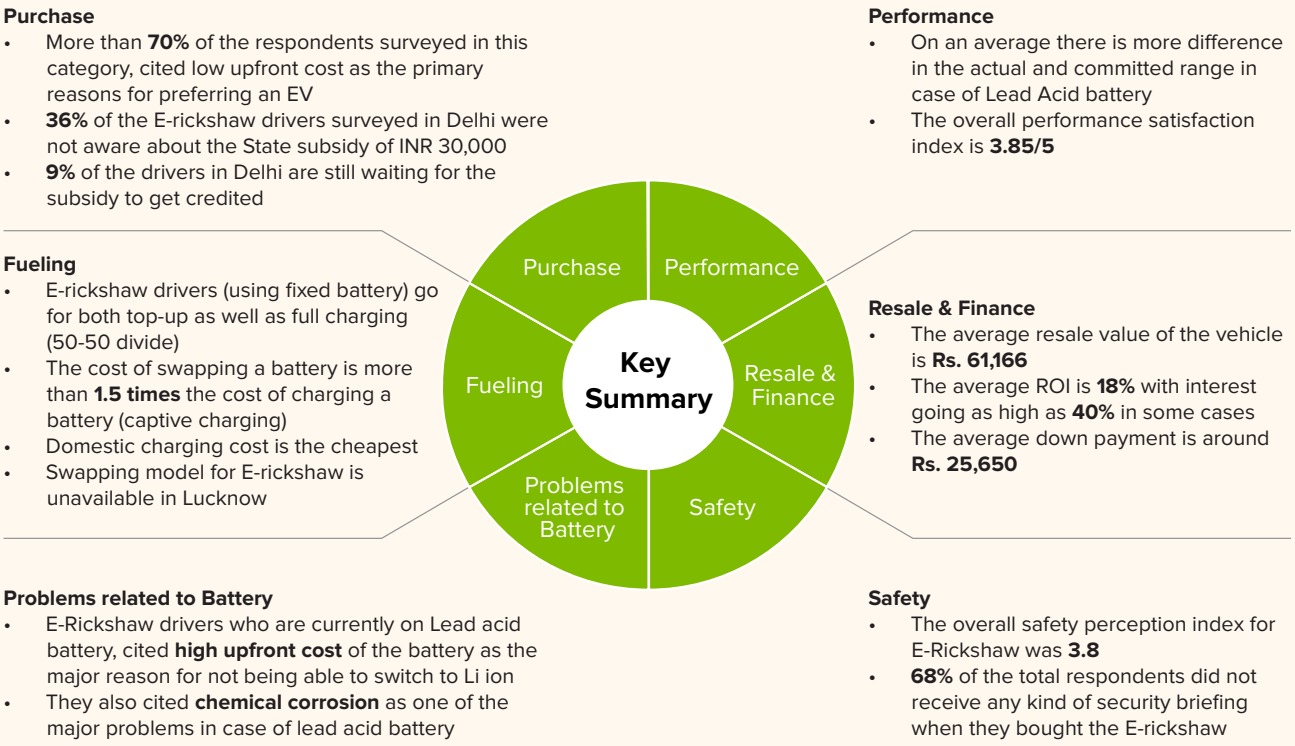


Figure 14: Key e-rickshaw survey findings

3.2 Driver experience with e-autos

A driver experience survey was conducted on goods and passenger e-autos in the cities of Delhi, Lucknow, and Bangalore. Approximately 142 drivers participated in the survey. The e-auto passenger segment had 63% individual ownership, with the remainder operated by fleet owners. In contrast, 94% of the e-auto goods segment is operated by fleet owners. A passenger e-auto costs Rs. 3.94 lakhs, whereas a goods e-auto costs 3.01 lakhs. Daily, they covered an average of 108 km as their duty cycle over 8 hours, through which they earned an average amount of Rs. 841 per day. 91% of the drivers who participated in the survey had completed their secondary education or had a lower level of education.

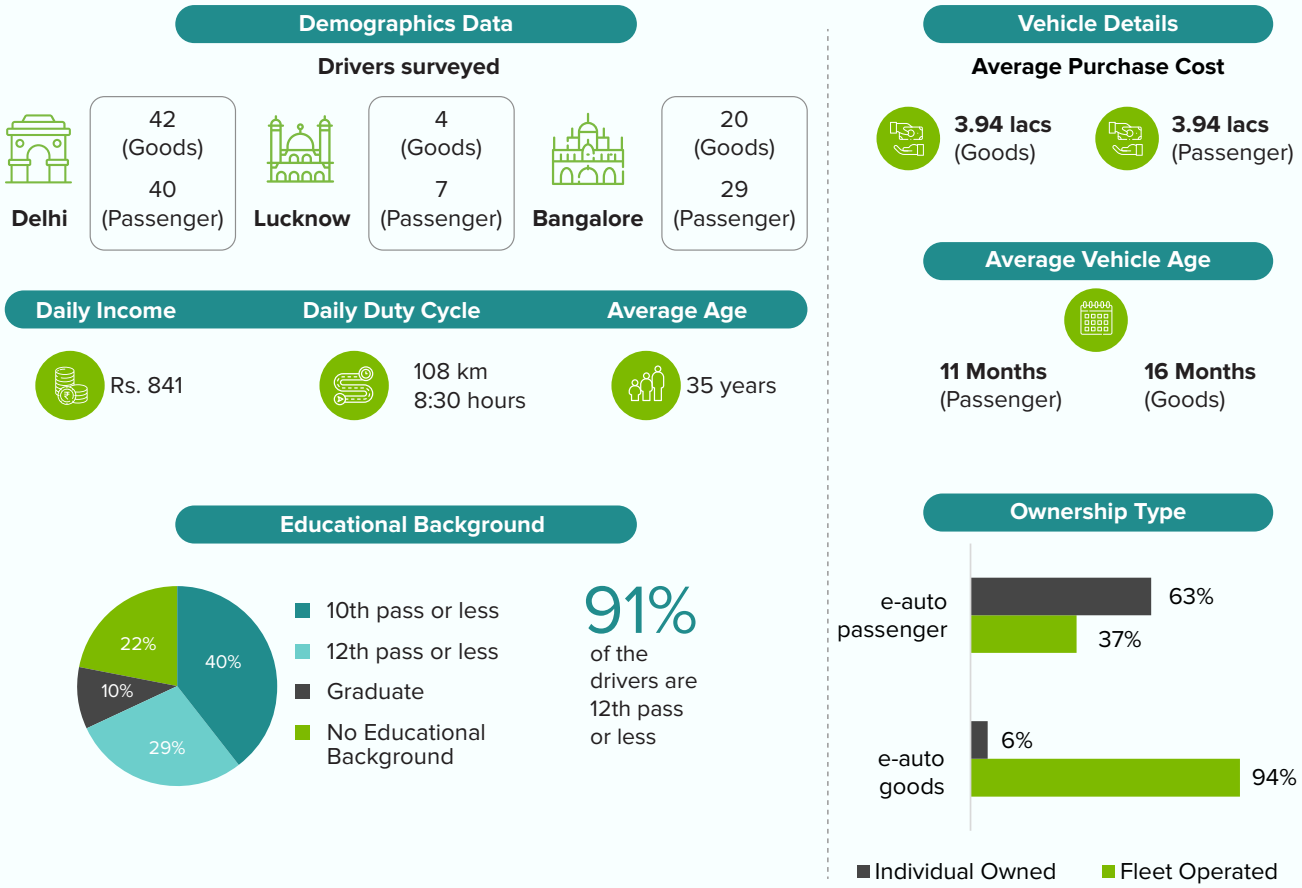


Figure 15: Surveyed e-auto driver demographic profile and vehicle data

Perception and challenges of e-auto drivers: There is a general lack of awareness about the availability of e-autos, as e-auto dealers are limited in number. Drivers who are aware about e-autos found the build quality to be comparatively poorer than that of ICE 3Ws. A few drivers have opted for retrofitting, out of which 13% stated that the available retrofitting kits are not dependable. 79% of the respondents think that new E3Ws are more robust than retrofitted ones. Regarding swappable batteries, the drivers believe that e-autos have lower ranges with them.

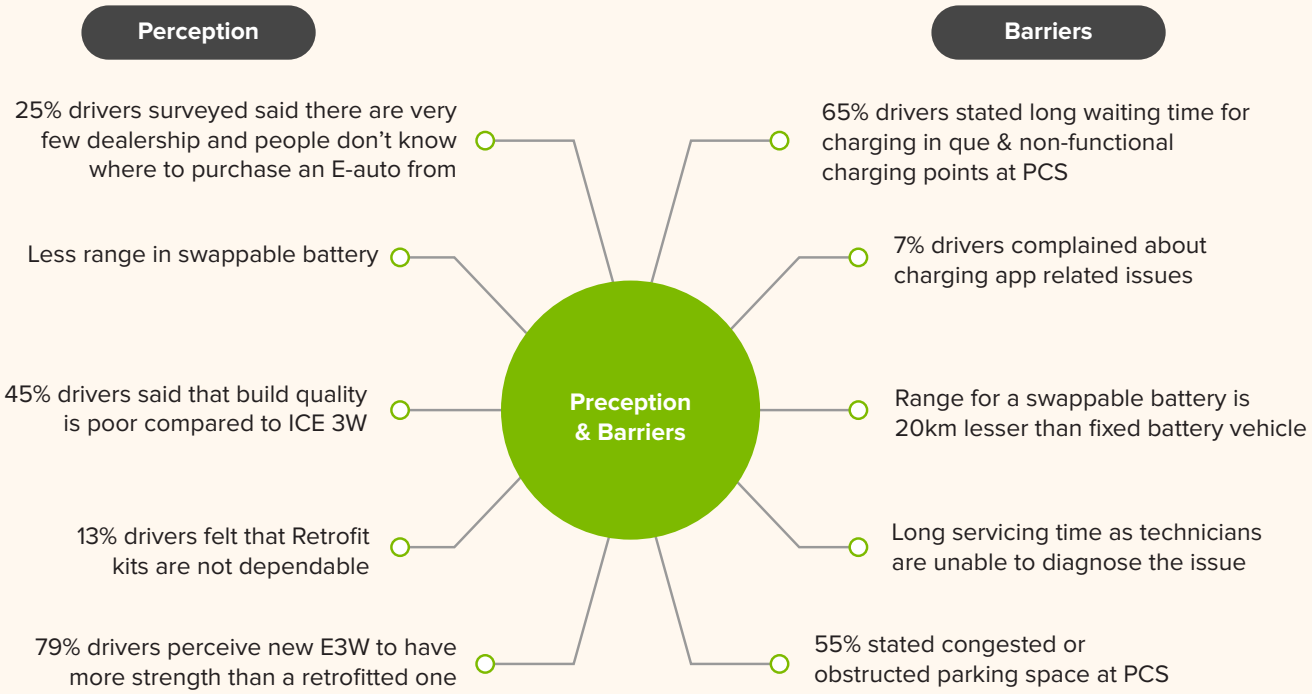
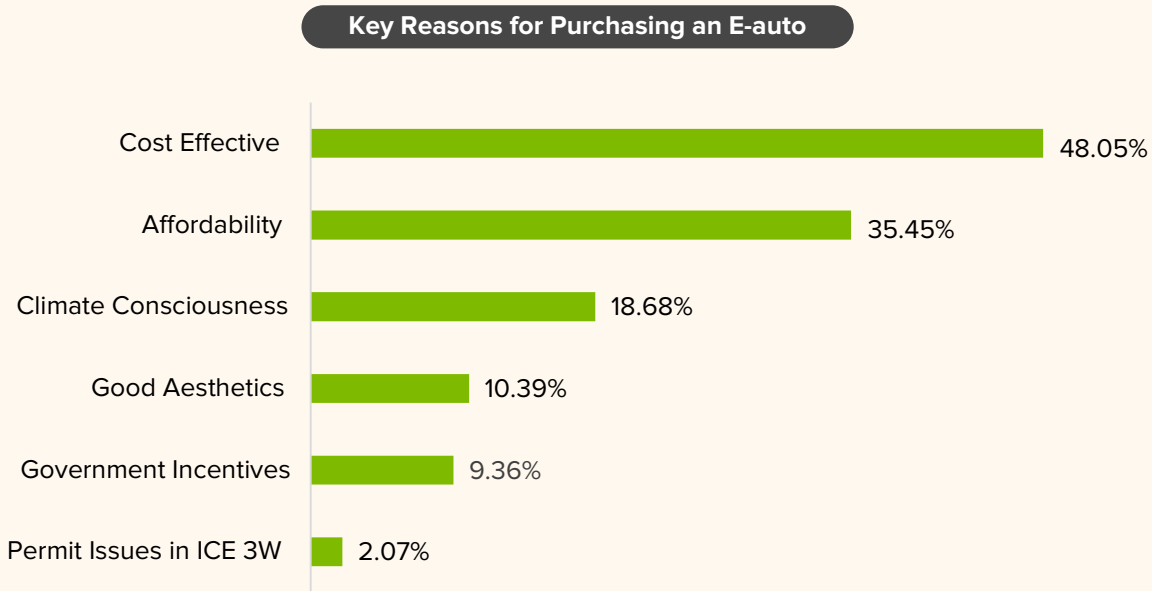


Figure 16: Perception and barriers (e-autos)

Experience with e-auto purchase: Cost effectiveness and affordability are the top reasons for purchasing an e-auto over the popular ICE 3W. Around **21%** of the drivers faced issues when purchasing an e-auto in terms of the limited number of the dealerships, but the registration process was smooth for the majority of buyers, as dealerships took initiative in handling the process. However, there is a serious delay in getting e-autos registered.



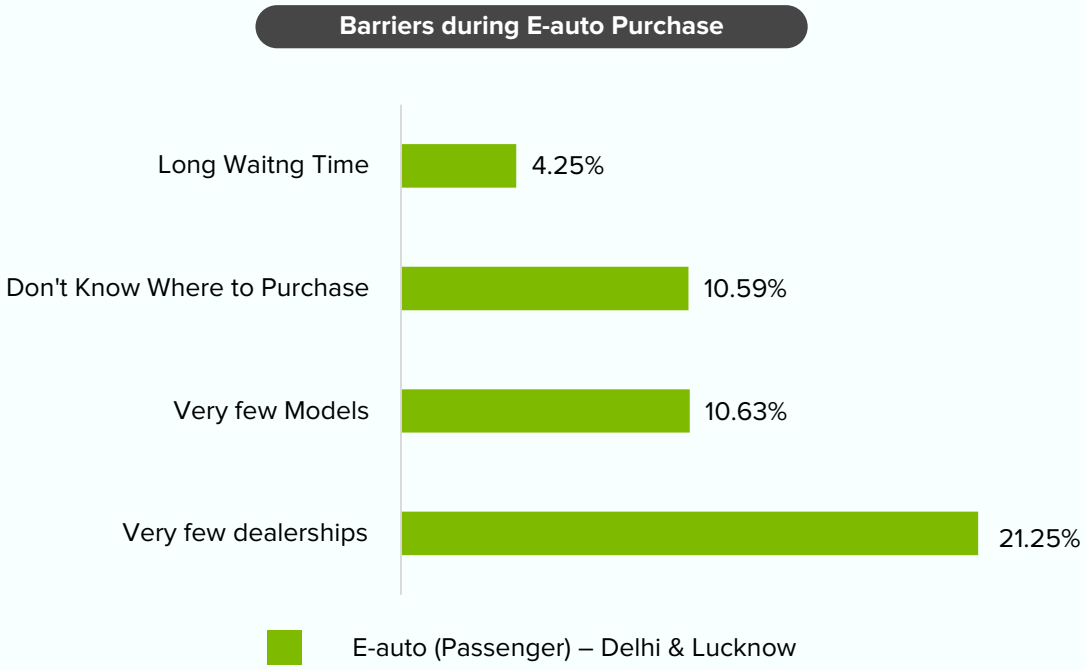


Figure 17: Key reasons for & barriers to purchasing e-autos

In Delhi, there is an INR 30,000 state subsidy available for purchasing a new E3W. It takes an average of **61 days** for the disbursement of the subsidy after applying. Drivers apply for the subsidy at the time of purchase at the dealership centres, and the amount directly gets credited to the driver's bank account later.

Figure 18: Percentage of buyers who claimed subsidy

Experience with charging infrastructure: Most of the goods e-auto drivers surveyed charged their vehicle at the captive charging stations installed in the fleet parking lot by the fleet owners. ***Passenger e-auto drivers (34%) complained about long queues, and over 13% highlighted the issue of non-functional charging points when asked about charging stations near their area of operation. On average, e-auto drivers need to cover around 5 extra km to find a charging/swapping station.***

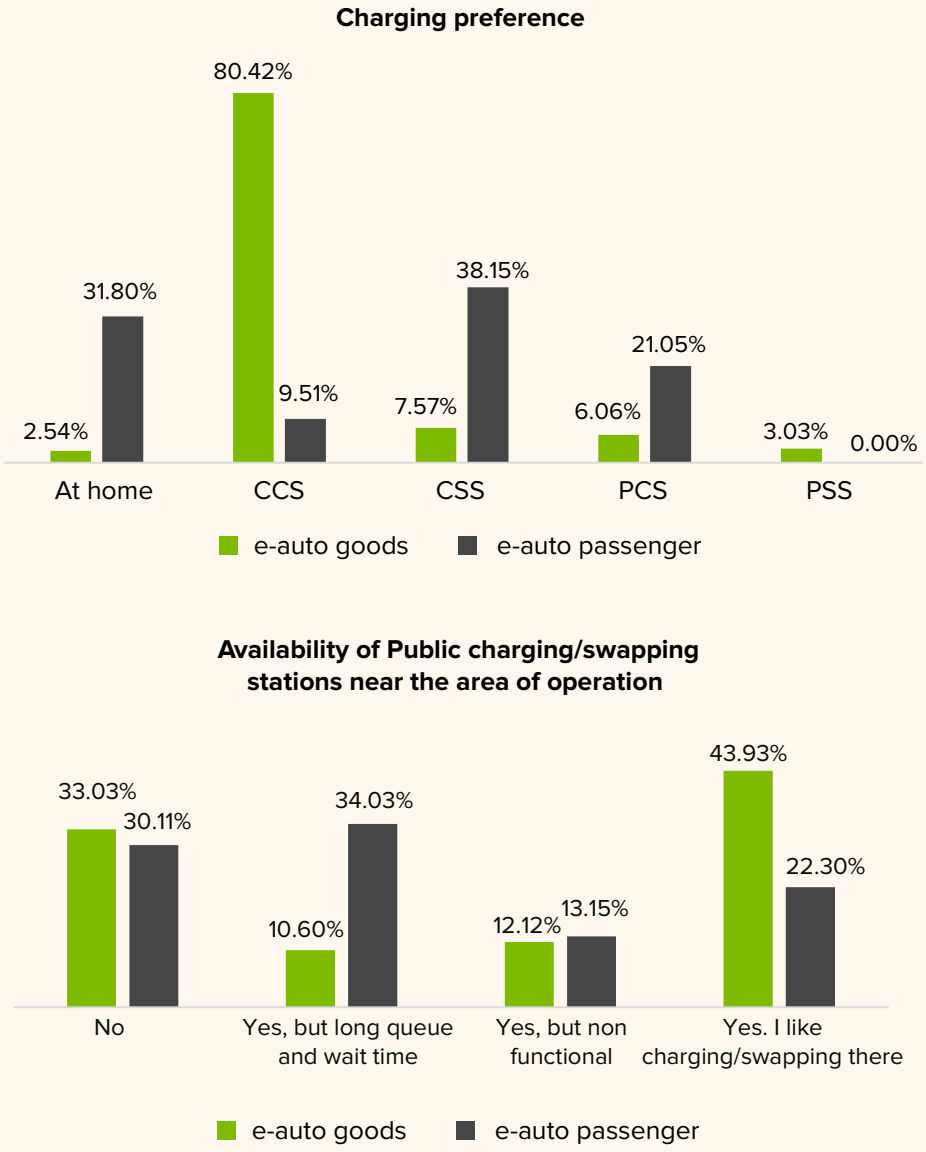


Figure 19: E-auto drivers' charging preferences

The majority of the goods e-auto drivers charged their vehicle batteries through slow charging. Passenger e-auto drivers preferred fast charging, but lack of adequate infrastructure at public charging stations (PCS) is a major concern. The average charging time required at PCS is 4.1 hours, which has a negative impact on the number of passenger trips and, ultimately, the drivers' earnings.

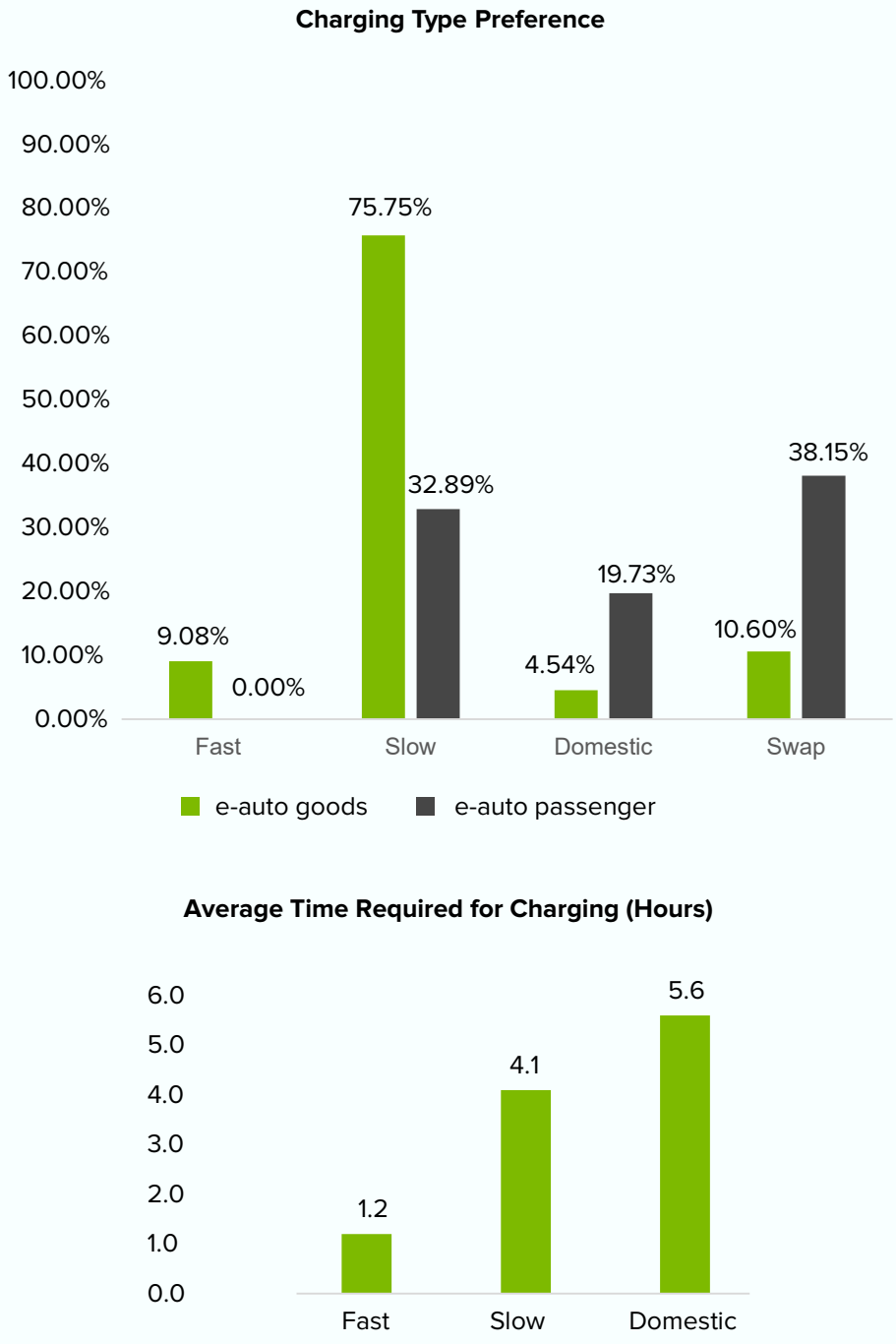


Figure 20: E-auto drivers' charging type preferences

Almost three-fourths of cargo drivers and half of passenger drivers surveyed prefer fixed batteries in their vehicle. 62% of the drivers surveyed stated the benefit of better range coverage as their reason for this preference.

The rest of the drivers, who preferred removable batteries, cited less time for refueling as the major reason for their preference, followed by higher earnings due to time saved in charging.

Figure 21: Reasons for battery type preferences

The above analysis is only for Delhi, as in Lucknow and Bangalore, the surveyed drivers do not use PCS. In general, the drivers surveyed were dissatisfied with their experience at PCS. 65% of the respondents stated long waiting time and non-functional chargers as the major issues. 55% of the drivers stated poor parking facilities or obstructed parking spaces (by other vehicles) at the PCS as problems.

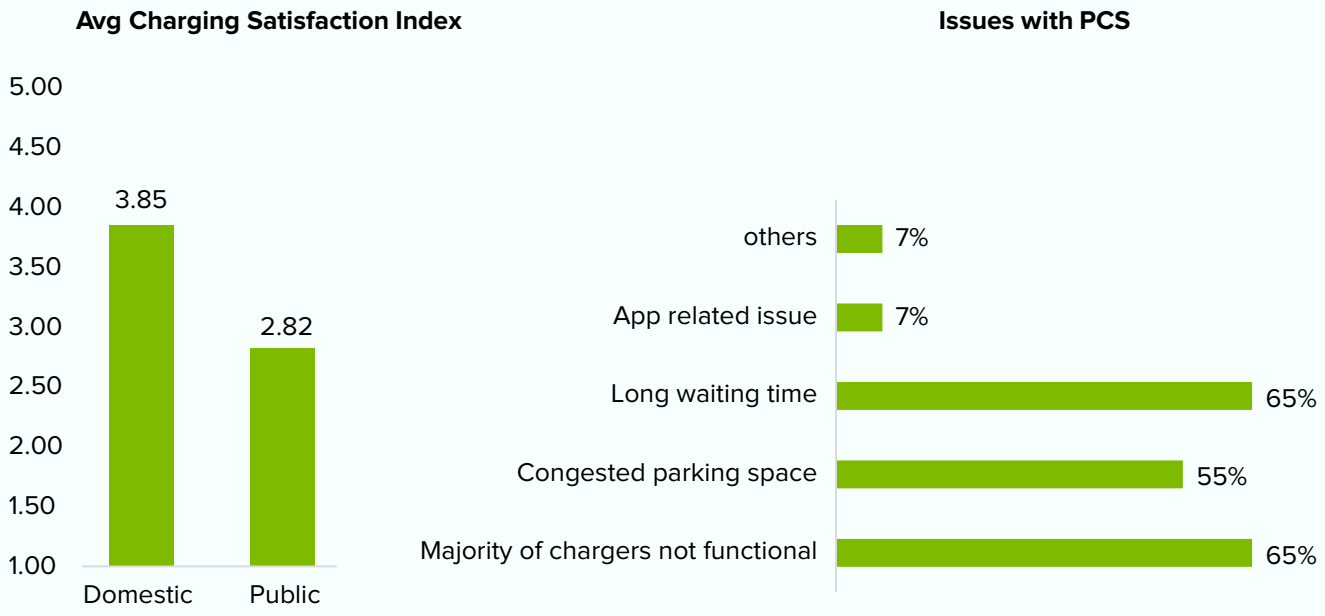


Figure 22: Satisfaction level and issues with PCS

Experience with e-auto performance: In the case of electric cargo vehicles, the difference between the actual and promised range is greater due to the linear decrease in range caused by the weight of the cargo. Some of the drivers surveyed in the passenger vehicle survey used removable batteries, reducing the average actual range. The average actual range for a removable battery is only 67 km, compared to 88 km for a fixed battery.

For both categories of e-autos combined, the average satisfaction level with authorised service centres was 3.60. The major issue affecting the quality of service was lack of expert technicians in service centres and the inability to identify the relevant issue.

Experience with finance and insurance: There is a lack of awareness on financing and insurance among e-auto drivers in Lucknow and Bangalore, and, hence, only drivers in Delhi were surveyed in detail on this topic. 80% of the passenger driver respondents largely financed their e-autos through private financing players. The average insurance premium for e-autos is on higher side – about Rs. 7924 on average. As stated by insurance companies, repairing or replacing batteries is costly, which is one reason the insurance premiums are higher.

Experience with e-auto safety: The average satisfaction index for e-auto safety and security was 4.04. 52% of respondents reported that they received no safety and security briefing when they bought their e-rickshaw or thereafter. Only 37% of the respondents had fire extinguishers in their e-autos, although it is mandatory to carry one.

Perception regarding e-auto retrofitting: A new e-auto is preferred by 65% of respondents over one that has been modified. The novelty factor and power of a new vehicle were the primary reasons for this preference.

The ones who preferred a retrofitted e-auto stated low upfront cost as the reason.

Purchase

- **58%** of passenger drivers, cited low operation cost and no permit fees as the reasons for preferring an EV
- **10%** of the passenger drivers surveyed were not aware about the State subsidy in Delhi
- **23%** of the passenger drivers are still waiting for the subsidy to get credited

Performance

- On average there is more difference in the actual and committed range in case of goods e-autos than in passenger ones with range being **86km** and **77km** respectively
- The overall performance satisfaction index is 4/5

Fueling

- Majority of the drivers surveyed had fixed battery type and also prefer fixed battery
- In Bangalore, Passenger drivers preferred removable battery while cargo drivers preferred fixed battery
- More than **60%** of the drivers go for slow charging (currently charging at PCS (ElectriVa) is free in Delhi)

Resale & Finance

- The average insurance premium of the passenger vehicle is **Rs. 7,924 per annum**
- The average ROI of passenger vehicle is **14.3%** with interest going as high as **22%** in some cases
- The average down payment of passenger vehicle is around Rs. **94,000**

Problems related to PCS

- On an average **65%** of the drivers faced issues related to non-functional charging ports and High waiting time at the charging stations
- **55%** of the drivers complained about obstructed / congested parking spaces
- Few of the drivers also faced issues with the PCS mobile applications as it kept getting crashed

Safety

- Majorly, the respondents **(65%)** preferred a new E-auto over a retrofitted one
- Major reason for the same was the Novelty factor of a new vehicle and vehicle strength in case of old retrofitted vehicles

Figure 23: Key e-rickshaw survey findings

3.3 Driver experience with ICE 3Ws

The ICE 3W driver experience survey was conducted in Delhi, Lucknow, and Bangalore with 186 participants. Among the surveyed vehicles, 89% were ICE 3W passenger vehicles. The ICE 3W passenger segment had 89% of the vehicles owned by individuals and only 11% operated through fleet owners, whereas the ICE 3W goods segment had half operated by fleet owners and the other half under individual ownership. A passenger ICE 3W costs 3.7 lakhs, whereas a goods ICE 3W costs 4.11 lakhs. Daily, the passenger ICE 3Ws covered an average of 141 km as their duty cycle over 9.5 hours, through which they earned an average Rs. 837 per day. 97% of surveyed drivers had completed their secondary education or had a lower level of education.

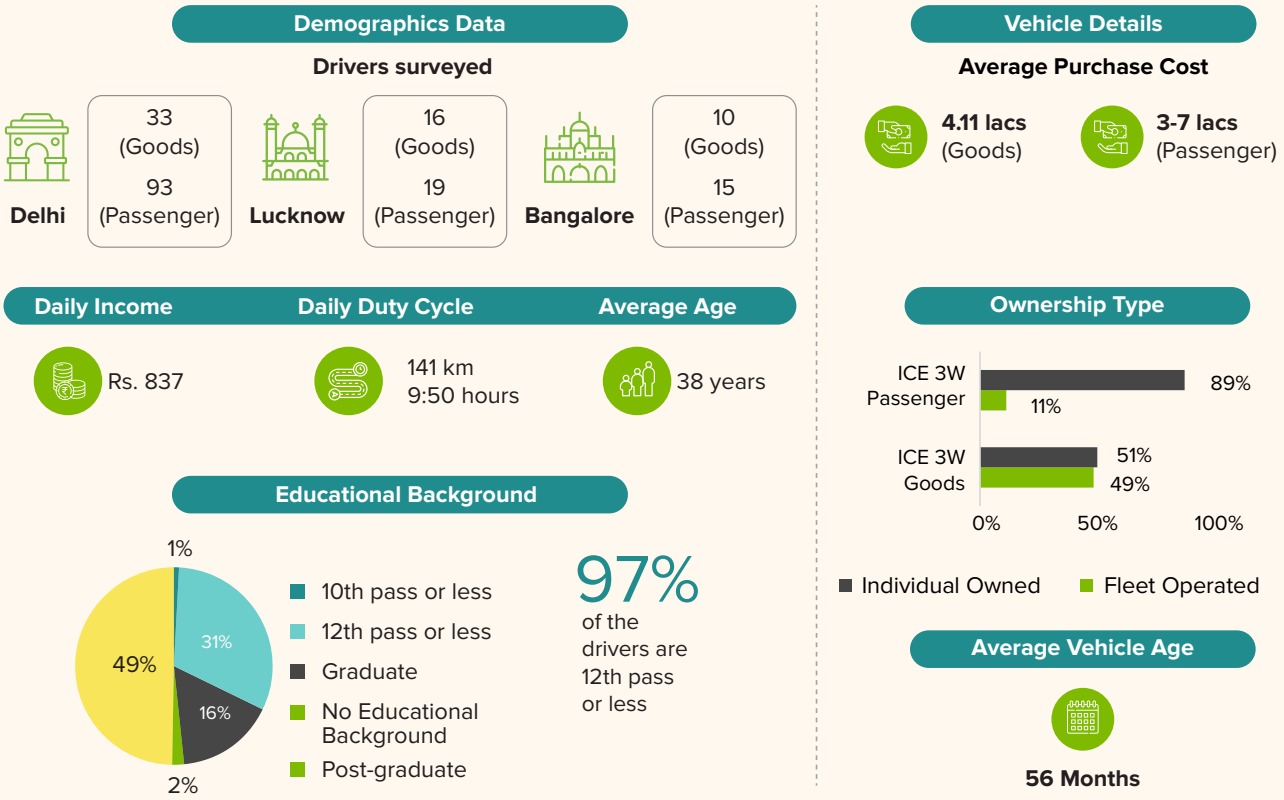


Figure 24: Surveyed ICE auto driver demographic profile and vehicle data

Perception and challenges of ICE auto drivers: The majority of the surveyed drivers highlighted the limited e-auto range and availability of charging infrastructure as reasons for their preference of ICE 3Ws over e-autos. A significant fraction of drivers said e-auto operating costs were lower than those of ICE 3Ws. Barriers to operating ICE 3Ws include high expenditure on CNG and lack of appropriate after-sales servicing at authorised centres. Lack of awareness on charging station locations and the state subsidy in Delhi was also an issue.

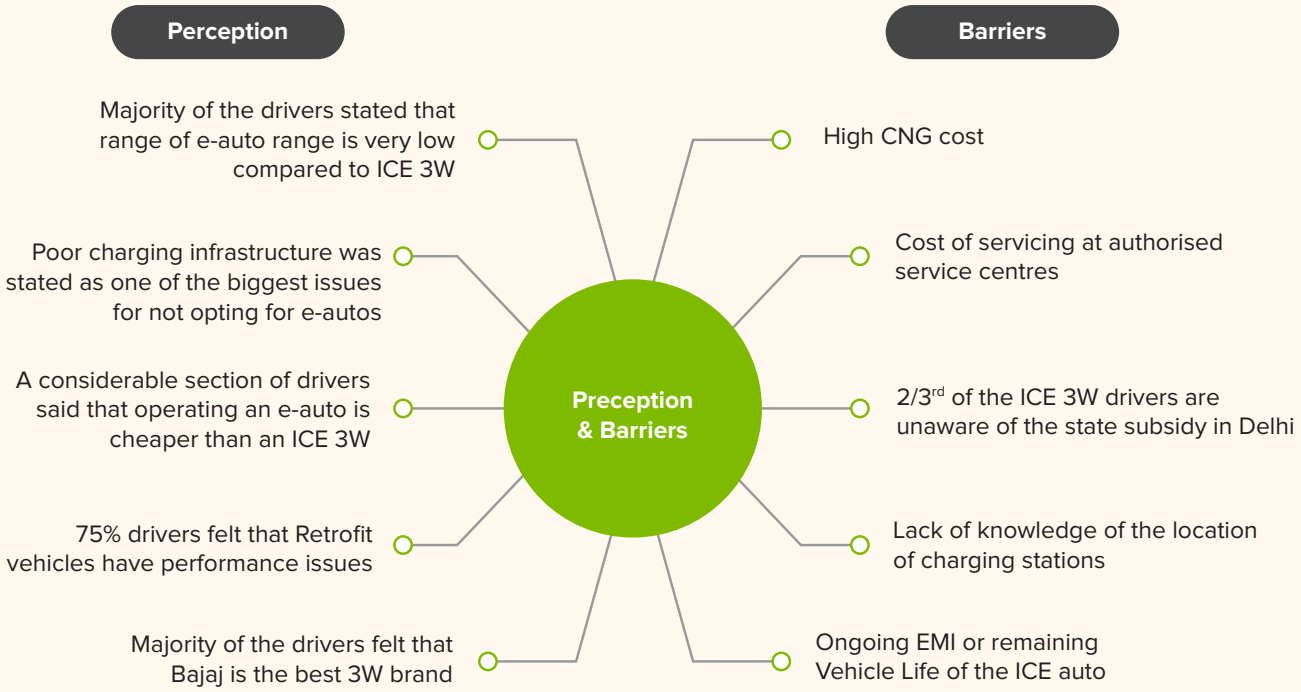
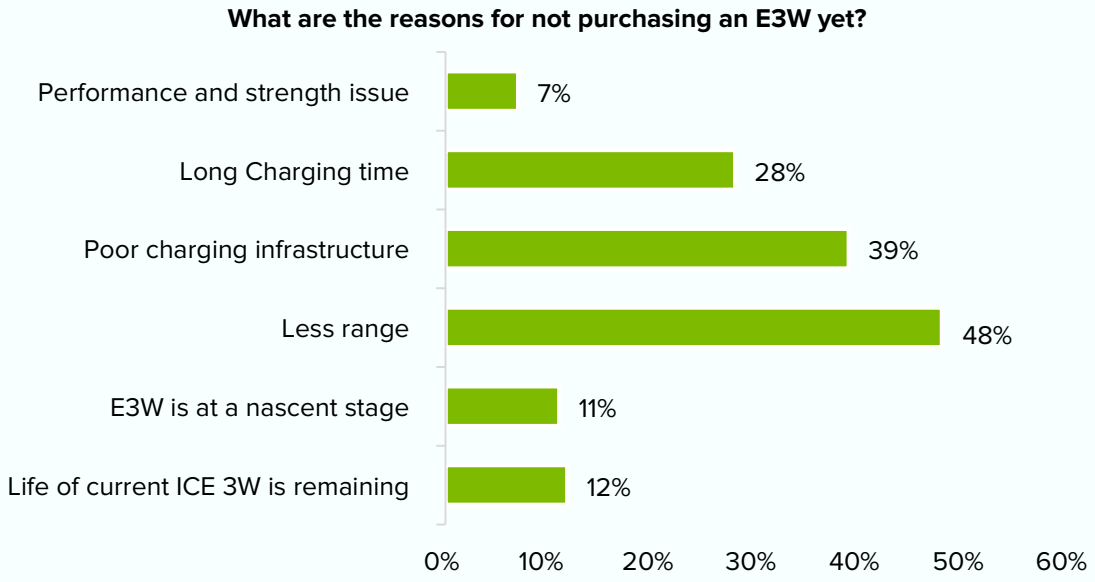


Figure 25: Perception and barriers (ICE autos)

Experience with ICE auto purchase: 48% of respondents stated that low range was the main reason they could not switch to an e-auto. Passenger drivers favoured a minimum range of 200 km for the ICE 3W and displayed brand loyalty towards Bajaj. When asked whether their next vehicle purchase would be an E3W, only 11% of drivers responded positively, with others citing range anxiety, safety concerns, and the high initial cost as issues that held them back. The high initial cost was especially an issue for drivers in Lucknow and Bangalore, where no state subsidy was available. At the same time, in Delhi, more than two-thirds of ICE 3W drivers surveyed were unaware of the government subsidy on E3Ws, which may be a big incentive to switch.



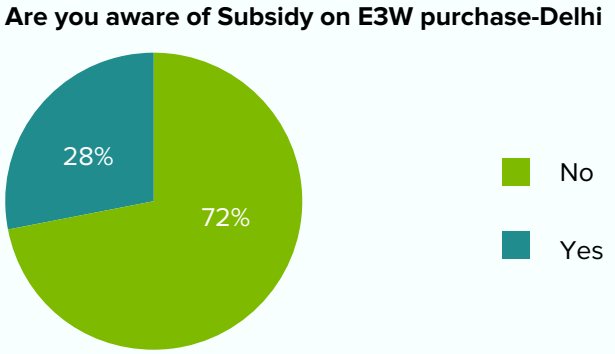


Figure 26: ICE auto drivers' purchase perception of e-autos

Figure 27: ICE 3W performance (Rating on 5 point likert scale)

Table 4: Comparison between ICE 3W-Cargo and ICE 3W-Passenger

	ICE 3W-Cargo	ICE 3W-Passenger
Monthly Avg Fuel Expenditure (INR)	9220	9606
Daily Avg Distance (km)	113	128
Monthly avg distance (km)	3390	3840
Vehicle run on 1 full tank (km)	210	185
Tank capacity (L)	7.47	6.34
Mileage (km/L)	28.11	29.17

The authorised after-sales service centres are very few in number, and therefore 80% of drivers get their vehicles serviced locally. An ICE 3W takes 3 hours to service on average, but 20% of drivers said ICE 3W servicing takes more than a day. Nevertheless, there are very few breakdowns recorded, indicating good ICE 3W reliability.

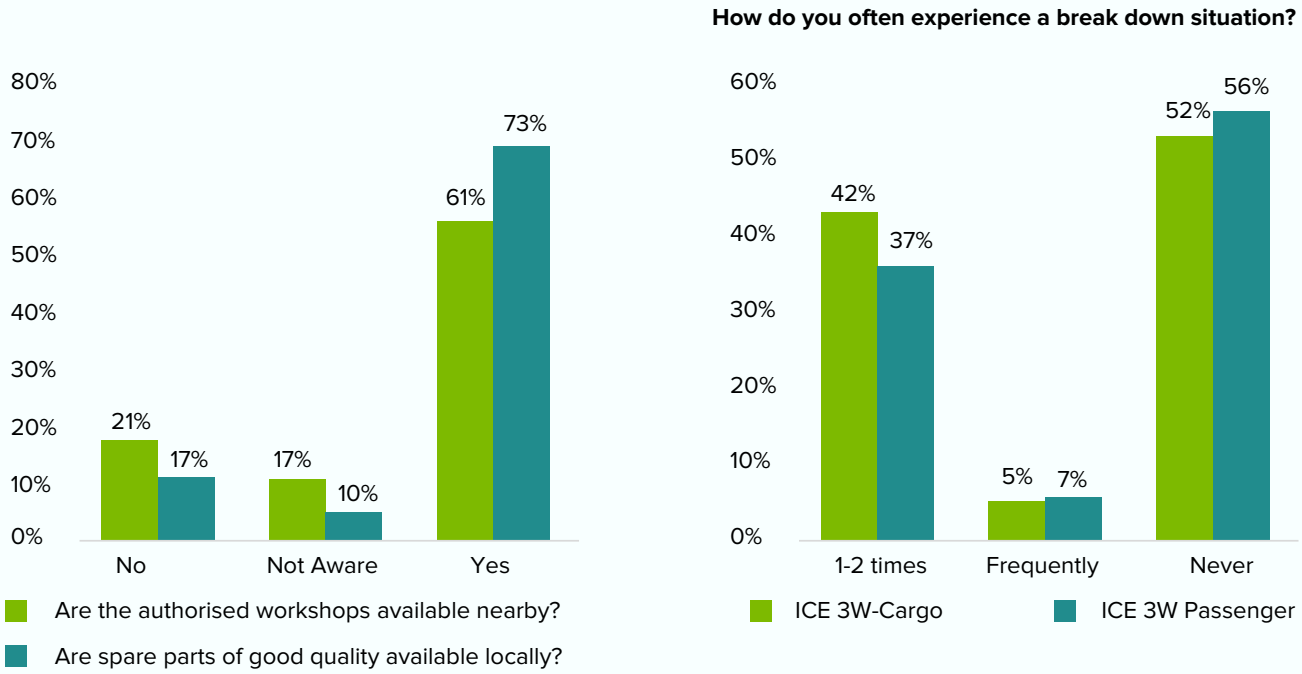


Figure 28: ICE 3W after-sales services & breakdown

Experience with finance and insurance: 61% of the surveyed passenger drivers financed their ICE 3Ws primarily through private financing entities. The average down payment was Rs. 69,059, and they received a return on investment of 12.71 percent. The ICE 3Ws have a lower insurance premium than e-autos—approximately Rs. 4500.

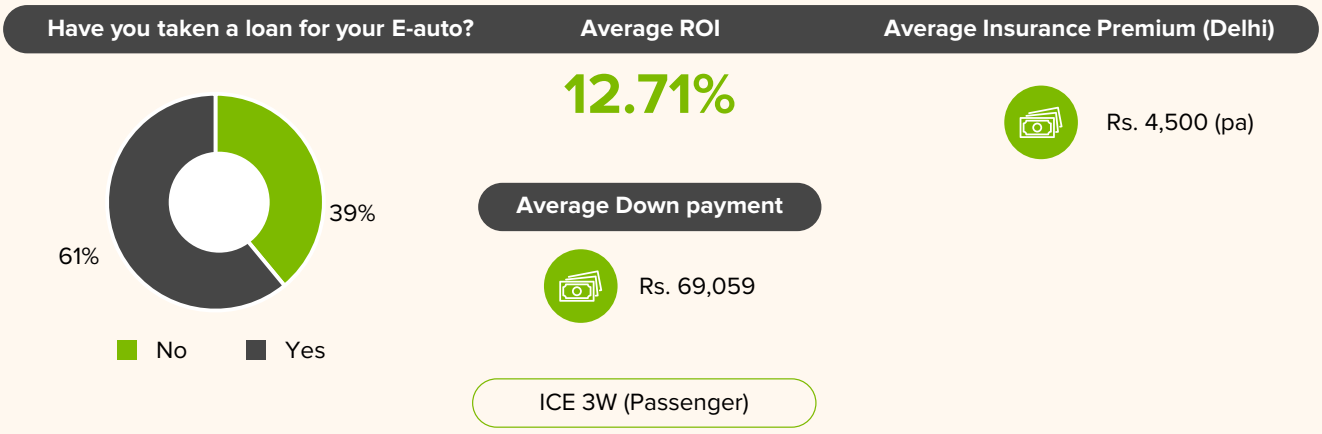


Figure 29: ICE auto financing & insurance

Perception regarding ICE auto retrofitting: The majority of drivers (30%) surveyed preferred to not retrofit their vehicle, as they lacked trust in EV performance and range. The surveyed drivers who had a retrofitted vehicle stated low upfront cost as the reason for retrofitting.

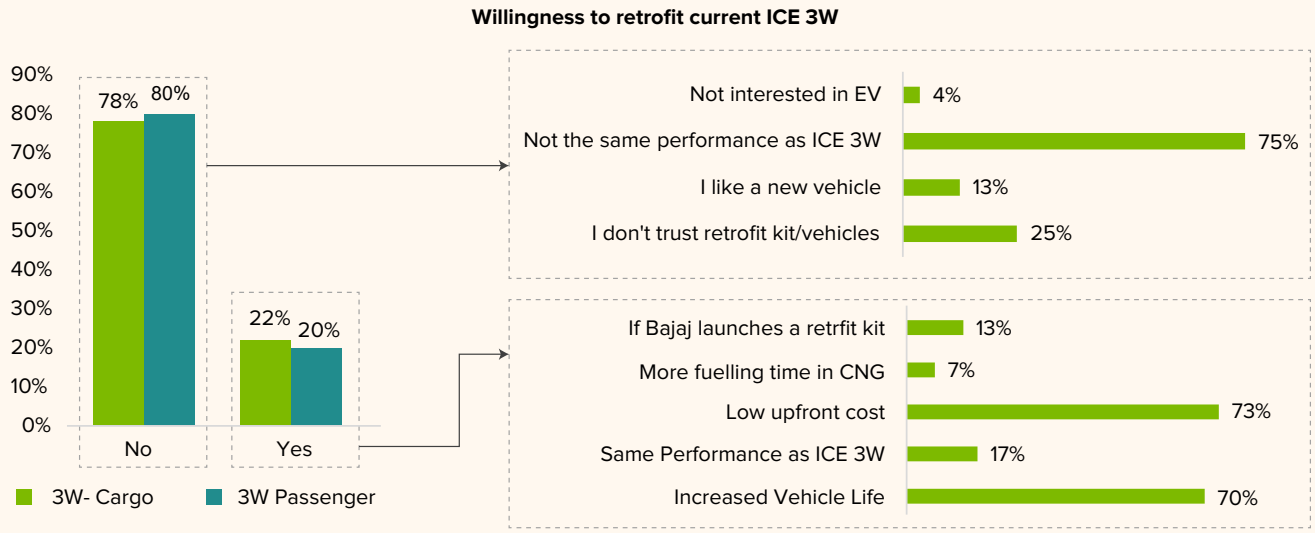


Figure 30: Willingness to retrofit current ICE autos

Purchase
- **48%** of the drivers, cited **less range** as the primary reasons for not preferring an EV
- **Poor charging infrastructure** is also one of the major reason that acts as a hindrance for E3W adoption
- A minimum range of **200 km** is acceptable by the respondents surveyed for an E3W

Performance
- On an average ICE 3W drivers were satisfied with the overall performance of their vehicles
- The overall performance satisfaction index is **4.29/5** for Passenger and **3.96/5** for Goods

Fueling
- The fuel expenditure for a cargo 3W is almost similar to that of a passenger 3W
- Around **30%** of the drivers were not aware of the location of any PCS near their area of operation

Resale & Finance
- The average resale value of the vehicle is over **Rs. 3 lacs** including the permit transfer (Passenger)
- The average ROI for passenger vehicle is **12.71%**
- The average down payment is around **Rs. 69,059**

After sales
- On an average 20% of the drivers surveyed stated that more than a day is required for servicing of their ICE 3W in Delhi
- Average annual servicing cost for ICE 3W segment comes out to be around **Rs. 11,884** and **Rs. 11,704** for Goods and Passenger respectively

Retrofitting
- Majorly, the respondents were not in favor of retrofitting their current ICE 3W
- One of the major reasons for not considering retrofitting was related to the **performance** of an E3W when compared to ICE 3W followed by the **trust issues in retrofitting kits**

Figure 31: Key ICE 3W survey findings

3.4 Perspective of dealerships and service centres

This section discusses the perspective of dealerships and service centres regarding the different key elements related to the E3W ecosystem, as indicated in **Figure 32**.

Figure 32: E3W ecosystem

1. Servicing

- The average time required for e-auto servicing is 3-4 hours.
- The main wire harness of the vehicle is located below the vehicle chassis, which causes issues during rain (water damage) and leads to the battery retaining moisture.
- In some cases, due to the unavailability of spare parts, servicing time increases.
- Financing and Leasing
- The typical ratio of downpayment to finance is 20:80.
- The major financing players include cKers, 3 wheel United, and Vidyut Finance.
- The leasing model is also prevalent, wherein the vehicle is leased for three years, and a fixed equated monthly installment (EMI) is charged by the dealerships, and after a stipulated time period, the ownership is transferred.

2. Purchase

- The cost of the permit is included in the overall vehicle cost.
- E3Ws have the advantage of not having any time restriction for entry for the cargo vehicle or entry into diplomatic areas, unlike ICE 3Ws.

3. Safety

- There are various safety checks and features incorporated into the vehicle design – system activation warning, power auto cut in case of motor/battery overheating due to excessive load, etc.
- Fire extinguishers were missing from the vehicles, which was against the government mandate.

4. Charging

- In the majority of cases, the charging systems included with the vehicles were slow chargers, and if the drivers wanted to upgrade them to fast chargers, they did so via third-party players, which falls in a grey area concerning the mandated safety and security standards.

3.5 Perspective of fleet owners

This section discusses the perspective of fleet owners, as captured in the survey.

Vehicle Details

42V & 72V Battery
Li-ion battery

Load Capacity
400-650 kg

48V Battery
Li-ion & Lead Acid battery

E-auto (Cargo)

E-Rickshaw

Cost of Operations

AMC

The annual maintenance contact is Rs. 16,000 per vehicle per Annum which includes all the service-related costs

The monthly cost for charging is Rs. 3,500 per vehicle

The monthly cost for parking is Rs. 2,500 per vehicle

Charging & swapping

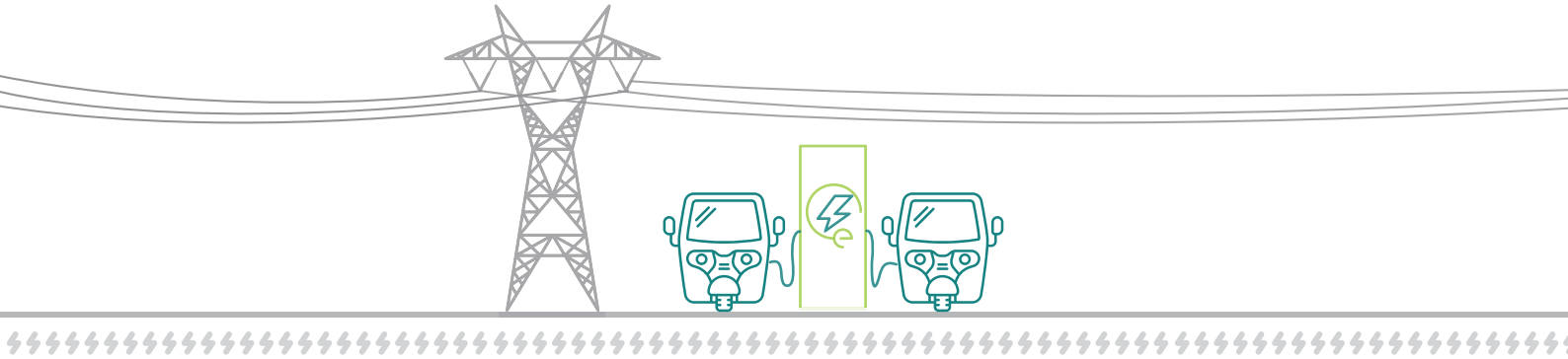
E3W charging was commonly performed at vendor facilities using two distinct methods: fast charging and slow charging. To utilize fast charging, it is recommended that the vehicle's battery have a minimum of 15-20% charge. In contrast, slow charging is intended for batteries that have been completely depleted and require a full recharge

Safety

The e-auto fleet vehicles were equipped with several safety features, including an SOS button, a fire extinguisher, a system activation warning, and a battery overheating warning. To ensure the safety of the drivers and passengers, the company (OEM) conducted regular dummy runs and included drivers in security briefings to familiarize them with the vehicles' safety features

The research team conducted in-depth consultations with stakeholders to identify key measures to facilitate the large-scale adoption of E3Ws and address the key barriers in their value chains. As part of the analysis of the prerequisites for an E3W market transformation, stakeholder consultations were carried out to obtain an ecosystem-wide understanding of the various challenges and corresponding areas of intervention. As illustrated in Figure 33, the broad themes of indigenisation of manufacturing, end-of-life management, and consumer safety aspects were covered as part of the group consultation sessions. These sessions saw participation from sixteen unique stakeholders spread across the value chain, ranging from OEMs, charging service providers, and government departments to civil society, end-users, funding agencies, and the end-of-life management industry. Additionally, one-on-one discussions were held with two stakeholders involved in R&D, EV aggregation, and fleet operations to get their unique perspectives. The list of stakeholders is available in Annexure 1. The following section provides summaries of the various sessions. The key takeaways across the EV ecosystem have been collated to provide an overview of the perspectives obtained from the stakeholder consultations.

Figure 33: Main stakeholder consultation topics

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04 | Insights from Stakeholder Consultation

4.1 Retrofitting of conventional three-wheelers to the electric drive train

Tailpipe emission reduction can be achieved in one of two ways; one can either alter the engine capacity, i.e. upscaling or downscaling, or completely retrofit the fossil fuel-based power train with a nonpolluting one like an electric power unit. The procedure followed in the latter approach requires a suitable electric motor to retrofit the existing ICE-based system and perform on par with it (Pattar et al., 2018).

Retrofitted EVs use almost the entire body frames of the original vehicles. They offer the same economic and environmental benefits as new EVs of comparable specifications, while allowing for the reuse of body parts and materials that would otherwise be disposed of. This helps reduce both the cost of purchasing a new electric car and the amount of scrap created by existing vehicles. Furthermore, retrofitting of existing vehicles helps maintain the traffic on road by reducing the influx of new (electric) vehicles on road without additional measures to replace the older (ICE) vehicles.

The central government has established guidelines for retrofitted automobiles. According to BIS regulations, the retrofitted vehicle must be evaluated and certified by ARAI or ICAT. The companies doing the electric retrofitting for ICE vehicles that are approved by ARAI or ICAT are treated as the manufacturers of those vehicles (Avinash Reddy, 2021).

FAME II does not offer incentives on retrofitted vehicles, but many state EV policies support such retrofits. For example, Telangana's EV policy includes a 15% subsidy, or INR 15,000, for the first 3,000 retrofits of passenger E3Ws.

4.2 Manufacturing of electric three-wheelers

This session had the primary objective of discussing the key challenges related to E3W manufacturing. A diverse group of experts spanning government, civil society, battery experts, charging station providers, battery swapping providers, and OEMs participated in the session. Various aspects related to battery chemistry, EV finance, government regulations, policies on domestic component and battery manufacturing, and R&D requirements were discussed. The key identified areas of intervention include R&D for EV technologies, enhancement of battery life, interoperability, component manufacturing, certification procedure, safety standards, and standardisation for E3Ws.

Safety standards and standardisation

Below are the concerns related to the safety standards of batteries and other vehicle parts that are currently followed:

- **Safety concerns and guidelines** – Use partial discharge cycles, avoid charging to 100% capacity, slow rate of charge, limit battery temperature, avoid high charge and discharge, avoid deep discharge
- **Testing standards** – Complete testing under different climatic conditions, require dedicated testing centres, different conditions to cater to different climatic conditions within the country, emphasis required on testing and certification.

*The standards of countries with similar geographies and climatic conditions can be referred to, but it shall not be a complete replication.

As per the discussion during the stakeholder consultation, AIS 156 Rev 2 standards should be used, along with the relevant testing steps. However, there are a few major challenges in implementation:

- Thermal propagation test requirement – currently, few labs are setting up testing mechanisms.
- Manufacturers need to provide five cycles of charge and discharge cell data at a C/3 rate – this will take time, especially for E3Ws
- RFID and interfacing with the BMS – involve changes to BMS.

Battery life enhancement

In batteries, cell chemistry plays a major role. It is vital to tailor the cell selection to Indian conditions, but India is heavily dependent on raw material imports. Moreover, an effective BMS is needed to get good estimations of battery pack life and performance. Below are the steps that should be followed to enhance the battery life:

- Use partial-discharge cycles, not below 30%; batteries should operate in the range of 0.3-0.8 SOC.
- Avoid charging to 100% capacity. Follow slow rates of charge C/5 or C/10.
- Select the correct charge termination method.
- Limit the battery temperature – the ideal temperature of operation is 16-34 degrees Celsius.
- Avoid high charge and discharge (breaks >10C) currents.
- Avoid very deep discharges (below 2, 2.5, or 3 V, depending on the battery chemistry)
- Battery life depends on chemistry. Currently, lithium-cobalt-oxide (LCO)/nickel-manganese-cobalt (NMC)/nickel-cobalt-aluminium (NCA) vs. lithium-iron-phosphate (LFP) at the cathode side and graphite and lithium-titanium oxide (LTO) at the anode side is the best combination. LFP-LTO claims to give >3000 cycles (i.e. >8 years of life in normal operation).
- LFP is safer than LCO/NMC/NCA.

Interoperability

The principle of interoperability has been the common thread of widespread deployment of technologies and services that have enabled economies of scale, standardisation, safety norms, governance, and ease of operation. All these attributes have evolved and become sustainable through slow, iterative improvements over the years.

Implementation of interoperability is an issue since the industry is still at a nascent stage. The government should specify the guiding principles or a broad outline and not specifics related to form factor or battery shape. Such norms, standards, etc. should be industry-led rather than being imposed in a top-down manner. Industry's concern is that this should not hamper their freedom to experiment, evolve, and innovate, which is critical at this stage, as such restrictions could also dampen investments in the sector.

4.3 Financing challenges for electric three-wheelers

E3W financing falls into two brackets: 1. Individual financing, e.g. by last-mile connectivity players who own the vehicle and 2. Financing of fleet or government E3Ws for cargo, garbage collection, etc. that are owned by contractors. This session discussed the financial challenges associated with the E3W ecosystem.

Major risks associated with E3W financing

Collaboration between OEMs and financiers is needed. Currently, financiers are uncertain about the investment potential due to the lack of performance track records. It is necessary for the OEMs to provide details to the financiers about the technology, such as telematics, which enables tracking and can reduce the risk of non-performing assets (NPAs). It is imperative for the financiers to take care of credit risk and OEMs to take care of product risk.

Major risks highlighted during the discussion included the following:

- Low loan-to-value (LTV) ratio: In end-customer financing, depending on the product and customer segment, the rates and LTV ratios vary. This difference is seen across e-rickshaws, passenger autos, and cargo 3Ws.
- Short loan tenures: The loan tenure for EVs is generally shorter, which translates to higher EMIs. For E3Ws, the extension of loans for more than 36 months' tenure would be useful. Financing of EVs and ICE vehicles should not be viewed through the same lens. For EVs, the vehicle gets amortised in 8-10 years, with a new battery after 3-4 years, but a wholesale amortisation of 3 years is typically given in the financing.
- High interest rates: The interest rates offered by the financiers are slightly higher than those for conventional 3Ws.
- Finite financing options: At present, very limited financing options are available. There are alternative financing options such as boutique non-banking financial companies (NBFCs), regional NBFCs, and medium-to-large NBFCs, but the ticket sizes are smaller in these segments compared to buses, trucks, sedans, etc.

Financing electric three-wheelers without batteries

EV sales are not gaining the expected momentum even after various incentives have been provided to the consumers. Studies show that the initial purchase cost is the main barrier to EV adoption, and batteries account for 40% of this cost. Therefore, to tackle this problem, the Government of India has allowed the registration of electric two-wheelers and E3Ws without batteries and initiated the adoption of Battery-as-a-Service (BAAS). Under this model, customers can lease batteries from the OEMs or battery suppliers as a separate component from the vehicles. In addition, the customers can take out the discharged battery and exchange it for a fully charged one. The higher upfront EV cost was also one of the major unfavourable factors for financiers. Thus, this step will increase confidence among financiers and make E3Ws more financially viable.

There are several emerging innovative financing solutions, as summarised below:

- Big OEMs have started operating their own finance subsidiaries, e.g. Omega Seiki. The ease of access to financing options in this model may motivate consumers to buy E3Ws.
- As per the discussion, the current GST structure on vehicles and batteries is complicated. To accelerate E3W adoption, GST on batteries should come down to 5 percent.
- Financiers have to be made more aware of EV technology such as telematics, which enables tracking and can reduce the risk of NPAs.
- Financiers and OEMs should explore the option of EV leasing.

4.4 Battery swapping

This session explored the potential of battery swapping in accelerating EV adoption in India. Consumers have range anxiety and low confidence in switching to EVs due to long charging times. Battery swapping has the potential to eliminate this issue. However, every technology comes with pros and cons. Therefore, the following section discusses the advantages, disadvantages, and opportunities of battery swapping.

Challenges in battery swapping for electric three-wheelers

- Mishandling of batteries due to lack of training leads to losses for the operators. There is a need to educate drivers on battery use and handling. In the case of damage, the company should be responsible since it is a BAAS model. However, there is a need to develop a system to identify whether the damage to the battery is done intentionally.
- Currently, only customers linked with service providers like Sun Mobility can exchange batteries at a Sun Mobility swapping station. Such an approach limits the availability of battery swapping stations and therefore the scope of battery swapping.
- The cell quality of swapped batteries cannot to be guaranteed, and there is a risk of low-quality cells causing fires in quick interchange stations (QIS). Hence, there is a need to develop protective mechanisms for batteries.
- There is a need to focus on other aspects such as safety standards and battery efficiency. There have been no fire incidents with swappable batteries thus far. The batteries are checked by the operator, and the health of the battery is monitored. Furthermore, there is a mechanism to prevent overheating.
- The high cost of insurance is an issue. Vehicles, batteries, and swapping stations are insured. However, as the battery swapping technology is still developing, and there is no secondary market for E3Ws, the cost of insurance is high. New companies have emerged for insurance, as well as financing, with a specific focus on E3Ws in the past year, and as they are aware of the E3W ecosystem, insurance costs have slightly decreased but are still not on par with ICE 3Ws.
- As per the discussion, in the passenger E3W segment, the manufacturing is not keeping pace with demand.

Policy measures to facilitate electric three-wheeler battery swapping

- A battery swapping policy is expected to be released by NITI Aayog, which can then be incorporated into state EV policies.
- It is necessary to incentivise corporate purchases.
- There is a need to increase visibility and awareness, which will play an important role in driving E3W adoption.

Training for drivers and swapping station operators

Currently, when drivers buy vehicles from the dealers, they are briefed on battery handling, but there is a need for in-depth training. Other stakeholders such as non-governmental organisations (NGOs), government actors, etc. also need to be involved in providing training on handling batteries, replacing and swapping batteries, and resolving basic issues such as connector problems, as safety is partially the user's responsibility.

New and innovative ideas for the implementation of battery swapping charging infrastructure in India

On-call battery swapping - Batteries can get discharged anywhere, anytime, and it can be difficult to locate a swapping station every time. One approach to address this issue is "swapping trucks," which come to the discharged car on the highway or city road, providing more convenience to EV consumers.

Metro stations and other cluster locations - E-rickshaws and battery-operated autos will be a crucial segment of EVs in the near future. These vehicles will be critical for last-mile connectivity from transport hubs and therefore, one can locate swapping stations at metro stations or other transport hubs.

Malls and shopping centres: E-rickshaws and e-autos get a lot of passengers who travel to and from malls and shopping centres. Thus, these hubs could be another good location for swapping stations and enable consumers to easily change their vehicle batteries.

4.5 EV policies

State-level policies include E3W targets, purchase subsidies, road and registration tax exemption, scrappage policies, interest subvention, free permits, green zones for auto stands, reserve parking spots, capital subsidies on charging equipment, and battery swapping. State-level policies offer incentives via two methods: purchase subsidies for new E3Ws and retrofitting incentives for existing ICE 3Ws.

There are two major relevant central policies. First, the government has allowed the sale of E3Ws without batteries, which can reduce their upfront cost and facilitate battery swapping. Second, there is a new voluntary vehicle scrappage policy and age limit to undergo a fitness test for a private vehicle is set at 15 years..

Takeaways from the discussion:

- Subsidies for retrofitting 3Ws also need to be provided from the central government. Currently, the cost of a retrofitting kit is INR 1.8-2.2 lakhs for fixed batteries.
- Battery recycling and reuse should also be addressed in the state EV policies.
- Two models should be implemented to increase E3W adoption: 1. BAAS model, wherein battery swapping reduces the cost of E3W ownership; and 2. Mobility-as-a-Service model, wherein vehicles are provided on a rental basis.
- There is a need to address the structural safety of retrofitted E3Ws. Even in conversations with ICAT and ARAI, this point has been highlighted. There is also a need to conduct testing of retrofit kits.
- Uttar Pradesh has the highest number of registered E3Ws. However, the state does not offer any purchase subsidy, instead only providing road tax exemptions. The Delhi EV policy is a game changer, as it has a targeted mandate for fleet electrification. This can be adopted by other states.
- There is a need to address the lack of training of drivers and other workers.
- At the state level, when issuing licences to drivers, the government should include norms related to charging, discharging, battery life, etc.
- At the state level, worker training is needed, including online training; this is particularly needed for critical EV components such as the battery and motor.
- The safety perspective needs to be considered in the state EV policies.

05 Opportunities for E3W market transformation

5.1 Key recommendations

The following recommendations are derived from the various parts of the study, including the E3W technology classification, consumer survey, review of national and state-level policies and schemes, and stakeholder consultations. The recommendations aim to address the barriers to EV adoption in India, particularly in the E3W segment.

 **Government**	▶ Installation of more PCS and regular health check of PCS, as 65% of the drivers faced issues related to non-functional charging points and long waiting times ▶ Provide investment support to charging and swapping players, especially to start-ups, as this would help accelerate the rollout of charging stations ▶ Regular EV awareness forums to make people aware of EV-related benefits & incentives
 **Vehicle OEMS**	▶ Provide better training to service centre technicians, as this would help reduce the servicing time ▶ Improve build quality by seeking regular customer feedback, as 45% of the drivers stated that the build quality is better in ICE 3Ws ▶ Partner with major financial institutions to provide cheaper loans, as the average ROI & down payment are greater than for ICE 3Ws
 **Charging/swapping players**	▶ Make charging/swapping applications robust & user-friendly ▶ Replace old batteries at swapping centres with new ones, as the average range for swappable batteries is only 70 km ▶ Adoption of a single charging application, as 91.4% of drivers stated that there should be a single application with access to all PCS.

State-level policy recommendations

Analysis of the state-level policies indicates that states like Andhra Pradesh and Haryana are doing well with their policies, including capital subsidies, state GST reimbursements, power tariff subsidies, road tax exemption, registration fee exemption, retrofitting incentives, etc., which will accelerate E3W adoption in their state. According to the survey, 70% and 58% of e-rickshaw and e-auto passenger drivers cited low operating costs and no permit fees as the reasons for preferring an EV. Including these incentives in the other state policies could help them achieve their E3W penetration targets. The survey indicates that for approximately 40% of the consumers, it takes over 60 days to obtain the subsidy offered by the government, which is a discouraging statistic. The subsidy's timely disbursement would be a motivating factor for consumers. Several top-scoring state EV policies, including those of Andhra Pradesh, Haryana, and Kerala, provide capital subsidies, tax exemption/reimbursement &

interest subsidies, and land purchase & registration incentives to attract and motivate manufacturers to facilitate E3W adoption. The states can also offer incentives to retrofit kit manufacturers to establish their businesses, bringing more players into the market, increasing the competition, and leading to better product quality and price. This will help convert the existing conventional fleet to electric more quickly. The states can also offer incentives to strengthen the basic EV-supporting infrastructure by installing more chargers and swapping stations and providing electricity at a discounted price.

Research and development

Battery safety and performance are critical factors in EVs. The government and manufacturers should focus on improving battery quality, BMS, and safety. This will increase consumer confidence regarding EVs. A large and complex supply chain of essential raw materials supports Li-ion battery production in Gigafactories. India has reserves of manganese, nickel, copper, and aluminium, and an attempt should be made to produce high-value battery components from these ores. On another note, most ICE auto consumers believe that E3Ws have lower ranges than ICE 3Ws. The E3W provides an actual driving range of 70-80 km per charge, whereas, as per the survey, the average duty cycle is around 120 km per day. Therefore, consumers will be motivated to buy E3Ws when their desired driving range is obtained without interrupting their operational hours. Standardisation of battery packs is another aspect that the current research in EV adoption should focus on. Presently, the battery packs are generally not compatible with different vehicle segments, brands, and models. Thus, ensuring battery compatibility will enable the market for BAAS technology to thrive, bringing the overall lifecycle costs down. In addition, the overall efficiency can be increased by establishing a standard communication protocol between the BMS and motor controller. The safety and performance of the battery packs should also be routinely tested and checked by carrying out extensive product validations. Central and state governments should work together to create an ideal atmosphere to attract next-generation technologies from the global R&D community. Along with R&D, a focus on skill development in this field will lead to increasingly robust EV infrastructure.

EV infrastructure integration

Range anxiety is one of the significant barriers to EV adoption. Ensuring the availability of charging stations as per the customer's requirement is instrumental in shifting the consumer's preference towards EV adoption. Charging time also affects both EV adoption and the charging station utilisation rate. As the charging station requires a large capital expenditure, it is necessary to optimise charger location based on an analysis of the regional demand forecasting. Apart from optimising the location and efficiency of the chargers and charging stations, another technique that could help reduce the range anxiety of the customers is BAAS. BAAS operators need to ensure a uniform range per swap for customers, irrespective of the age of the battery pack, which can be achieved through smart software. Moreover, it is necessary to standardise the EV Li-ion battery packs to augment the process. Currently, only consumers linked to a service provider such as Sun Mobility can use the company's swapping stations, thus limiting their outreach and use. There is also a need to extend FAME II subsidies to battery swapping operators and bring the GST rate on swapping services (18%) down to compete with EVs with plug-in charging models (5%). There is also a need to focus on other aspects such as safety standards and battery efficiency, so that the battery is routinely checked and maintained by the operator. This generally also includes a mechanism to prevent overheating. Lithium batteries are highly flammable, and the recent vehicle battery fire incidents have only aggravated this concern. The risk increases when multiple battery packs are being handled in one place at the swap station, and in the event of fire due to bad practices, an entire area in a dense urban setting could be exposed.

There is also the high cost of insurance associated with the vehicles, batteries, and swapping stations, as the technology is still nascent, and there is no secondary market for E3Ws. New companies have emerged for insurance and financing with a specific focus on E3Ws in the past year, decreasing E3W insurance costs, but they are still not on par with those of ICE 3Ws. Therefore, it is necessary to incentivise corporate purchases. NITI

Aayog's expected battery swapping policy should be incorporated into state EV policies. Training should be provided to drivers and swapping station operators regarding safety precautions, proper swapping procedures, charging, etc.

Electric three-wheeler financing

The electrification of last-mile delivery, ride-hailing, and corporate transport fleets can act as a strong market signal for key stakeholders, especially manufacturers and financial institutions. Piloting and commercialising new business models, combined with the flow of patient capital, can demonstrate the sector's potential. Furthermore, this would help build trust in EVs and normalise them in the market. Presently, big OEMs have started creating their own finance subsidiaries. Thus, easy access to financing options may motivate consumers to buy E3Ws. As per the stakeholder discussion in Section 4, the GST structure on vehicles and batteries is complicated in the present condition. To accelerate E3W adoption, GST on batteries should come down to 5 percent. In addition, financiers must be made more aware of EV technology such as telematics, which enables tracking and can reduce the risk of NPAs. Moreover, financiers and OEMs should explore EV leasing.

In conclusion, the transformation of the electric 3-wheeler (E3W) market presents numerous opportunities for individuals, organizations, and governments to drive sustainable transportation solutions and reduce their carbon footprint. The recommendations presented in the whitepaper range from consumer incentives to addressing product issues and cover important aspects of the E3W ecosystem, such as batteries, charging, battery swapping, financing, and manufacturing. To maximize the benefits of this transformation, it is important to ensure widespread accessibility and affordability of E3W and to invest in the development of the charging infrastructure needed to support their widespread use. In addition, government policies and incentives can play a crucial role in promoting the adoption of E3W and driving the market transformation.

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Annexures

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9	Cygni	Venkat Rajaraman	CEO
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13	PwC	Garvit Kaushal	Senior Consultant-Electric Mobility
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