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Powering Progress:

A Blueprint for Retrofitting Three-Wheelers Internal Combustion Engine to Electric

WHITE PAPER

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Authors and Researchers

NRDC: Nitish Arora, Meshak Bandela

ASCI: Amartya Awasthi, Bhuvaneshwari Peddi

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POWERING PROGRESS:

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Abbreviations

ARAI	Automotive Research Association of India
BaaS	Battery as a Service
BMS	Battery Management System
BS IV/ BS VI	Bharat Stage Emission Standard
CFST	Citizen Friendly Services Telangana
CMVL	Central Motor Vehicle Laws
CMVR	Central Motor Vehicles Rules
CNG	Compressed Natural Gas
DC	Direct Current
e-3W	Electric 3 Wheeler
EGR	Exhaust Gas Recirculation
ELV	End-of-life Vehicles
ERFC	Electric Retrofitment Centre
EV	Electric Vehicles
FAME	Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles
GARC	Global Automotive Research Centre
GHG	Green House Gases
GHMC	Greater Hyderabad Municipal Corporation
GST	Goods & Services Taxes
HC	Hydrocarbon
ICAT	International Centre for Automotive Technology
ICE	Internal Combustion Engine
LPG	Liquefied Petroleum Gas
MUDRA	Micro Units Development and Refinance Agency Limited
NA	Not Applicable
NATRiP	National Automotive Testing and R&D Infrastructure Project
NATRAX	National Automotive Test Tracks
NBFC	Non- Banking Financial Companies
NCAP	National Clean Air Programme
NGT	National Green Tribunal
NO_x	Nitrogen Oxides
NIAIMT	National Institute for Automotive Inspection Maintenance & Training
OEM	Original Equipment Manufacturer
PM	Particulate Matter
RC	Registration Certificate
REESS	Rechargeable Electrical Energy Storage System
RTA	Road Transport Authority
RTO	Regional Transport Office
SOC	State of Charge
TCO	Total Cost of Ownership
TGPWU	Telangana Gig & Platform Workers Union
TSREDCO	Telangana State Renewable Energy Development Corporation
VRDE	Vehicles Research and Development Establishment

Source: Freepik

Introduction

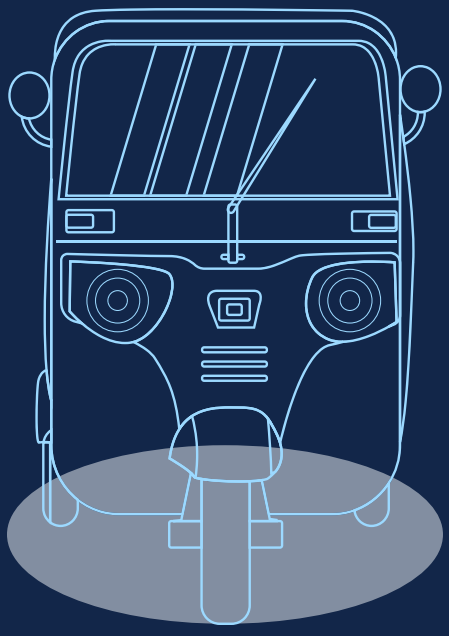
With India's transportation sector set to growing exponentially, a significant opportunity remains largely untapped - the electrification of passenger autorickshaws or the quintessential tuk-tuks. These autorickshaws serve as crucial first and last mile transport connectors in many Indian cities, facilitating about 5-25% of all motorized trips in cities.[1] Electrifying passenger autorickshaws could help boost electric vehicles adoption, decarbonize the road transport sector and reduce urban air pollution. The government aims to take advantage of this opportunity with its commitment to achieving a 30% market share of EVs among new vehicle sales by 2030 with an ambitious target of an 80% market share among new two and three wheeler registrations by 2030.[2] In order to fully take advantage of that opportunity, creating and following a blueprint to retrofit existing vehicles for electric use could help bridge gaps and support large-scale transport electrification.

India hosts an extensive fleet size of 7.4 million passenger-autos which is expected to reach 11 million by

2030

Retrofitment extends the useful lifespan of existing vehicles by 5-7 years while significantly reducing capital expenditure by at least

50-60%



Currently, India hosts an extensive fleet size of 7.4 million passenger-autos which is expected to reach 11 million by 2030. This constitutes nearly one-fourth of the overall[3] three-wheelers (3W) on ground and provides livelihood to 11 million drivers.[4]

The tailpipe emissions from auto rickshaws under best case operating conditions constitute nearly 10% of the total road transport emissions in cities.[5] It is estimated that over the 10-year period lifespan, the emissions of an ICE-auto escalate by almost 49%, with each ICE passenger auto rickshaw producing as much as 37 tons of carbon emissions.[6] Diesel operated passenger auto-rickshaws dominate the fleet of auto-rickshaws by 44% and emit significant 7.5 tons amounts of CO_2, particulate matter, black carbon, and nitrogen oxides (NOx), among other gases.[7] Electrifying passenger-auto rickshaws presents an opportunity to decarbonize and achieve zero tailpipe emissions for a sizable commuting mass.

India's transportation sector is a major source of energy-related CO_2 emissions, constituting 14% of the country's total emissions.[8] Within this sector, road transport emerges as the predominant contributor, accounting for a substantial 90% share of these emissions.[9] The increasing demand for private mobility and the transport of goods could double the energy use and CO_2 emissions from road transport by 2050 in India.[10] The exponential growth of India's road transport sector is leading to a rise in urban air pollution, with its emissions constituting for 20-30% of overall pollutants.[11] Furthermore, the rising cost of crude oil and India's increasing reliance on imports makes it critical to develop alternate fuel technologies. One estimate finds that electrifying one-third of all vehicles by 2030 might result in savings of INR 1.1 lakh crores per year on crude oil imports for India.[12] Electric vehicles (EVs) powered by a progressively cleaner electricity grid, with a growing share of renewable energy sources have the potential to decarbonize the carbon-intensive road transport sector. Regardless of their power source, EVs produce zero tailpipe emissions, making them instrumental in reducing urban air pollution by an estimated 30% and mitigating its adverse health impacts.[13]

Despite the array of fiscal and non-fiscal incentives provided by both national and sub-national governments in India, the penetration rate of passenger electric auto-rickshaws remains low, standing at only 6.2%.[14] This sluggish adoption can be attributed to the high capital costs of new electric vehicles and lack of public awareness regarding cost-effective technologies to retrofit older vehicles to electric. Understanding the 3W passenger market is crucial as it primarily operates under two ownership models: driver-owned or on a lease rental basis. The segment is also highly price-sensitive. The high upfront costs associated with transitioning to new electric three-wheelers often delay the switch to electric. Therefore, retrofitting existing ICE-autos to electric offers a viable and expedited transition solution. Additionally, retrofitment extends the useful lifespan of existing vehicles by 5-7 years while significantly reducing capital expenditure by at least 50-60% compared to purchasing new electric three-wheelers.[15] Although some states and union territories such as Tamil Nadu, Telangana, Rajasthan, Goa, Assam, and Chandigarh have introduced retrofitment incentives, gaps in the implementation framework hinder large-scale adoption, despite it being an effective pathway to transitioning the 3W fleet to electric.

In this context, this report aims to comprehensively analyze the e-3W retrofit ecosystem, evaluating its feasibility by examining the supply chain, technology, and business models. It also addresses operational hurdles, incorporating perspectives from certifying agencies, insurance companies, Regional Transport Offices (RTOs), and driver partners. The NRDC-ASCI team carried out extensive primary and secondary research, including stakeholder consultations and interviews with industry actors and driver partner unions. Additionally, the research includes a techno-commercial feasibility assessment of retrofitted e-3Ws with both fixed and swappable battery options, comparing them with existing ICE autos powered by diesel, petrol, and Compressed Natural Gas (CNG). Drawing from these extensive stakeholder consultations, it offers deeper insights into the challenges and potential solutions that Indian states can adopt to facilitate the conversion of existing 3W fleets to electric vehicles.

Source: Freepik

Landscape Assessment of Three-Wheeler Market in India

1

1.1 THREE-WHEELER MARKET IN INDIA

Auto-rickshaws, also known as tuk-tuks, bajajis, baobaos, and baby taxis, are motorized three-wheeled vehicles, widely used for passenger transport in developing nations.[16] Auto-rickshaws (autos) play a vital role in shared mobility and provide crucial first and last-mile connectivity in urban areas, with approximately 7.42 million vehicles operating across India, or about a quarter of all urban trips.[17] Auto rickshaws constitute the dominant mode of public transport in medium (1-10 million population) and small (<1 million population) cities, accounting for 42–76% of public transportation modes.[18] Even in larger cities with populations exceeding 10 million, auto-rickshaws account for 8% of public transport modal share and contribute substantially to last-mile connectivity and feeder services, seamlessly integrating with other mass transportation modes like buses and metros. In many cities, auto-rickshaws exhibit a mode share significantly higher than their proportion in vehicle registrations. For instance, in Amritsar and Jaipur, auto-rickshaws represent merely 2% of motor vehicle registrations but account for 22-25% of all trips taken. In cities such as Mumbai, which has a population of over 20 million, the mode share of auto-rickshaw stood at 20 percent.[19] This demonstrates the significant role auto-rickshaws play in urban commuting and in facilitating seamless connectivity between public transportation hubs.

Source: Freepik

As of March 2024, India (not including Telangana) has about 9.32 million registered 3Ws, doubling from 4.8 million in 2010.[20] Out of this, 1.67 million are 3W goods vehicles, 7.42 million are 3W passenger vehicles, and 0.22 million are 3W personal vehicles. The trend is that newly registered 3Ws continue to surpass their previous high from the last 10 years.[21] India leads the global three-wheeler market, with well-established manufacturers such as Bajaj Auto, Mahindra, and Piaggio commanding over 90% of the domestic market share.[22] In the fiscal year 2021-22, India produced over 7.5 lakh units of 3Ws, of which 4.9 lakh units (60%) were exported to destinations like Sri Lanka and Nepal.[23]

Despite this, the electric auto-rickshaw manufacturing landscape in the country remains in its early stages, with only 4,250 e-autos registered in 2022.[24] In the domestic market, over 10.5 lakh three-wheelers (including petrol, CNG, LNG, and electric variants) were sold between April 2023 and February 2024. Nearly 54% were electric, indicating that every second three-wheeler sold in India is now an EV.[25] While e-rickshaws account for over 90% of the sales in the 3W category, followed by cargo-carrying three-wheelers, passenger auto rickshaws only represent 5%, indicating a fledgling stage.[26] E-autos face challenges such as higher upfront costs and stringent regulations, resulting in low adoption rates despite their favorable total cost of ownership (TCO) and lower operating expenses compared to ICE counterparts.[27] Additionally, barriers like inadequate charging infrastructure and limited access to financing further hinder adoption by fleet operators and individual owners.[28]

1.2 INDIAN 3WS: FUEL TYPE & ASSOCIATED EMISSIONS

As of February 2024, 44.5% of the total registered passenger three-wheelers in India are powered by diesel, 13% by petrol, and 19% operating with a mix of petrol, CNG, and LPG. The rest are CNG/LPG and Electric (Vahan Dashboard). The lifecycle emissions for diesel and CNG auto-rickshaws, encompassing emissions from manufacturing, operations, and end-of-life processes, are 177 grams of carbon dioxide equivalent (gCO2e) and 122 gCO_2e of GHG emissions per vehicle kilometer, respectively.[29]

Studies have shown that pollutant concentrations in unenclosed transportation modes are substantially higher than ambient. Specifically, fine particle concentrations within these vehicles are 1.5 times greater than those present in the surrounding environment, while black carbon concentrations reach a staggering 3.6 times ambient levels.[30] Such heightened levels of pollutants pose a severe threat to public health, exacerbating respiratory and cardiovascular issues.[31] This concern is compounded by the widespread use of auto-rickshaws for school transportation in Indian cities. Consequently, children, who are among the most vulnerable groups, are disproportionately exposed to these harmful emissions, potentially impacting their health.

Table 1: Pollutants in Vehicle vs Ambient Levels[32]

Pollutant	Unit	In-vehicle	VS	Ambient	Ratio
Fine particles (PM2.5)	µg / m^3	190	vs	130	1.5x
Black carbon	µg / m^3	42	vs	12	3.6x
Ultrafine particles	µg / cm^3	280,000	vs	35,000	8.4x

Note: Black carbon, a byproduct of incomplete combustion and a component of PM2.5, is linked to "probable" human carcinogens like diesel exhaust and polycyclic aromatic hydrocarbons.[33]

Source: Freepik

Emission standards are relatively less stringent for the three-wheeler category, compared to four-wheeler vehicles.These three-wheeled vehicles are powered by small, single-cylinder diesel engines with less than 500 cc displacement; if this engine size is exceeded, regulations for four-wheelers will apply under the Central Motor Vehicle Rules. Experts note that these small engines, with their unstable emissions and high exhaust temperatures, limit the applicability of advanced and effective after-treatment systems typically used in other diesel vehicles. These vehicles generally meet emission standards through improved calibration and optimization, as most solutions for larger engines are not adaptable to these small engines. None of these diesel models employ widely used systems in cars, such as automatic fuel injection timing control, catalytic converters, or exhaust gas recirculation. Instead, they focus on optimizing combustion, automatic ignition timing, reducing friction, and improving air filters and lubricating oil. Additionally, given the price sensitivity of this market, expensive solutions are not feasible. Under the advanced BSVI regime, while testing parameters for all other vehicle segments will significantly improve, three-wheelers will still be subjected to the same outdated testing systems and requirements, such as the much less rigorous and older Indian Driving Cycle.[34] For instance, under the BS IV emissions guidelines, diesel autos were permitted to emit 1.7 times more PM and 1.3 times more NOx + HC than BS IV diesel cars. Under BS VI standards, a diesel auto-rickshaw emits approximately six times more PM and two times more nitrogen oxide as compared to a diesel car.[35]

Additionally, a majority of the ICE auto-rickshaws in India still operate on two-stroke and single stroke engines. With their unstable emissions and high exhaust temperatures, these engines release excess amounts of PM_{10} emissions.[36] A 2017 study found that a fleet of over 1.2 lakh auto-rickshaws in Bengaluru produced over 1,200 tonnes of carbon dioxide emissions per day. A complete transition to e-autos within Bengaluru could potentially decrease 0.45 million tonnes of carbon dioxide emissions each year.[37] It would also lower emissions of other pollutants, with an estimated reduction of 164.6 tonnes of PM_{10} and 1,445.3 tonnes of NOx[38]. On an average, a single ICE auto releases 3.72 tons of CO_2, 0.014 tons of NO_x and 0.004 tons of PM_{10} signifying substantial potential to mitigate vehicular emissions in urban areas by shifting from internal combustion engine (ICE) auto-rickshaws to electric ones.[39]

However, the high initial costs of new electric auto-rickshaws, which are nearly 50% more expensive than conventional ICE autos, remain a major deterrent to the switch to electric. For example, the cost of a new electric autorickshaw ranges from INR 3 - 4.5 lakh. Retrofitment can reduce this cost by 50-60%, offering similar environmental benefits as purchasing a new electric vehicle.[40] Retrofitting offers a potential solution to overcome the significant obstacle of range limitation in new e-3Ws, by ensuring a substantial portion of capital expenditure can go towards enhancing battery capacity and effectively addressing operational concerns. This strategic approach to retrofitment can improve the range of e-3Ws and thereby better meet the needs of users.

1.3 BENEFITS OF RETROFITMENT

1.3.1 Material Savings from Retrofitting Internal Combustion Engine (ICE) Three-Wheelers to Electric

Retrofitting has emerged as a viable solution to address the declining efficiency and increasing operational costs associated with aging vehicles, such as ICE auto-rickshaws that have already surpassed the 4-5 years lifespan.[41] This technology extends the lifespan of these vehicles by an additional 5-7 years, resulting in direct reductions in resource consumption and carbon emissions.[42] With an estimated 7.5 lakh three-wheelers reaching end-of-life (ELV) status by 2025, nationwide retrofitment initiatives present an opportunity to salvage a significant amount of valuable metal resources.[43] For example, retrofitting a single auto-rickshaw can reclaim approximately 220-230 kilograms of metals from the existing ICE engine and components, while also extending the lifespan of existing ELV autos, thus saving the approximately 390 kilograms of metal required for each new auto introduced.[44] This conservation is made possible by reusing the same chassis, body frame, braking systems, trailing arm, and steering system. For example, in the retrofitting process of an L5M ICE autorickshaw, approximately 41 components are retained, and the following 15 components are added.[45]

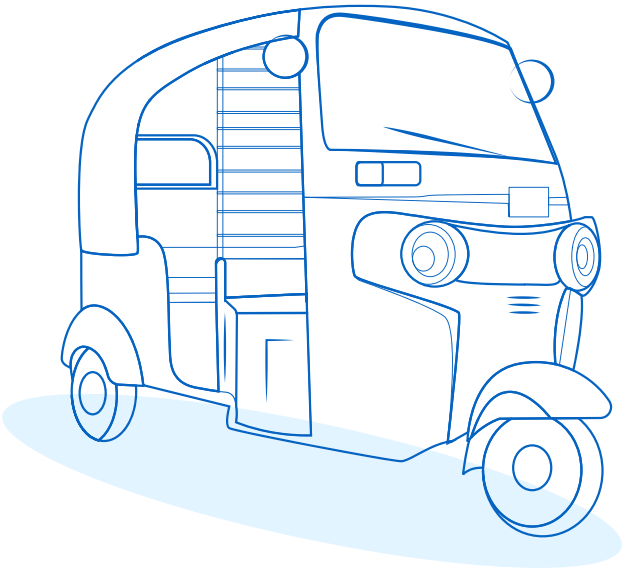


Table 2: Components that are Added to the Auto-rickshaw during Retrofitment[46]

Notably, the weight of an ICE-autorickshaw, including the engine, is around 392 kgs. Retrofitting reduces the net weight by approximately 10-15% (considering the weight of an 8-kWh battery), thus lightening the load of the vehicle.[47]

Source: Freepik

1.3.2 Health Benefits of Retrofitment: Insights from a Survey Analysis

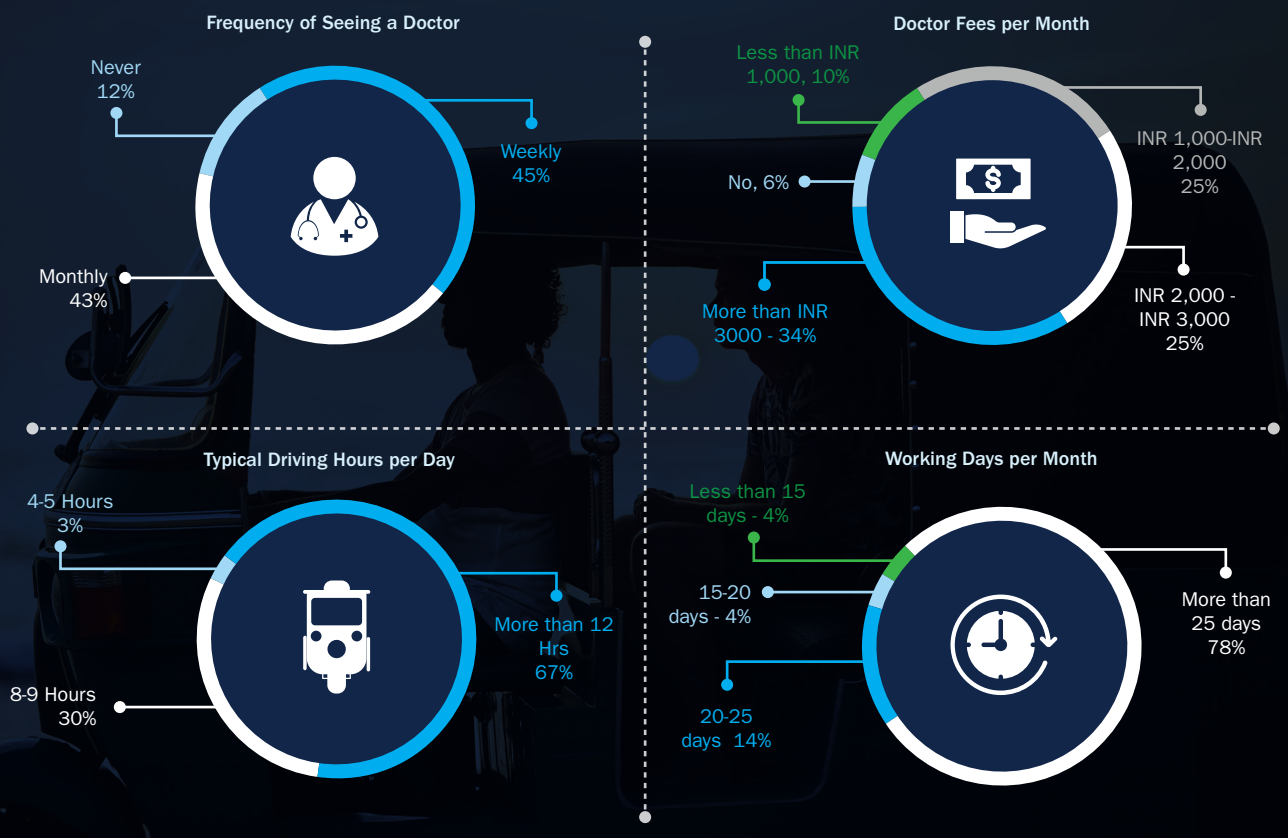
In partnership with the Telangana Gig and Platform Workers Union, NRDC-ASCI conducted a survey among approximately 50 auto drivers within the Greater Hyderabad Municipal Corporation (GHMC) limits to evaluate the musculoskeletal health issues and associated costs incurred due to operating ICE-autorickshaws. The findings reveal:

- The majority of ICE-autorickshaw drivers experience frequent musculoskeletal issues, including back pain (82%), shoulder pain (77%), knee & leg pain (92%), and neck pain (82%) on a daily or weekly basis. A significant portion of these drivers seek medical attention either on a weekly (45%) or monthly (43%) basis, while some opt to ignore their health symptoms due to financial constraints.
- The severity of these health impacts is exacerbated by the extended daily driving hours, with 67% driving for more than 12 hours daily, and 30% driving for at least 8-9 hours. Additionally, 78% of drivers operate vehicles for over 25 days in a month.
- While 69% of respondents possess basic awareness regarding the health and cost benefits of e-autorickshaws, barriers such as upfront costs and limited understanding of financing and uptake mechanisms hinder their interest. Among those unaware of retrofitment benefits, 92% express a willingness to learn more.

These findings underscore the urgent need to transition to electric autorickshaws, highlighting the significant health benefits associated with such a shift, particularly given the health costs incurred from operating ICE-autorickshaws.

The following figure shows the survey data illustrating the average driving hours, working days per month, frequency of doctor visits, and associated medical expenses.

Figure 1: Survey Data Illustrating Average Driving Hours, Working Days per Month, Frequency of Doctor Visits, and Associated Medical Expenses.



These significant health issues and related medical costs are due to the specific driving requirements with ICE-autorickshaws such as the high number of gear changes ~1300 times per day.[48]

Understanding the Electric Vehicle Retrofitment Process – What Does It Entail?

2

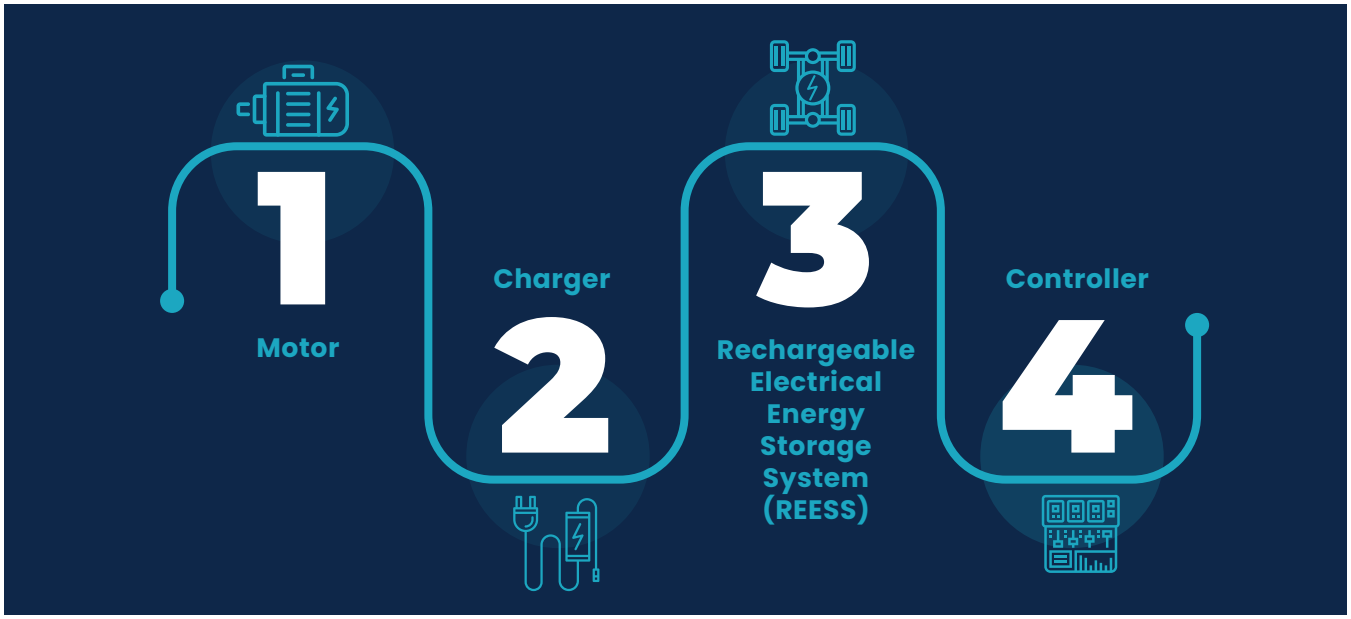
2.1 WHAT IS ELECTRIC VEHICLE RETROFITMENT?

Electric vehicle retrofitting involves converting conventional petrol or diesel vehicles into electric ones by replacing the original engine with an electric powertrain.[49] Any retrofit kit must undergo approval from a designated testing agency, as mandated by rule 12b of CMVR 1989.[50] The Automotive Research Association of India (ARAI) has published the Automotive Industry Standard AIS-123 (Part 3) to regulate retrofit kits, also known as electric propulsion kits.[51] Following homologation (i.e. essential approvals required by vehicle manufacturers before marketing and selling a vehicle) by ARAI or ICAT and approval from local state transport authorities, retrofitting can proceed for specific vehicles. Once completed, the vehicle must be re-registered at the RTO as an electric vehicle. The company conducting the retrofitment, approved by ARAI or ICAT, is considered the vehicle manufacturer and provides all necessary documentation for RTO compliance, similar to new vehicle manufacturers.[52]

2.2 WHAT COMPONENTS GET REPLACED IN THE ICE TO ELECTRIC VEHICLE RETROFITTING PROCESS?

Retrofitters adapt the old vehicle's chassis and body to accommodate the electric powertrain, but this process of disassembling and reassembling the vehicle presents its own set of engineering complexities. The fuel tank, engine, fuel pipes, and exhaust system are removed and substituted with a battery, inverter, and a motor. Engineering challenges in the retrofitment process include determining the appropriate size for the battery and motor, as well as effectively coupling the motor with the existing vehicle transmission system. According to India's Automotive Industry Standards 123 (AIS 123), it is considered ideal if the weight difference between the original and retrofitted vehicles is approximately 10%.[53]

Figure 2: Key Components for the Retrofit Kit



The Electric Propulsion Kit for retrofitting vehicles primarily comprises of four major components: [54]

- Motor with Controller
- Throttle Body
- Rechargeable Electrical Energy Storage and Supply System (REESS)
- Charger and Other Accessories

Additionally, minor components such as the Throttle Controller, State of Charge Display, Transmission Wires, DC/DC Converter, and Battery Management System are integral to the retrofit process.[55] A visual schematic illustrating the retrofit kit is provided in Annexure 1.

2.3 OVERVIEW OF THE RETROFITTED 3W & THE ASSOCIATED COST STRUCTURE

The retrofitted auto specifications include a 5,000 W motor capable of achieving a maximum speed of 50 km/h. These e-autos have a gross vehicle weight (GVW) capacity of up to 680 kg and can carry loads of up to 380 kg. Featuring a peak power of 7,700 W and an impressive range of 80-100 km, they offer versatility for urban transportation. Charging typically takes 3-4 hours using a standard 220/230 V power source, with the option for battery swapping. Both the battery and motor/controller components come with a 3-year warranty. With a peak torque of 58.5 Nm, these vehicles ensure sufficient acceleration and power delivery to meet diverse urban transportation demands.[56] For details on the testing parameters of the retrofit kit please refer Annexure 2.

Table 3: Overview of Retrofitted 3W Specifications

Motor	5,000 W	**Range**	80-100 km
Speed	50 km/h	**Charging**	Time: 3-4 hours Type: 220/230 V Battery swapping is also possible
Weight	GVW: up to 680 kg Load: up to 380 kg	**Warranty**	3 years for both battery & motor and controller
Peak Power	7700 W	**Peak Torque**	58.5 Nm

Based on the stakeholder consultation with retrofitment kit providers, the costs associated with the various components are captured below.

Table 4: Cost of Components[57]

Kit Name and Description	Cost (Avg)
Motor with Controller - core element of the electric propulsion system, responsible for converting electrical energy into mechanical motion	INR 40,000
Throttle Body - component, contributes to the overall functionality of the electric propulsion system by controlling the power output	INR 15,000
REESS - Component responsible for storing and providing energy (an 8 kWh battery assumed with approximate costs at INR 11,000 per kWh)	INR 88,000
Other Accessories - Charger and more	INR 10, 000

Additional costs involved with retrofitment would be:

- Installation Charge: approximately INR 5,000
- GST (Goods and Services Tax): 5% on the overall cost

Therefore, the Total Cost of Retrofitment = (Cost of Kit) + (Installation Charge) + (GST) which would cost approximately INR 1,65,900 in total.[58]

2.4 ELIGIBILITY OF ICE-3W FOR ELECTRIFICATION

While the age of the auto-rickshaw remains a critical factor in determining eligibility for retrofitting, clear standards are still lacking in many states. In practice, the age limitations for converting ICE auto-rickshaws to electric vary depending on fuel type, emission levels, and regulatory factors. Diesel autos might have stricter age restrictions due to their higher emissions. For example, following NGT norms, the Delhi government has outlined regulations stating that diesel/petrol/CNG autos under 15 years old are eligible for retrofitment.[59] However, petrol and CNG vehicles older than 15 years require re-registration and a fitness certificate to qualify for retrofitment, while diesel autos over 15 years old are not eligible for retrofitting. This criterion could serve as a guideline for other states too.[60] Further details are discussed in the following section.

2.5 STEP-BY-STEP GUIDE TO RETROFITTING: A CASE STUDY OF DELHI'S RETROFITMENT PROCESS

The Delhi government has established a procedure to ensure the retrofitment process is in compliance with safety and regulatory standards, as per Rule 47A of the CMVR, 1989. Vehicle owners seeking retrofitment must submit a retrofitment request using Form 22 PART-I to the registering authority.[61] They are also required to fill out Form 22C PART-I, providing details such as vehicle registration number, make, model, month and year of manufacturing, category, existing fuel type, pure electric kit manufacturer/importer name, kit name, kit identification number/name, and the name and address of the Electric Retro-fitment Centre (ERFC) chosen for the retrofitting process. Upon submission of the form, permission for retrofitting would be granted or denied within seven working days from the submission date.[62] If the registering authority fails to approve or reject the application within this period, the approval is deemed to be granted automatically. Once permission is obtained, vehicle owners proceed to an approved ERFC to have their vehicles retrofitted with the approved pure electric kit. This procedure could be replicated in other states as well.[63]

Figure 3: Process of Retrofitment in Delhi[64]

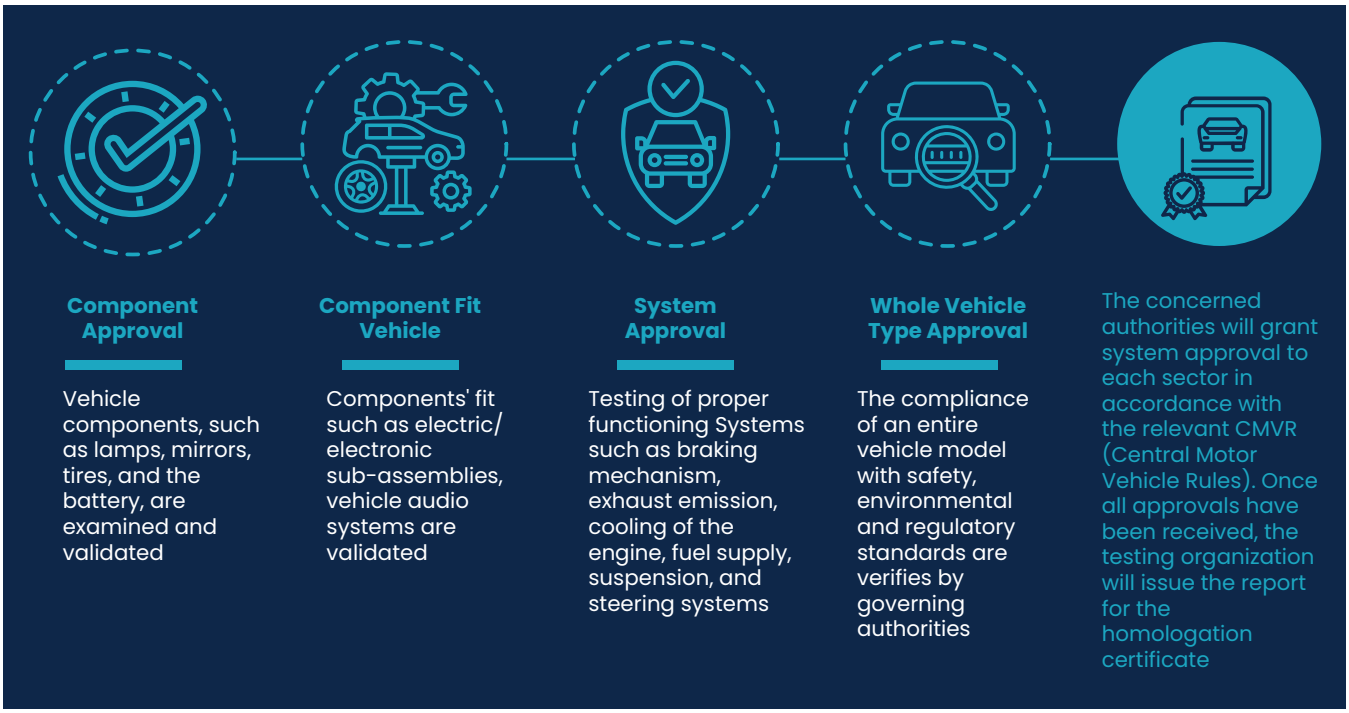
After the retrofitment process, vehicle owners need to apply for the new registration certificate (RC) certifying the conversion to electric fuel. It takes about seven working days to issue the new RC.[65] For more details on forms 22F22A, 22C please refer to Annexure 3.

A significant challenge hindering the adoption of retrofitment is the dearth of retrofit kit providers, mainly due to the limited scale and the complexities of the homologation process for retrofitment kits. Therefore, it is imperative to delve into the homologation process, identify the challenges to chalk out the roadmap for smooth operationalization of the retrofitting process.

2.6 NAVIGATING HOMOLOGATION: UNDERSTANDING THE PROCESS AND ASSOCIATED CHALLENGES

In India, there are two agencies, ARAI and ICAT, that are responsible for conducting comprehensive vehicle and kit-related tests and issuing certifications. The homologation tests ensure that electric vehicles adhere to the Central Motor Vehicle Regulations, verifying their compliance with standards for roadworthiness, safety, and emissions within India.

Figure 4: Process of Homologation



For the process of retrofitting ICE vehicles to electric autos, homologation of the retrofit kit is necessary. This is a multi-phase process ranging from component-level approval to whole vehicle compliance. The process of homologation is detailed above in Figure 4, illustrating the comprehensive steps involved in ensuring regulatory compliance and safety standards for electric vehicles. Annexure 4 provides a comprehensive list of testing & safety standards that the retrofit kit needs to comply with.

2.7 UNDERSTANDING OWNERSHIP MODELS TO ENHANCE RETROFITMENT SOLUTIONS

Research indicates that owning an auto-rickshaw typically yields greater savings and higher overall incomes for drivers compared to renting.[66] However, many drivers face challenges in vehicle ownership due to limited access to formal and affordable credit, leading them to resort to renting autorickshaws instead. Given the price-sensitive nature of this segment, it is crucial to explore various ownership models to make retrofitment solutions more appealing. These models typically fall into two categories: fixed battery ownership and battery-as-a-service (BaaS), which decouples the EV and its battery by enabling the use of the battery as a service, rather than requiring ownership of the battery.

Battery Ownership Models

Fixed Battery: A fixed battery refers to a battery that stays connected to a specific EV for its entire period of use in mobility applications. EVs equipped with fixed batteries can only be charged via plug-in charging, which requires utilization of public charging stations, workplace charging facilities, or home charging setups.

Battery Swapping: Battery swapping refers to a method of addressing the charging needs of battery-powered EVs by replacing depleted or partially charged batteries with fully charged ones. This process can be carried out manually or with mechanical assistance. It allows for the separation of the cost of the EV battery from the overall vehicle cost, enabling the purchase of the vehicle without the added expense of the battery. To support this approach, NITI Aayog released a draft battery swapping policy in 2022. However, there are operational challenges related to standardization and safety of swappable battery form factors that need to be addressed for the development of a comprehensive swapping network.

Image 1: Typical Retrofitted e-3W with fixed and swappable battery pack (Source: RACEnergy and Zero 21)

Both fixed charging and battery swapping are two distinct approaches for recharging e-autorickshaws, each with their own set of use-cases and advantages. The choice between these methods depends on the needs of the owner and the available battery charging and/ or battery swapping infrastructure. Therefore, the next crucial step involves comprehending the market landscape of retrofitment service providers and their offerings concerning fixed and swappable battery packs.

2.8 RETROFITMENT SERVICE PROVIDERS

As of January 2024, India had approximately 956 Retrofitment Centres (excluding Telangana) specializing in converting vehicles from petroleum to CNG and diesel to CNG. However, there are only a few retrofitment service providers offering the conversion of ICE auto to electric auto. The table below provides the list of electric retrofit kit providers:

Table 5: Current Suppliers of Retrofitment Kits[67]

Retrofit Supplier	Category	Battery Type	Vehicles Retrofitted
3 EV	e-3W	Fixed	Not Available
Zero 21	e-3W	Fixed	46+ (as of 06.04.2024)
Velev Motors	e-3W	Fixed	Not Available
RACEnergy	e-3W	Swappable	90 (as of 03.10.2022)
Envirosmart	e-3W	Fixed	60 (as of 30.10.2023)
Bounce	e-3W	Swappable	Not Available

Existing EV retrofit operators and OEMs typically provide complete retrofitted vehicles rather than just retrofit kits. Telangana, the first state to recognize and incentivize retrofitment, has become a hub, with 70% of retrofit kit providers located there. These retrofit kit providers offer services such as fixed battery retrofit kits and swappable battery retrofit kits, catering to diverse customer needs. While fixed battery retrofit kits entail higher capital expenditure compared to swappable battery options, both alternatives boast significantly lower operational costs compared to traditional ICE vehicles. In the realm of autorickshaws, several certified providers of retrofitment kits exist, including Zero 21, Envirosmart Enterprises, and RACEnergy, all situated in Telangana.[68] These service providers are equipped to retrofit any ARAI "L5M" category autorickshaw intended for passenger transport. While headquartered in Hyderabad, these entities extend their services beyond Telangana, catering to other states as well.

SERVICES PROVIDED BY TWO RETROFITTING COMPANIES

ZERO 21 commenced its operations in 2018, focusing on fixed battery options ranging from 5 kWh to 10 kWh capacities. The retrofitment kit offered by the company has received approval from ICAT. In 2024, they initiated a project named Gagan with an ambitious goal of converting at least 100,000 ICE-autorickshaws into e-autorickshaws through retrofitment or by exchanging them with new e-autorickshaws over the next five years. This initiative aims to support India's transition towards sustainable transportation and a zero-emission future.

Envirosmart Enterprises commenced operations in 2021 and provides fixed battery choices ranging from 6 kWh to 9.6 kWh in capacity. Their retrofitment kit has received approval from both ICAT and ARAI. According to Envirosmart, their retrofitment kits are compatible with platforms such as TATA Ace, Honda Active, Bajaj RE, and Piaggio Ape autorickshaws.

Techno Commercial Aspects

3

This section offers a comprehensive techno-commercial analysis of retrofitted autorickshaws in contrast to their ICE counterparts. The evaluation draws upon data gathered from retrofit kit providers, auto driver partners, and on-site surveys. The primary aim of this endeavor is to furnish policymakers with an in-depth understanding of Total Cost of Ownership (TCO) parity, operating costs, and the payback period linked to retrofitment models employing fixed and swappable battery technology. This understanding serves as the cornerstone for devising strategies to incentivize retrofitment.

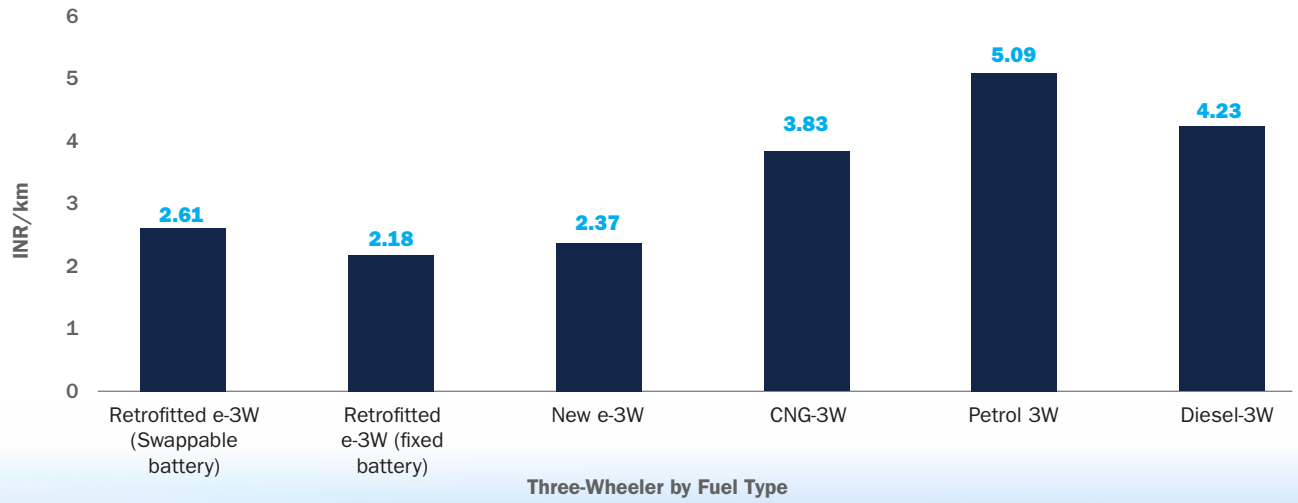
Table 6: Total cost of ownership for auto-rickshaws by fuel type over a 10-year period

	Type of cost	Retrofit - Swappable	Retrofit- Fixed	New E-3W	CNG-3W	Petrol-3W	Diesel-3W
Capital Cost	Vehicle/Kit Cost (₹) (inclusive of GST)	65,000[69]	1,53,000[70]	3,17,000[71]	2,35,398[72]	2,27,000[73]	2,48,073[74]
	Installation & Misc. Cost	5,000	5,000	-	-	-	-
	GST on retrofit vehicle @5%	3,500	7,900				
	Registration Fee (New + renewal)[75]	3,100	3,100	0	3,100	3,100	3,100
	Permit Fee[76]	-	-	-	1,200	1,200	1,200
	Road Tax @ 12% (₹)	-	-	-	28,248	27,240	29,769
	State Financial Incentive (₹)	0	15,000		-	-	-
	EMPS Subsidy	-		50,000	-	-	-
	Average 3-year Insurance Cost (₹)	19,704[77]	19,704[78]	20,094[79]	18,723[80]	18,543[81]	18,093[82]
	Effective Vehicle Cost (₹)	96,304	1,73,704	2,87,094	2,86,669	2,77,083	3,00,235
	Remaining Insurance Cost (₹)	45,955	45,955	46,886	43,687	43,267	42,217
	Interest Rate (%) for 3 years at 90% LTV ratio	18	18	14	11	11	11
	Additional Interest Paid [83](₹)	26,673	47,133	59,531	46,078	44,537	48,258
	Total Capital Cost (₹)	1,68,932	2,66,792	3,93,511	3,76,434	3,64,887	3,90,710
Operational Cost	Energy Cost (₹/kWh; ₹/kg; ₹/L)	25[84]	14	14	90.5	107.41	95.65
	Mileage (km/l, km/kWh)	10	10	12	28.4[85]	20.1[86]	25.4[87]
	(Fuel/charging cost)/km	2.5	1.4	1.16	3.18	5.34	3.76
	Average Yearly Energy/Fuel Cost (₹) (considering 110 VKT/day) (300 days/year)	82,500	46,200	38,500	1,05,158	1,76,344	1,10,551
	Battery Replacement[88] (₹) (@INR 11000/Kwh)	-	88,000	88,000	-	-	-
	Maintenance Cost[89] (₹/km)	0.10	0.05	0.05	0.8	0.75	0.75
	Running Cost per km Including Maintenance	2.6	1.45	1.21	4.6	6.09	4.51
	Annual Maintenance Cost (₹)	3,300	1,650	1,650	26,400	24,750	24,750
	Total Operational Cost (10 years) (₹)	8,58,000	5,66,500	4,89,500	13,15,580	20,10,940	13,53,010
Average TCO [90](₹/km)		**2.61**	**2.18**	**2.37**	**3.83**	**5.09**	**4.23**

NOTES:

- **Vehicle Selection:** The analysis focuses on the Bajaj RE model and its variants: CNG, petrol, diesel, and electric.
- **Fuel Prices:** Fuel prices are assumed to reflect the current rates in Hyderabad as of April 15th, 2024.
- **Driving distance**: An average driving distance of 110km/day, with 25 days a month as operational are assumed.
- The loan tenure is assumed for 3 years i.e. 36 months
- Battery capacity assumed of 6 KW for swap scenario, 8 KW for fixed battery, mileage of 10km/kWh.
- The assumed resale value at the end of the holding period is 5% for retrofitted autos and 10% for ICE and new e-auto. Similarly, discount rates of 5% for retrofitted auto and 10% for ICE and new e-auto are applied at the end of the holding period.
- TCO for retrofits only considers the post-retrofitment period, excluding expenses from ICE operation, focusing solely on the expenses incurred after the conversion to electric power. In contrast, TCO calculations for ICE vehicles encompass the entire lifespan of the vehicle. This approach provides a more accurate view of electric propulsion's economic benefits from retrofitting.
- For details on insurance costs related to retrofit auto please refer to Annexure 5.

Figure 5: Total Cost of Ownership for Auto-Rickshaws by Fuel Type over a 10-year period (INR/km)



Source: Freepik

Figure 6: TCO breakdown (INR/km)

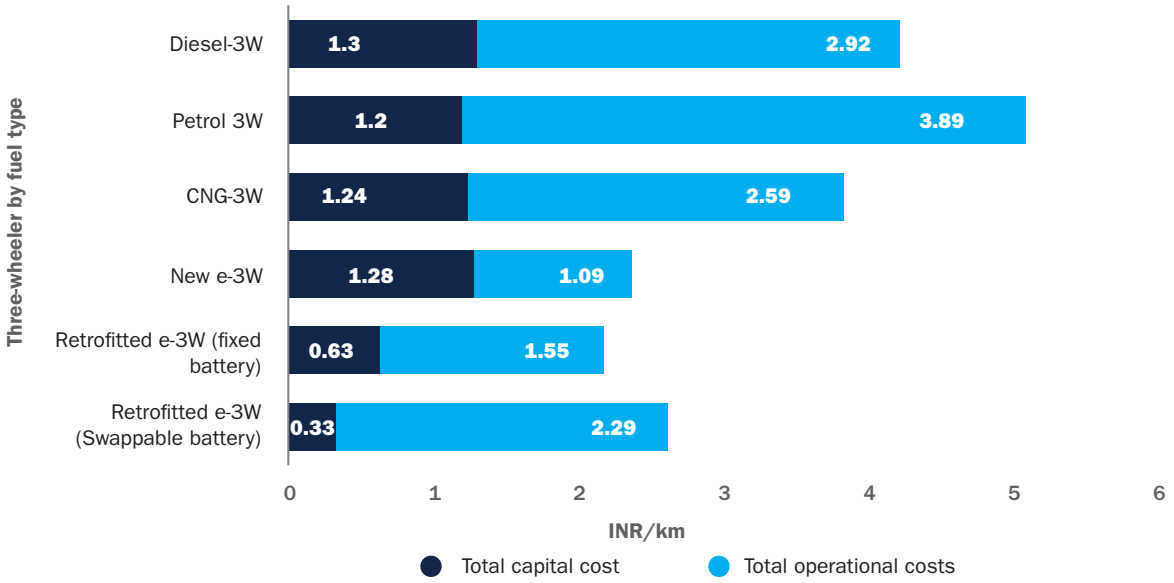


Figure 7: EMI Payable for Auto-Rickshaw Models Over a 3-Year Period by Fuel Type (Retrofitted, New Electric, Diesel, Petrol, CNG)

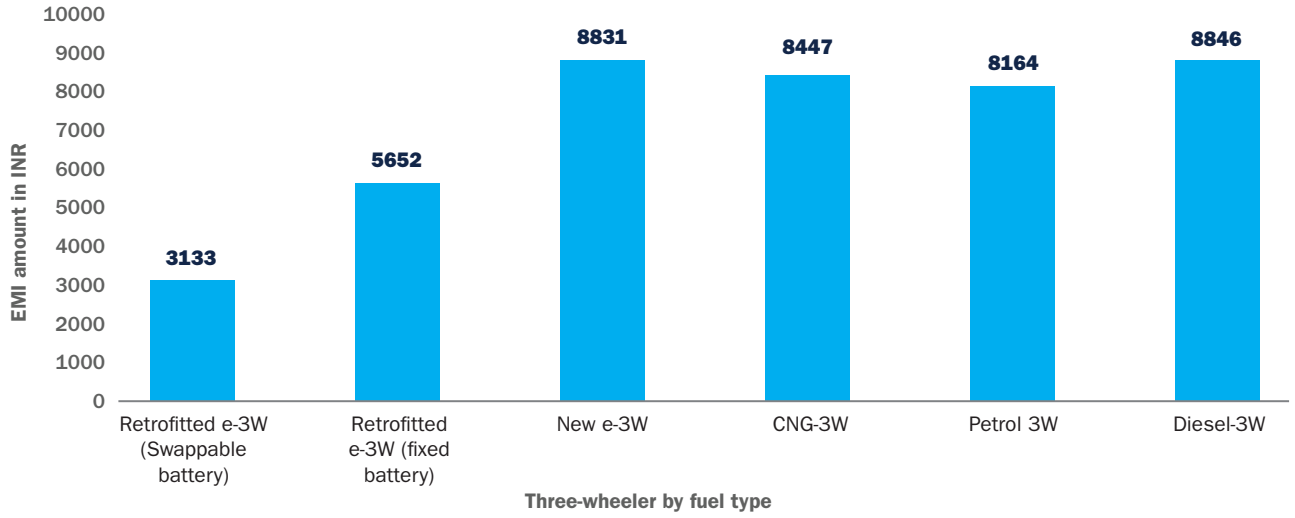


Table 7: Payback period analysis for retrofit, new electric and ICE autorickshaw models.

		Passenger retrofitted e-auto (fixed battery) with ICE-auto			Passenger retrofitted e-auto (Swappable battery) with ICE-auto		
Payback period	Description	CNG	Diesel	Petrol	CNG	Diesel	Petrol
	Fuel savings per km (INR)	1.78	2.36	3.94	0.68	1.26	2.84
	Total Saving per km (incl. maintenance) (INR)	2.53	3.06	4.64	1.38	1.91	3.49
	Working Days in Year (days)	300	300	300	300	300	300
	Fuel Savings in Year (INR)	58,740	77,880	1,30,020	22,400	41,580	93,720
	Savings in Maintenance in Year (INR)	24,750	23,100	23,100	23,100	21,450	21,450
	Total Savings in Year (INR)	83,490	1,00,980	1,53,120	45,500	63,030	1,15,170
	Cost of Retrofitment to Consumer (including GST, re-registration) (INR)	1,73,704	1,73,704	1,73,704	96,304	96,304	96,304
	Amount Payable with Interest (INR)	2,03,467	2,03,467	2,03,467	**1,12,805**	**1,12,805**	**1,12,805**
	Payback Period (years)	2.44	2.01	1.33	2.48	1.79	0.98

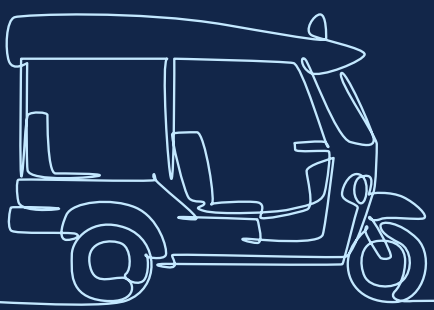
The table above presents a brief comparative analysis of petrol, diesel, and CNG autorickshaws with retrofitted e-autos, considering both fixed and swappable battery configurations, within the urban settings of Delhi.

Source: Freepik

3.1 KEY FINDINGS

OPERATING COSTS

The aforementioned analysis indicates that concerning operating costs, the running expenses of retrofitted autos with fixed batteries, are 62% lower than diesel, 70% lower than petrol, and 54% lower than CNG/ICE counterparts. On the other hand, the operating costs of retrofitted autos with swappable batteries are 34% lower than diesel, 48% lower than petrol, and 20% lower than CNG/ICE counterparts. Retrofitment with fixed battery results in slightly higher savings vis-à-vis swappable battery. From conversations with retrofitment kit service providers, this is mainly due to the relatively higher costs related to swapping (cost per swap) and lower range with swappable batteries as compared to fixed battery charging (cost per kWh). It is pertinent to note that players such as Zero21 and EnviroSmart have customised offerings with 10 kWh batteries, providing a range of 140-180 kms on full charge, a significant distance that directly mitigates concerns around range anxiety.



PAYBACK PERIOD

The payback period for retrofitting e-auto rickshaws with fixed batteries varies from approximately 1.33 to 2.44 years, contingent upon the type of ICE-auto (Petrol, Diesel, or CNG). Likewise, for retrofitting e-auto rickshaws with swappable batteries, the payback period ranges from about 0.98 to 2.48 years. For petrol and diesel autos, the payback period is relatively shorter, ranging from less than a year to 2.4 years. Since auto drivers typically rely on Non-Banking Financial Companies (NBFCs) or private financiers for loans, the above estimations assume an interest rate of 18% per annum on retrofitment-related costs. However, if demand incentives & affordable financing options with lower interest rates and a three-year tenure are made available, the value proposition of retrofitment becomes even more lucrative for the driver partner. Based on the data and analysis, a diverse mix of regulatory and market-based instruments is necessary to unlock and operationalize retrofitment solutions. These solutions hold immense potential to transform and transition the 3W fleet to electric. Therefore, the following section delves into the regulatory framework governing retrofitment and the incentives provided by various sub-national governments in India.

MONTHLY EMI

The analysis of Equated Monthly Instalments (EMIs) for various auto-rickshaw models over a 3-year period by fuel type highlights the cost-effectiveness of retrofitting existing vehicles with electric components, particularly those with fixed batteries. With EMIs substantially lower than those of new electric three-wheelers, retrofitted auto-rickshaws present a financially attractive option for driver partners. Despite offering environmental benefits, the higher EMIs associated with new electric models may deter some drivers from transitioning to electric vehicles. Conventional fuel options, while having varying EMIs, generally fall within a similar range. However, they entail higher operating costs and contribute to pollution. Affordable financing schemes can significantly enhance the appeal of retrofitting, making it a more lucrative option for driver partners and potentially accelerating the adoption of electric vehicles in the auto-rickshaw segment.

Navigating the Regulatory Landscape of 3-Wheelers and Retrofitment

4

To promote the rapid adoption of electric and hybrid vehicles, the government introduced the FAME II (Faster Adoption and Manufacturing of Hybrid and Electric Vehicles) scheme in 2019, offering purchase incentives across various vehicle segments and charging infrastructure. While the scheme provided purchase incentives for new electric 3Ws, it did not cover retrofitment. The absence of subsidies or incentives for 3W retrofitting under the FAME II scheme posed a significant challenge to achieving cost parity with new ICE three-wheelers. While several Indian states have established goals to electrify their three-wheeler fleets, many states are not on track to achieve the national objective of attaining an 80% market share of electric three-wheelers by 2030. They have struggled to meet these targets primarily due to the characteristics unique to this segment. The current targets set by each state are outlined in the table below:

Table 8: ZEV targets set by states in India

State	Policy Period	Target
Karnataka	2017-2022	Transition to 100% electric auto-rickshaws by 2030.
Kerala	2018-2023	Procure 90,000 e-autos by 2022 with a pilot fleet of 50,000 by 2020.
Tamil Nadu	2019-2024	Conversion of all auto-rickshaws within 10 years in a phased manner.
Uttar Pradesh	2019-2024	Achieve 100% electric auto-rickshaw fleet in 5 major cities by 2030.
Punjab	2019-2024	25% of new auto-rickshaw sales to be electric by 2024.
Bihar	2019-2024	Phase out manually-pedaled rickshaws and upgrade them to 100% electric rickshaws by 2022.
Maharashtra	2021-2026	At least 20% new 3W registrations to be electric by 2025. At least 25% of the urban fleet operated by fleet aggregators and operators in the state to be EVs by 2025.
Assam	2021-2026	Deploy 75,000 e-3Ws by 2025.
Goa	2021-2026	30% of annual registrations to be electric from 2025.
Chandigarh	2022-2027	All new auto-rickshaw registrations to be electric by 2025.
Rajasthan	2022-2027	30% of all new 3W-wheeler sales to be electric by 2027.

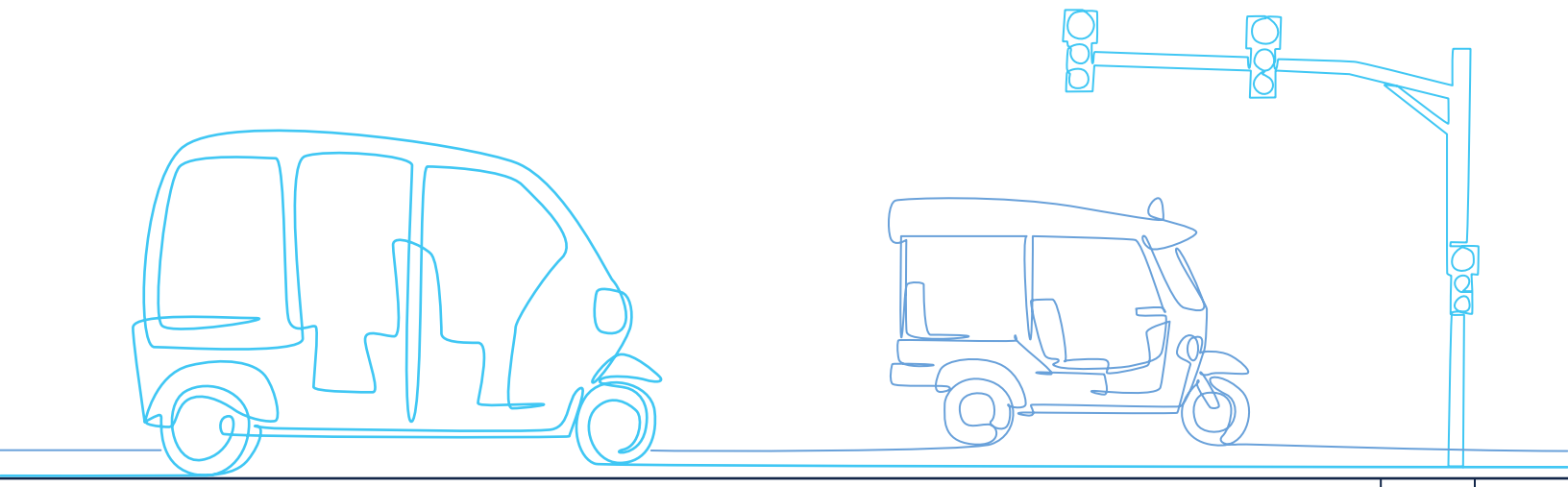
As states push for increased adoption of electric three-wheelers, retrofitting emerges as a potentially quicker and unique solution for transitioning this segment to electric power.

While the Government of India's FAME II scheme does not offer incentives for retrofitted e-autorickshaws, several state EV policies have integrated incentives for autorickshaw retrofitment.[91] Telangana, which was the first state to promote retrofitment incentives through its Electric Vehicle and Energy Storage (EVES) Policy 2020–2030, has inspired other states and Union Territories such as Goa, Assam, Tamil Nadu, Rajasthan, Chandigarh, and Delhi to propose incentives for retrofitment. The table below outlines the retrofitment-related incentives proposed in various state policies.

Table 9: Comparison of Incentives for 3-Wheeler Autorickshaw Retrofitment

State	Policy Period	Incentive	No. of Vehicles
Tamil Nadu	2023-2027, but vehicle cap period is 2023-2025	INR 10,000 per kWh of battery capacity and a maximum incentive of INR 20,000	15,000[92]
Telangana	2020-2030	15% of Retrofitment cost capped at INR 15,000	First 5,000 retrofitted vehicles (250 from the GHMC area and the remaining 4,750 from the non GHMC area)[93]
Rajasthan	2022-2027	15% of the Retrofitment kit cost (including taxes) upto INR 10,000 per vehicle	3,000[94]
Goa	2021-2026	Purchase incentive for conversion of old ICE vehicle into EV vehicle by retrofitting kit subject to approval by the RTO, will be provided to the registered owner of the EV as per the capacity of the battery or maximum upto capping of the state subsidy whichever is applicable[95].	
Assam	2021-2026	15% of Retrofitment cost capped at INR 15,000[96]	(no mention)
Chandigarh	2022-2027	15% of Retrofitment cost with a maximum incentive of INR 15,000	For the first 1,000 e-autorickshaws registered during the policy period including new e-autorickshaws and retrofitted e-autorickshaws[97]

Despite some states offering incentives for retrofitment, uptake has been limited, underscoring the importance of delving deeper into the challenges that constrain adoption and examining the perspectives of various ecosystem players.



Challenges and Recommendations

5

5.1 CHALLENGES

A. The Fundamental Challenge of Accessing Affordable Finance for Retrofitment

Access to financing stands as a formidable obstacle hindering the transition from ICE auto-rickshaws to e-autos. While banks and NBFCs increasingly offer financing options for e-2Ws and e-4Ws, loans for e-3Ws remain scarce and costly. Securing financing for retrofitment poses an even greater challenge. Banks are hesitant to extend auto-rickshaw loans due to borrowers' lack of credit history, unstable income, absence of collateral, and perceived high default risks in the sector. Moreover, the lengthy and complex loan application processes, along with stringent documentation requirements, inconvenience auto-rickshaw drivers seeking financing for electric models.

In instances where formal loans are available, financing institutions impose high interest rates, low loan-to-value ratios, short repayment periods, or strict collection mechanisms (such as demanding daily or weekly payments), which are unfavorable for borrowers.[98] Additionally, as part of the retrofitment process, drivers typically receive only around INR 20,000 as the scrap value for the ICE engine and components. Given that drivers typically take 3-5 years to repay loans for their ICE autos before owning the asset, their willingness to take on another loan for the same asset is minimal, especially when faced with exorbitant interest rates ranging from 18-24% per annum.[99]

Source: Freepik

Navigating Constraints: Retrofitment Solutions Pave the Way for e-3W Adoption – Looking through the Lens of Driver Partners

Current ownership patterns highlight that affordable financing remains one of the foremost challenges for driver partners. Financial apprehensions persist among auto drivers, leading a significant majority to seek assistance from financial institutions for vehicle procurement. Approximately 76% of vehicle owners opt for loans from banks and non-banking financial institutions, ranging from INR 2–2.75 lakh. The repayment period spans from three and a half to five years, with monthly installments ranging between INR 4,300 to INR 6,200. Consequently, a driver partner only assumes full ownership of the auto after approximately five years. As a result, they may hesitate to transition to new electric three-wheelers, which are even more expensive than conventional ICE three-wheelers. Retrofitting old vehicles presents an enticing opportunity, as it not only prolongs the vehicle's lifespan but also provides an opportunity to reduce operational costs.

While retrofitment presents a financially viable alternative, it necessitates substantial upfront subsidy support. Currently, retrofitment solutions are priced between INR 160,000-180,000 (INR 60,000 retrofit kit + INR 1-1.2 lakhs for the battery). One could likely see a significant adoption boost with a subsidy increase to 50% of the kit cost, as proposed by driver associations and unions.[100] Reducing the retrofitment costs to INR 1,00,000 could go a long way in accelerating adoption.

High charging costs also remain a challenge, as electricity bills for driver partners' residences can climb to INR 1500 or 2000.[101] To counter this, governments could intensify efforts to incentivize EV charging, mirroring successful practices implemented in other states.

Retrofitment – A unique value proposition for driver partners to be part of the Clean Mobility Transition

The adoption of e-3Ws faces numerous challenges, but retrofitment solutions offer hope for auto drivers. Range limitations remain a significant barrier, with new e-3Ws typically offering a real-life range of about 70 kilometers, falling short of the average daily run for drivers, which ranges from 110-140 kilometers.[102] However, retrofitment solutions provide a distinct advantage by directing much of the capital expenditure towards enhancing battery capacity, thereby addressing operational concerns more effectively.

Shaik Salauddin

National General Secretary, Indian Federation of App Based Transport Workers (IFAT) & Founder State President, Telangana Gig and Platform Workers Union

B. Permit Challenges Hindering Retrofitment for Electric Three-Wheelers

Local contract carriage permits are issued to auto-rickshaws, providing them with legal authorization to transport passengers at fares determined by state or Regional Transport Authorities. These permits are typically restricted in major cities to regulate the number of vehicles on the roads and ensure equitable livelihoods for auto-rickshaw owners and drivers. Consequently, permits play a pivotal role in facilitating the transition to electric auto-rickshaws.[103] The Ministry of Road Transport and Highways issued a 2018 notification directing states to exempt electric vehicles EVs from permit requirements but, most states are yet to implement this directive. [104] Permitting requirements, therefore remain a significant obstacle to the advancement of the retrofitment industry. Drivers often procure permits from the secondary market at inflated prices, and, if they choose retrofitment, the vehicle must undergo re-registration, which requires the permit to be surrendered for a substantially lower rate than its original acquisition cost. Additionally, the current digital infrastructure and processes within Regional Transport Offices (RTOs) frequently lack the capacity to manage the re-registration of existing ICE vehicles into electric ones. Additionally, many states' existing regulations and administrative procedures lack provisions specifically tailored for converting ICE vehicles to electric ones. This regulatory void creates uncertainty and impedes the re-registration process.[105]

C. Getting insurance for the retrofitted vehicle

Establishing an insurance ecosystem tailored to retrofitted vehicles poses a multifaceted challenge for insurers. Central to this challenge is the assessment of risk, which plays a crucial role in determining premiums for such vehicles. The inherent modifications involved in retrofitting presents difficulties for insurers in accurately gauging the safety and reliability of retrofitted vehicles, thereby impacting their ability to underwrite policies effectively.[106] Furthermore, the scarcity of extensive historical data in the nascent market of retrofitted vehicles exacerbates this challenge. Insurers heavily rely on historical data to accurately predict claims frequency and severity.[107] However, the lack of sufficient data hampers their ability to make precise predictions, potentially resulting in higher premiums or reluctance to provide coverage.

Another obstacle is the cost implications associated with repairing or replacing custom parts in retrofitted vehicles. These specialised components often come at a higher price, or their pricing is not yet standardized by the market compared to standard parts. As a result, insurers may consider charging higher premiums or imposing coverage limitations to mitigate potential losses in the event of an accident. Moreover, the early stage of the retrofitment market further complicates matters for insurance companies. The fundamental principle of the 'law of large numbers,' which posits that selling more policies enhances the predictability of claims, is challenged by the limited penetration and unpredictability of the retrofit market.[108]

Navigating Insurance Challenges in the Retrofitted Vehicle Landscape. Strategies and Solutions

Getting insurance for retrofitted vehicles presents a significant challenge, as traditional insurance principles, such as the law of large numbers, do not seamlessly apply. This difficulty is compounded by the lack of comprehensive information regarding the various components of retrofitted vehicles. While this poses obstacles, the retrofitment space holds immense promise. Retrofitting breathes new life into aging vehicles, offering drivers a sustainable livelihood while keeping costs manageable. Many private and public sector insurance providers are open to covering retrofitted vehicles, provided there are sufficient numbers to substantiate potential losses and accurate RTO descriptions.

To underwrite risks associated with retrofitted vehicles, insurance companies typically require several pre-requisites. These include valid RTO registration, traceability of the vehicle in case of loss or damage, unique identification numbers for key components, and comprehensive coverage options such as extended warranties and product recall insurance. When underwriting the risks of retrofitted three-wheelers, insurers consider factors such as roadworthiness, vehicle value, usage (commercial or private), and driver licensing. Clear RTO certification significantly influences insurers' willingness to underwrite risks associated with retrofitted vehicles. To reduce financing costs associated with retrofitted three-wheelers, insurers may prioritize paying financiers first in case of total loss, theft, or fire, provided the policy and RTO endorsements are in place.

Challenges in this space can be mitigated through enhanced data sharing from kit manufacturers, OEMS, and battery providers. Access to comprehensive data enables insurers to conduct more accurate risk assessments and offer tailored coverage options. Simplifying the insurance process for retrofitted vehicles requires streamlined documentation and pre-inspection risk reports provided to underwriters during the insurance application process. This approach ensures smoother coverage and claims management, benefiting both insurers and vehicle owners alike.

Sundaram Venkatavaradhan

Mananing Director, Abhivridhi Insurance Brokers

D. Infrastructure and Homologation Challenges: Barriers to Market Entry in the Retrofit Ecosystem

Homologation often comes with high costs, with expenses reaching up to approximately INR 18 lakhs.[109] The costs serve as a major barrier for many startups seeking to enter the EV retrofitment space. Moreover, the absence of proper electronic testing facilities exacerbates the issue, impeding product innovation and development for early-stage startups.

Consequently, companies struggle to ensure the quality and safety of their retrofit kits at competitive prices. The current infrastructure for retrofitting is limited, with only around 10 retrofit kit provision centers in the country nationwide. Although there are approximately 956 retrofitment centers listed on the Vahan Sewa portal, they primarily cater to the conversion of vehicles from petrol/diesel to CNG, further limiting the scope and reach of services in the EV retrofitment sector. [110]

CHALLENGES ASSOCIATED WITH HOMOLOGATION OF RETROFIT KITS:

While the homologation process is efficiently designed to uphold safety and environmental standards for emerging technologies in the automotive industry, the homologation of retrofit kit continues to face several challenges, as follows:

HIGH COSTS

The homologation process for a 3W retrofitment can cost up to INR 15 - 18 lakh, which is which is a significant amount considering that most companies involved in this solution are startups, and the scale is limited.[111]

LIMITED TESTING FACILITIES

Currently, homologation centers are concentrated in Pune and Manesar, posing significant challenges to local or regional players who lack access to proper electronic testing facilities. To address some of the issues with testing facilities, the Government of India has allocated over INR 3,727 crore for the National Automotive Testing and R&D Infrastructure Project (NATRiP).[112] This initiative aims to establish state-of-the-art automotive testing facilities dedicated to homologation and research and development in automobile engineering. Agencies such as ARAI (Pune) and ICTA (Manesar) have been tasked with homologating Electric 2Ws and 3Ws. Additionally, new centers such as GARC (Chennai), NATRAX (Indore), NIAIMT (Silchar), and VRDE (Ahmednagar) are being developed.[113] This government initiative aims to ensure that electric vehicles meet regulatory requirements and undergo rigorous testing to ensure safety, performance, and compliance with standards. However, some of these facilities are yet to be operationalized, and even if they are, they may not have the capacity to certify retrofit kits.

MODEL-SPECIFIC CERTIFICATIONS

Each retrofit kit needs to be certified for each vehicle model, requiring a significant investment of finances and time, which may not be viable at the current scale.

RECERTIFICATION REQUIREMENTS

Updates in government policies often necessitate different testing standards for vehicle components, leading to the need for re-certification.

CERTIFICATION TIME

Ambiguity and lack of awareness regarding documentation and processes during the application phase are increasing certification times.

E. Warranty and After-Service Concerns in Retrofit Kits and Battery Packs

Driver partners express significant concern regarding the warranty and after-service support for retrofitted vehicles, particularly concerning the battery and kit beyond the warranty period. Since battery costs constitute more than 50% of the retrofitted vehicle, any malfunction directly impacts the asset's earning potential, driver's livelihoods and ability to repay loans.[114] Additionally, the scarcity of service centers where retrofitted vehicles can be serviced adds to their apprehensions. Moreover, the lack of charging infrastructure further limits drivers willingness to pursue vehicle retrofitting.

Based on the challenges identified in the previous section, extensive on-ground surveys and stakeholder consultations were conducted with technology service providers, insurance and finance facing retrofitment solutions, which are outlined in the order of importance in the following section.

5.2 RECOMMENDATIONS

A. Fiscal incentives to harness potential of retrofitment solutions

Implementation of following steps could help accelerate the adoption of retrofitment technologies in the three-wheeler's segment:

- Offering Fiscal Incentives: Policymakers could implement an incentive of INR 25,000 to INR 30,000 per auto-rickshaw to offset retrofitting kit costs, and reduce the upfront costs for auto owners. This reduction in upfront costs for retrofitted e-3Ws can have significant impact in attracting entrepreneurs to explore business opportunities if scaled up.
- Streamlining State Incentive Processes: Policymakers should establish consistent and transparent processes across states. Despite some states offering retrofitment incentives, the lack of operationalization and consistency in processes hampers adoption. Streamlining and standardizing incentive processes can provide clarity and encourage wider participation from auto owners and retrofitment providers.
- Retrofit kit providers could offer a comprehensive three-year warranty and retrofit service providers could establish retrofitment service centers in each state.

B. Facilitating Affordable Financing for Retrofitment

To address the challenge of high financing costs associated with retrofitted three-wheelers, the following strategies are recommended:

- Interest subvention: Governments can provide financial incentives to reduce the cost of financing retrofitted vehicles, thereby making them more accessible to drivers. For example, the Kerala Financial Corporation, a government-owned enterprise, offers accessible loans for the conversion of ICE vehicles to e-autos. These loans cover up to 80% of the total vehicle conversion cost, including charger expenses, with a repayment period of up to 5 years. The interest rate for these loans stands at 7%, with the state government providing a 3% interest subvention.[115]
- Increased access to Green Funds (Green Funds, also known as sustainable or eco-friendly funds, are investment vehicles that primarily focus on companies and projects that promote environmental sustainability) for financing EVs: Financiers can leverage green funds or sustainable financing initiatives to offer loans at lower

interest rates for retrofitted vehicles, incentivizing their adoption.[116]

- Credit guarantee mechanisms: Governments or financial institutions can establish credit guarantee schemes to mitigate the risk for lenders, encouraging them to provide loans at lower rates to retrofitted vehicle owners. Collaboration with developmental banks such as SIDBI and the World Bank to establish a risk-sharing facility for scaling EV financing could further facilitate this process.
- Expansion of existing government schemes: Existing government schemes like the Micro Units Development and Refinance Agency Ltd. (MUDRA) and the National Clean Air Programme (NCAP) could be expanded to include financing for the retrofitment of ICE vehicles to electric autos. This expansion would enhance liquidity in the e-auto lending sector and provide collateral-free loans to small businesses and individuals, including auto-rickshaw drivers.[117]

Scaling up Retrofitment: Innovations and Challenges in the EV Financing Landscape

In Indian culture, the principles of reduce, reuse, and recycle are deeply ingrained in daily life. These principles also extend to larger investments like vehicles, where repurposing and extending their lifespan are prioritized. At Evate, we recognize the vast potential of the retrofitment market, estimated at upwards of USD 130 billion, based on the current on-road fleet. To catalyze this industry, we offer a tailored loan product for retrofits with flexible payment options and zero down payment, aiming to introduce leases and hybrid loan/lease options in the future.

Partnering with retrofitting companies, we've worked alongside Go-digit to craft an insurance product for retrofitted vehicles, considering parameters such as technology risk, asset condition, compliance, service support, and credit risk in our underwriting process. However, despite our efforts, we are yet to issue a loan due to the unavailability of OEMs meeting our rigorous criteria.

Challenges persist in ensuring the reliability of retrofit kits, scaling up on-ground service support, maintaining prompt issue response times, and complying with state-level regulations. Greater data sharing among kit manufacturers, OEMs, and battery providers could significantly mitigate these challenges. Implementing CAN-connected telematics devices to monitor drivetrain and battery health and sharing this data among stakeholders could facilitate preventive maintenance, product improvement, and better securitization for financiers, ultimately fostering a more robust retrofitment ecosystem.

Vijay H Madhusudan

Co-Founder, Evate

C. Ratifying Permit Regulations to Drive Adoption of Electric Three-Wheelers

To expedite the transition to electric auto-rickshaws and promote retrofitment, policymakers can implement the following permit-related measures:

- Ban on New Permits and Registrations for ICE Auto-Rickshaws: Following the examples set by other states, such as the Commission for Air Quality Management's ban on registrations of petrol and diesel auto-rickshaws in the National Capital Region, and similar initiatives by the Punjab Pollution Control Board in major cities of Punjab, states can enforce a ban on issuing new permits for ICE auto-rickshaws. This policy signals a commitment to shifting away from fossil fuel vehicles and incentivizes the adoption of EVs.[118]
- Non-Renewal of Permits for ICE Auto-Rickshaws: State Transportation Authorities (STAs) can emulate successful practices from other regions by halting the renewal of permits for ICE auto-rickshaws. Mandating a conversion to electric vehicles as a prerequisite for permit renewal, as seen in various states, would prompt existing auto-rickshaw owners to transition to EVs.[119]
- Implementation of Priority Permits and Open Permits for E-Autos: Drawing inspiration from states that have introduced priority permits and restricted open permits solely for electric auto-rickshaws, STAs can adopt similar measures. By providing incentives for e-autos, including retrofitted ones, through prioritized permit availability, new entrants into the auto industry are encouraged to opt for electric vehicles.[120]

To complement these permit regulations, fiscal support instruments such as subsidies and incentives for e-autos and retrofit kits should also be introduced.

D. Zero Emission Vehicle Credits: Incentivizing Electric Retrofit Solutions

Globally, zero emission vehicle (ZEV) credits have been effectively utilized to incentivize OEMs to transition to EVs. Our interactions with stakeholders indicate that India is at a pivotal juncture where it should chart a roadmap that is not solely reliant on subsidies. Instead, it's time to gradually introduce a framework for ZEV credits.

Similar to the system implemented for new vehicles, ZEV credits for retrofit solutions can play a crucial role in incentivizing the adoption of electric retrofitment technologies. By rewarding OEMs and retrofitment providers with ZEV credits based on the emissions reduction achieved through retrofitting ICE vehicles to electric, we can encourage widespread adoption of cleaner transportation solutions.

Implementing a ZEV credit framework will not only incentivize manufacturers to invest in electric retrofitment technologies but also stimulate innovation and competition in the market. This approach aligns with India's ambitious goals for reducing vehicular emissions and transitioning to a sustainable transportation ecosystem.

E. Fostering an Insurance Ecosystem for Retrofitted Vehicles

To address the challenges surrounding the insurance ecosystem for retrofitted vehicles, insurers could prioritize collaborative efforts with industry stakeholders to establish standardized safety protocols and certification processes. This will enhance insurers' ability to accurately assess risk and determine premiums.

- Standardized Safety Protocols and Certification Processes: Insurers could work closely with industry stakeholders to develop and implement standardized safety protocols and certification processes for retrofitted vehicles. This collaborative approach ensures that all retrofitted vehicles meet minimum safety standards, reducing insurers' risk exposure and enhancing their confidence in providing coverage.
- Enhanced Data Sharing: Insurers could advocate for enhanced data sharing from kit manufacturers, OEMs, and battery providers. Access to comprehensive data enables insurers to conduct more accurate risk assessments and offer tailored coverage options, ultimately improving the affordability and availability of insurance for retrofitted vehicles.

By fostering an insurance ecosystem that prioritizes collaboration, standardized safety protocols, enhanced data sharing, and streamlined processes, insurers can effectively address the unique challenges associated with insuring retrofitted vehicles, ultimately promoting the widespread adoption of electric vehicle retrofitment technologies.

F. Addressing infrastructure barriers

To address infrastructure barriers hindering the adoption of retrofitment technologies, concerted efforts are needed to reduce certification costs for retrofit providers and enhance testing infrastructure. Budgetary provisions from the Ministry of Heavy Industries could be allocated to promote research and development (R&D) and foster innovation in the retrofitment sector. The government could prioritize the establishment of electronic testing facilities accessible to OEMs, facilitating product innovation and streamlining the certification process. These facilities could offer testing

slots at affordable rates to encourage widespread utilization. Furthermore, support could be extended for capacity building in existing retrofit services to enable them to transition to electric retrofits effectively. This includes providing training and resources to equip employees with the necessary expertise in retrofit technology. By leveraging the existing network of 956 centers, the government can expedite the incorporation of retrofitment services into their offerings, thereby expanding the market for electric retrofits. Although the VAHAN is a portal that facilitates the retrofitting process from diesel/petrol to CNG, individual states should develop similar portals dedicated to transitioning from ICE to electric vehicles. These portals should streamline procedures and eliminate existing inefficiencies in the process, ensuring a smoother transition.

By investing in R&D, enhancing testing infrastructure, and supporting capacity building initiatives, the government can overcome infrastructure barriers and accelerate the adoption of retrofitment technologies, driving the transition from ICE to electric vehicles.

Furthermore, the lack of adequate infrastructure for scientific engine disposal poses a barrier to sustainable transition by risking environmental hazards and the illegal re-circulation of outdated technologies. Establishing robust mechanisms for the responsible disposal of engines is crucial to safeguarding environmental integrity and preventing the resurgence of obsolete technologies in the auto-rickshaw sector. Additionally, stringent enforcement measures and regulatory oversight are essential to deter illicit activities and uphold sustainable practices in engine disposal.[121]

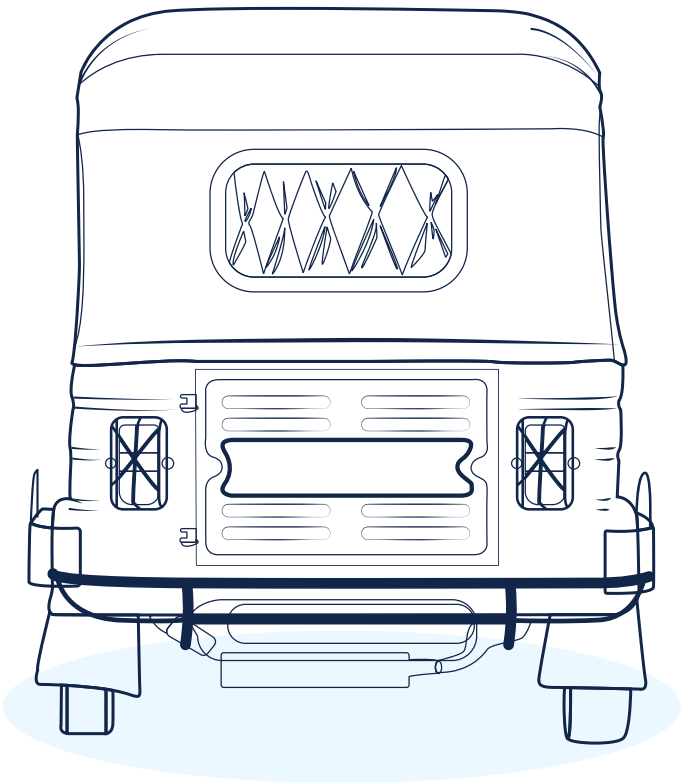
G. Promoting Awareness: Equipping Driver Partners with Retrofitment Technology Knowledge

To expedite the adoption of retrofitment technology among driver partners, it's essential to develop sustained outreach campaigns aimed at educating them comprehensively. These campaigns could focus on various facets of the technology, including operational features, total cost of ownership, charging requirements, safety regulations, and health benefits associated with switching to electric vehicles, including the alleviation of musculoskeletal health issues often faced by ICE-autorickshaw drivers. Implementing a standardized color scheme for retrofitted models can improve their visibility. Furthermore, organizing roadshows and events provides driver partners with practical experience and the chance to engage with experts, streamlining the transition to electric vehicles.

Source: Freepik

Conclusion

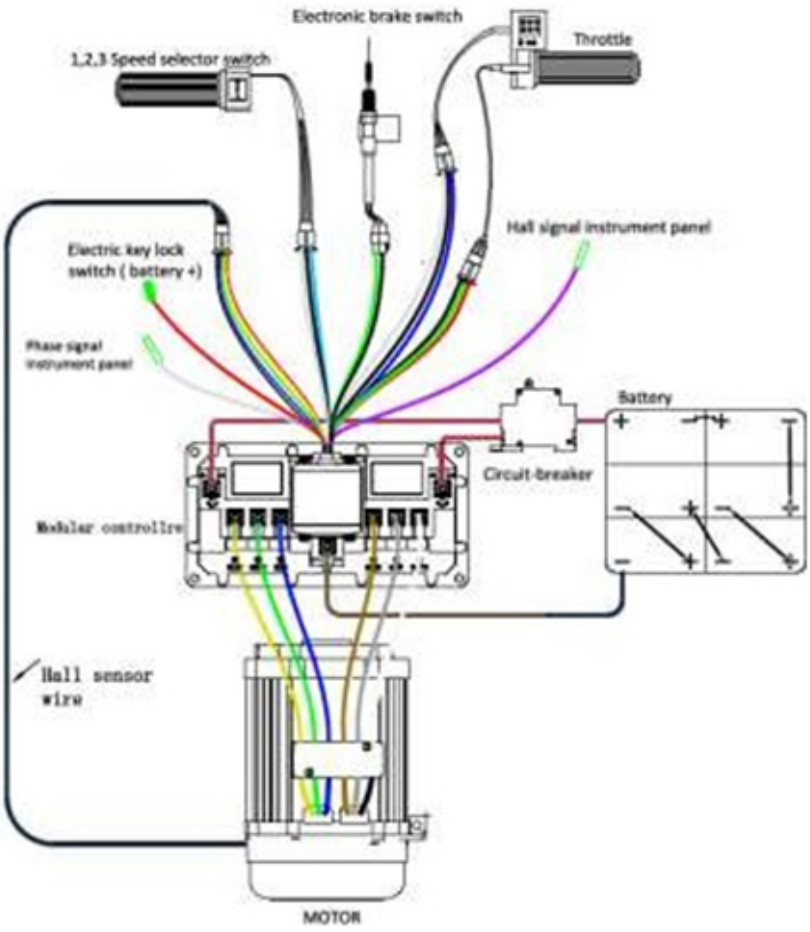
In conclusion, this paper offers a comprehensive blueprint for the widespread adoption of retrofitment technologies across the country. By prioritizing fiscal incentives, streamlining state processes, facilitating affordable financing, and addressing regulatory challenges, India can accelerate the transition to electric vehicles in the auto-rickshaw segment. Initiatives such as zero emission vehicle credits, fostering an insurance ecosystem, addressing infrastructure barriers, and promoting awareness among driver partners further contribute to creating an enabling environment for nationwide retrofitment adoption. Through these coordinated efforts and insightful findings, India can effectively pave the way for a sustainable and electrified future for its three-wheeler fleet, significantly reducing emissions and operational costs while extending the lifespan of existing vehicles.



Annexures

ANNEXURE 1: ARAI KIT SCHEMATICS

LAYOUT OF 3-WHEELER KIT



A. A. BADUSHA
SR. DEPUTY DIRECTOR & HEAD,
HOMOLOGATION MANAGEMENT &
REGULATION, ARAI PUNE

ARAI
THE AUTOMOTIVE RESEARCH ASSOCIATION OF INDIA

ANNEXURE 2: ASSESSMENT PARAMETERS OF THE RETROFIT KIT

Assessment parameters of the retrofit kit			
COMPONENT	**Parameter**	**Description**	**Specification**
MOTOR	Type	Type	BLDC
	Power Rating (kW)	Power Rating (kW)	3 kW
	No. of Phases	No. of Phases	three-phase
	Maximum Power (kW @ xxxx rpm)	Maximum Power (kW @ xxxx rpm)	5.6 kW @ 38 kmph
	Maximum torque (Nm)	Maximum torque (Nm)	55 Nm
	Maximum Thirty Minutes Power, kW	Maximum Thirty Minutes Power, kW	3 kW
	Maximum Thirty Minutes speed (kmph)	Maximum Thirty Minutes speed (kmph)	37.5 kmph Air
	Cooling System	Cooling System	3 kW
REESS	Type	Li-ion, Lead Acid, etc.	Li-ion
	Voltage (V)	The potential difference which the battery can generate	60 V
	End of discharge voltage value (V)	The Potential difference which is there in the battery when completely discharged	39 V
	Weight of REESS	The weight of the overall battery pack	38.3 kg
	Capacity (kWh)	Battery Capacity	6 kWh
CONTROLLER	Rated Voltage	Rated Voltage	60 V - 72 V
	Control Principle	Control Principle	
	Cooling System	Cooling System	Air
CHARGER	Type	Li-ion, Lead Acid, etc.	Li-ion
	Rating (Ah)	Charge rating	20 Ah
	Charger type	on board / external	External
	Cooling System	Liquid /Air / Naturally air cooled	Air

ANNEXURE 3: FORMS RELATED TO RETROFITMENT

ANNEXURE 3(A): FORM 22F

FORM 22F

(See rules 47B(3), 112(3), 112(4), 112(5), 112(6), 112(7), 112(8), 112(9),126)

COMPLIANCE REPORT FOR ALTERATION/RETROFITMENT

(To be submitted by the company/workshop who has carried out alteration/retrofitment either electronically on the Portal to the owner and owner shall submit this report to registering authority for the endorsement in registration certificate)

I hereby submit the compliance report for the alteration/retrofitment work carried out as detailed below:—

Sr. No.	*Item*	*Details*
(1)	(2)	(3)
1.	Motor Vehicle Details	
1.1	Motor Vehicle Make & Model	
1.2	Registration Number	
1.3	Chassis number (Optional)	
1.4	Engine number/Motor number (in case of battery operated vehicles) (Optional)	
1.5	Name, address and mobile number of the motor vehicle owner	
2.	Details of the Alteration/ Retrofitment carried out	
2.1	Nature of Alteration (Body Structure/ Fuel Source/ Chassis replacement / Engine replacement)	
2.2	Brief Details of the alteration/retrofitment carried out	
2.3	Applicable rules from the CMV rules followed for alteration/retrofitment	
2.4	Standard as specified in applicable rules followed for carrying out alteration/retrofitment	
2.5	Compliance report regrading alteration/retrofitment in the form type approval issued by the authorized testing agency or self-certification report, as the case may be.	To be attached
3.	Name, address and contact details of the firm who has carried out the subject alteration/retrofitment work	

This is to certify that the subject alteration/retrofitment work has been carried in such a manner that specific provision of the rules related to alteration/retrofitment are followed and it is ensured that motor vehicle so altered comply with the requirements of the Central Motor Vehicles Rules, 1989.

Place:.....

Date:.....

(Authorised signatory of the firm who carried out alteration/retrofitment)

Name of the person: .....

Name of the firm which carried out alteration/retrofitment .....

Mobile Number .....

ANNEXURE 3(B): FORM 22C

FORM 22C

[(Refer rule 47A (1)]

REQUEST AND PERMISSION FOR
ALTERATION/RETROFITMENT/ADAPTATION

PART I

(To be submitted by the Motor Vehicle Owner)

I hereby request the Registering Authority to accord prior permission to undertake alteration/ retrofitment in my Motor Vehicle as per details mentioned below:

I hereby submit that I shall carry out the permitted alteration/ retrofitment as per the provisions under CMVR 1989 and shall ensure that motor vehicle so altered shall be submitted for endorsement in the registration certificate along with necessary compliance documents.

Place:.....

Date:..... (Signature of the Owner)

Name:.....

Designation:.....

Mobile Number .....

PART II

(To be issued by the Registering Authority)

Motor Vehicle, bearing Registration Number ....., is hereby permitted/not permitted to alter and/or retrofit as per provisions of CMVR 1989. After the retrofitment/alteration is completed, the motor vehicle shall be produced for verification and endorsement in the Registration Certificate.

2. In case permission is not accorded reasons .....

Place:.....

Date:.....

(Signature of the authorised person)

Name:.....

Mobile Number .....

ANNEXURE 3(C): FORM KMV 29

FORM KMV 29

[See Rule 49 (1)]

NOTICE IN REGARD TO AN ALTERATION IN A MOTOR VEHICLE

TO,

The Registering Authority,

.....

I,..... the owner of Motor Vechicle

No.....residing at.....

Hereby given the notice that I desire to make the following alteration to the said vechicle.

1.

2.

3.

4.

5.

Date..... Signature of the owner

OFFICE USE

REGIONAL TRANSPORT OFFICE

.....Bangalore

TO,

.....

.....

Approval is hereby accorded/refused for making the following alterations in the motor vehicle No.

1.

2.

3.

4. Registering Authority, Regional Transport Officer

ANNEXURE 4: TESTING & CERTIFICATION STANDARDS FOR HOMOLOGATION

Vehicle weighment	Permissible increase in vehicle unladen weight due to Electric Propulsion Kit shall be as follows: L5M = 25% L5N = Equal to weight of Electric Propulsion Kit	IS 11825-1986
Coast down test	Coast down test shall be done as per IS 14785-2000 to find out vehicle road load coefficients for range and electric energy consumption tests	IS 14785-2000
Visual indication	Electric Propulsion Kit manufacturer/supplier shall provide minimum following indications: Rechargeable Energy Storage System State of Charge (REESS SOC) Motor temperature Electric Kit fault	AIS-071 (Part 1 and Part 2)
Gradeability test	The vehicle fitted with Electric Propulsion Kit shall meet requirement of gradeability as specified in AIS-049(Rev 1), as per AIS-003	AIS-049(Rev 1) and AIS-003
Brake performance	The vehicle fitted with Electric Propulsion Kit shall meet the requirements of brake performance test when tested as per IS 11852-2001 (Part 1 to Part 9)	IS 11852-2001 (Part 1 to Part 9)
Measurement of electric range and electric energy consumption	The electric range of vehicle fitted with Electric Propulsion Kit shall be measured as per AIS-040(Rev1):2015. The electric energy consumption of vehicle fitted with Electric Propulsion Kit shall be measured as per AIS-039(Rev 1):2015. Reference mass for chassis dynamometer setting shall be as per AIS 049(Rev 1) and Driving cycle shall be as per clause 5.1 of AIS-039(Rev 1):2015	AIS-040(Rev 1):2015 AIS-039(Rev 1):2015 AIS 049(Rev1)
Measurement of pass by noise level	The vehicle fitted with Electric Propulsion Kit shall meet the requirement of pass by noise level as per IS 3028-1998 with additional test conditions as specified in AIS-049(Rev 1).	IS 3028-1998 AIS-049(Rev 1)
EMC test	Electric Propulsion Kit electronic components shall meet the requirements of EMC test as per AIS-004 (Part 3):2009. REESS charger shall be excluded from the test as it is utilized when vehicle is in off condition.	AIS-004 (Part 3):2009
Requirements for constructional and functional safety	The vehicle fitted with Electric Propulsion Kit shall meet requirements for constructional and functional safety as per AIS-038(Rev 1):2015	AIS-038(Rev 1):2015
Vertical orientation of dipped beam – head lamp	Electric Propulsion Kit manufacturer / supplier shall carry out head lamp leveling adjustment on converted vehicle to comply with the requirement of AIS-008 (Rev.1): 2010 This requirement is not applicable to L5 category converted vehicles.	AIS-008 (Rev.1): 2010
Traction motor test	Motor Power Test: Test shall be carried out as per AIS-041(Rev 1):2015 Environmental validation tests for traction motor: Thermal Shock test shall be carried out as per IS:3141:2007 Media resistance test shall be carried out as per IS:3141:2007 Impact test shall be carried out as per IS:9000 Part 7/Sec1:2006 Dust Test shall be carried out as per IS: 3141:2007 Water immerse test shall be carried out as per IS: 8925:1978	AIS-041(Rev 1):2015 IS:3141:2007 IS:3141:2007 IS:9000 Part 7/ Sec1:2006 IS: 3141:2007
Requirements for rechargeable energy storage system (REESS)	The REESS of the Electric Propulsion Kit shall meet the requirements of AIS-048	AIS-048

ANNEXURE 5

digit

Go Digit General Insurance Ltd.

Digit Commercial Vehicle Package Policy - Passenger Carrying Vehicle

Schedule/Certificate

UIN No.: IRDAN158RP0002V01201819

Name	**Vehicle Registration No.**
Address	**Partner Name**
	Partner Code
Mobile	**Partner Email**
Email	**Partner Mobile No.**
Aadhar No.	**For claims,contact us at**

YOUR POLICY DETAILS

Policy No.		**Policy Issue Date**	26-Oct-2023	**Invoice Date**	26-Oct-2023
Period of Policy	**From**	26-Oct-2023 12:48:00			
	To	25-Oct-2024 23:59:59			
NCB % (Current Policy)	0 %	**Policy Type**	Public Carrier		
Compulsory Deductible	500	**Voluntary Deductible**	--		

YOUR VEHICLE DETAILS

Make	BAJAJ AUTO	**Trailer Reg. No.**		**RTO Location**	Rangareddy,TELANGANA
Model/Vehicle Variant (Sub-Type)	RE COMPACT / RETROFIT E AUTO	**Year of Regn. / Manufacturing**	2016 / --	**Licensed Seating Capacity**	4
Engine No.	SP24S4004	**Chassis No.**	MD2A96AYXGWG01938	**Power**	10.8 KW
Fuel Type	Electric	**Gross Vehicle Weight**	780KG	**Vehicle Body Type**	PCV -3W
Goods Type	--	**Permit Type**	Public Carrier	**Wheels**	3
Odometer		**FASTag Number**		**Financier Details**	

YOUR VEHICLE IDV (THE MAXIMUM MONEY YOU CAN GET IN CASE OF A CLAIM)

Vehicle IDV (₹)	IDV of Electrical Accessories (₹)	IDV of Non-Electrical Accessories (₹)	CNG/LPG KIT IDV (₹)	Trailer IDV (₹)	Body IDV (₹)	Total IDV (₹)
157700	--	--	--	--	--	157700.00

OWN DAMAGE PREMIUM [A] (₹) / LIABILITY PREMIUM [B] (₹)

Own Damage Premium (₹)	1171.55	Basic Third-Party Liability (₹)	4015.00
Add-Ons Premium (₹)	0.00	PA cover for Owner-Driver (₹)	330.00
NCB Discount Amount (₹)	-0.00		
		Legal Liability to Paid (₹) Driver (Persons:1)	50.00
Total OD Premium (₹)	1171.55	**Total Act Premium** (₹)	4395.00

Net Premium [A+B} (₹)	5566.55
IGST @ 18% = (₹1001.98)	1001.98
Total Premium (₹)	6568.53

CSC ID	
VLE / RAP Name	
VLE / Mobile Number	

Note: The above total OD premium is inclusive of all applicable loading / discounts viz (automobile association memberships, voluntary excess, anti-theft handicap person, driver tuition, fiber glass, CNG/ LPG unit, geographical extension, imported vehicle etc., wherever applicable).

If the "Own Damage Cover" under your policy is cancelled during the policy period, then your policy shall be governed by the standard terms and conditions of "Act only" policy for the Third Party Cover during the remaining period of policy.

Deductible Applicable to Theft Claims: 25% of Insured Declared Value (IDV). In case of an accident to your vehicle, please intimate us immediately for SPOT SURVEY. Failure to intimate in time could prejudice your claim.

ENDORSEMENT

Invoice Number	Invoice Date	Net Premium	Igst	Cgst	Sgst	Utgst	Cess	Gross Premium
		0.00	0.00	0.00	0.00	0.00	0.00	0.00

Policy No: D121756530
Page No: 1 of 2

Go Digit General Insurance Ltd. Address: Atlantis, 95, 4th B Cross Road, Koramangala Industrial Layout, 5th Block, Bengaluru, Karnataka 560095. IRDAI Reg No. 158 CIN U66010PN2016PLC167410, GST Reg. No.: 33AACCO4128Q1Z7 HSN: 997134/General Insurance Services, GSTIN Address: Chennai Business Centre,No 528, Old no.559, Anna Salai, Above Skoda Showroom, Teynampet,Chennai,Tamil Nadu,PIN-600018

Go Digit General Insurance Ltd.

Digit Commercial Vehicle Package Policy - Passenger Carrying Vehicle

Schedule/Certificate

UIN No.: IRDAN158RP0002V01201819

OTHER DETAILS

Previous Insurer	--		
Previous Policy No.	--	**Previous Policy Expiry Date**	--
IMT - Endorsements	IMT-21,IMT-23,IMT-40		
Invoice Number			
GSTIN/UIN No.	Unregistered	**State Code**	36
Payment Mode	Float	**Cheque/Transation No**	
Bank Name		**IFSC/MICR No**	--
Premium Payment Details	**Receipt No.** RA129949878	**Receipt Date**	
Nominee Details	--		
Details of Existing Damages	Excluding Existing Damages As Per Photos;		
Other details	--		

Follow these rules like you follow the rules of the road.

Geographical Area -Any accidental loss damage and/or liability caused sustained or incurred within India shall be covered subject to and Conditions, unless specifically agreed and endorsed. **Limitation as to use** - The policy covers use of the vehicle only under a permit within the meaning of the Motor Vehicles Act 1988 or such a carriage falling under sub-section (3) of Section 66 of the Motor Vehicles Act, 1988. The policy does not cover use for Organised racing, Pace Making, Reliability Trials, Speed Testing, Use whilst drawing a trailer except the towing (other than for reward) of any one disabled Mechanically propelled vehicle (only for Passenger Carrying Vehicle). **Person or Class of persons entitled to drive** - Any person including the insured 1) Provided that a person driving holds a valid & effective driving license at the time of the accident and is not disqualified from holding or obtaining such a license.2) Provided also that the person holding a valid & effective Learner's license may also drive the vehicle and that such a person satisfies the requirements of Rule 3 of the Central Motor Vehicles Rules, 1989 and any subsequent amendment as applicable. **Limits of Liability:** 1) Under Section I of the policy - IDV as shown in the schedule. 2) Under Section II - 1 (i) of the policy: Death of or bodily injury - Such amount as is necessary to meet the requirements of the Motor Vehicles Act, 1988. 3) Under Section II - 1 (ii) of the policy: Damage to Third Party Property - ₹750000 4) P.A. Cover for Owner Driver under Section III (CSI): ₹ 1500000
PUC Declaration: The Policy has been issued subject to valid Pollution Under Control (PUC) Certificate disclosed by you as an insured on or before the date of commencement of the Policy . **NCB Declaration:** The premium has been charged and policy has been issued subject to NCB declared by you as an insured. In the event of NCB found wrongly declared at any point of time during policy period, all benefits and coverages under the Policy in respect of section I of the Policy will stand forfeited. If there is any disagreement, write to us within 7 days from the date of issuance of policy or before the start date of period of insurance whichever is earlier.
Important Note: Please inform the Company in case of change on account of addition of CNG/PNG kit.

Break in Insurance: In case of a break-in, the company may conduct pre-inspection of the vehicle and in such a case, Own Damage cover (Section -I) of the policy would not commence unless the pre-inspection of the vehicle has been done and the acceptance of risk is subject to evaluation of the vehicle inspection report. In case of any adverse findings in the report, the Company, at its discretion, may cancel the Policy as per the Motor Tariff.
Pre-existing Damages: All types of pre-existing damages or cost of repair of such damage will be excluded at the time of claim settlement.
Policy would be void on the ground that it was obtained of material fact or by a representation of fact which was false in some material particular.
Cheque dishonor / Non-receipt of payment premium paid through Cheque, the policy is void ab-initio in case of dishonor of Cheque or non-receipt of payment.

Violation of Motor Vehicle Act: This policy is issued in accordance with the provision of Chapter X and Chapter XI of MV act, 1988 and any subsequent amendment as applicable. Any violation will forfeit all benefits and coverages under the Policy. The insured is not indemnified if the vehicle is used or driven otherwise than in accordance with this Schedule. This policy is subject to the standard policy wordings, warranties and conditions applicable for this product in addition to Indian Motor Tariff. Any payment made by the Company by reason of wider terms appearing in Certificate in order to comply with the Motor Vehicle Act, 1988 is recoverable from the insured. See the Clause headed (Avoidance Of Certain Terms And Right Of Recovery) in the policy.
Note: The policy is issued in utmost good faith, relying on the information shared by insured at the time of obtaining the policy. The terms and conditions detailed in this policy schedule as well as the policy document sent by Digit shall prevail in case of any dispute.

In case of claim or any other query, please contact our 24-hour Call Centre at 1800-258-5956 or email us at hello@godigit.com or visit our website www.godigit.com.

For & On Behalf of Go Digit General Insurance Ltd.

Praveen Bhat
Senior Vice President - Customer Experience
praveen.bhat@godigit.com
Authorized Signatory
Printed, Signed, and Executed at Bengaluru
Consolidated Stamp Duty has been paid as per Letter of Authorization No.67-B/04/2017-18 Date: 30th May 2017 issued by Department of Stamps and Registration , Bengaluru- 560009 - KARNATAKA.
Hey,our document is now digitally signed
Click here to view the certificate.
For instant resolution, you can ping us "Hi" on WhatsApp at 702 606 1234

Policy No: D121756530
Page No: 2 of 2

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References

1 NIUA, A Guidebook for Electrification of Auto-rickshaw Fleets in Indian Cities, October 2023. https://citiis.niua.in/web/sites/default/files/2023-11/E-Auto%20Guidebook.pdf (accessed on January, 2024)

2 NITI Aayog, Status quo analysis of various segments of electric mobility and low carbon passenger road transport in India, 2023. https://www.niti.gov.in/sites/default/files/2023-03/Status-Quo-Analysis-of-Various-Segments-of-Electric-Mobility-And-Low.pdf (accessed on January, 2024)

3 CEEW, India's EV Transition Catalysing Kochi's Electric 3-Wheeler Market Through Local Policy, November 2022. https://www.ceew.in/sites/default/files/ceew-research-on-electrification-of-3-wheeler-auto-rickshaw-market-through-local-policy-in-kochi.pdf (accessed on January, 2024)

4 CPI, financing for low-carbon auto rickshaws Instrument analysis, September 2018, https://www.climatepolicyinitiative.org/wp-content/uploads/2018/10/Financing-for-Low-Carbon-Auto-Rickshaws_Instrument-Analysis.pdf (accessed on February, 2024)

5 Tailpipe emissions the meanemission of gaseous and particulate pollutants. MoRTH https://morth.nic.in/sites/default/files/circulars_document/Draft_Amendment_No._8_regarding_Part_XIX.pdf

6 Anumita Roychowdhury and Sayan Roy, CSE, Strategy to Electrify Three-Wheeled Passenger and Goods Vehicles in Cities of Odisha, 2023. https://www.cseindia.org/content/downloadreports/11411#:~:text=Willingness%20and%20awareness%20to%20shift,to%20Rs%2012%2C000%20per%20vehicle.

7 Vaahan Dashboard, https://vahan.parivahan.gov.in/; NIUA, A Guidebook for Electrification of Auto-rickshaw Fleets in Indian Cities, October 2023. https://citiis.niua.in/web/sites/default/files/2023-11/E-Auto%20Guidebook.pdf (accessed on February, 2024)

8 NITI Aayog, Decarbonising Transport: Redefining Mobility Policies in India, https://www.niti.gov.in/decarbonising-transport-redefining-mobility-policies-india

9 (accessed on February, 2024)(accessed on February, 2024) Decarbonising the Indian transport sector pathways and policies, Climate Action Tracker, 2020, https://climateactiontracker.org/documents/832/CAT_2020-12-09_Report_DecarbonisingIndianTransportSector_Dec2020.pdf

10 IEA and NITI Aiyog, "Transitioning India's Road Transport Sector," July 2023, https://iea.blob.core.windows.net/assets/06ad8de6-52c6-4be3-96fc-2bdc3510617d/TransitioningIndiasRoadTransportSector.pdf (accessed on January, 2024)

11 Ibid Idib https://www.iea.org/reports/transitioning-indias-road-transport-sector/executive-summary

12 Abhinav Soman, Harsimran Kaur, Himani Jain, and Karthik Ganesan, CEEW, India's Electric Vehicle Transition, November 2020, https://www.ceew.in/sites/default/files/CEEW-Indias-EV-Transition-Post-COVID-19-22Dec20_0.pdf (accessed on February, 2024)

13 NITI Aayog, IEA, Transitioning India's Road Transport Sector, July 2023. https://iea.blob.core.windows.net/assets/9635288b-5794-40e3-9898-d685aa8ad315/TransitioningIndiasRoadTransportSector.pdf (accessed on January, 2024)

14 CPI, financing for low-carbon auto rickshaws Instrument analysis, September 2018, https://www.climatepolicyinitiative.org/wp-content/uploads/2018/10/Financing-for-Low-Carbon-Auto-Rickshaws_Instrument-Analysis.pdf (accessed on February, 2024)

15 Consultation with retrofit kit provider 'Zero 21'

16 Auto Rickshaw. https://en.wikipedia.org/wiki/Auto_rickshaw

17 Ibid

18 CSE, Strategy to Electrify Three-Wheeled Passenger and Goods Vehicles in Cities of Odisha, September 2022, https://www.cseindia.org/content/downloadreports/11411#:~:text=Willingness%20and%20awareness%20to%20shift,to%20Rs%2012%2C000%20per%20vehicle(accessed on January, 2024)

19 NIUA, A Guidebook for Electrification of Auto-rickshaw Fleets in Indian Cities, October 2023. https://citiis.niua.in/web/sites/default/files/2023-11/E-Auto%20Guidebook.pdf

20 CSE, Strategy to Electrify Three-Wheeled Passenger and Goods Vehicles in Cities of Odisha, September 2022, https://www.cseindia.org/content/downloadreports/11411#:~:text=Willingness%20and%20awareness%20to%20shift,to%20Rs%2012%2C000%20per%20vehicle. (accessed on February, 2024)

21 SIAM, Context paper ELC recycling status of circular economy in india, 2022, https://www.siam.in/uploads/filemanager/377ChakriytaContextPaper.pdf (accessed on February, 2024)

22 Electric car sales speed to 25,000 units in April-November, headed for 40,000 in FY2023, https://www.autocarpro.in/analysis-sales/electric-car-sales-speed-to-25000-units-in-april-november-headed-for-40000-in-fy2023-113606 (accessed on January, 2024)

23 SIAM, Annual reportreport 2021-22, 2022 https://www.siam.in/uploads/filemanager/414SIAMAnnualReport202122Final.pdf (accessed on January, 2024)

24 NIUA, A Guidebook for Electrification of Auto-rickshaw Fleets in Indian Cities, October 2023. https://citiis.niua.in/web/sites/default/files/2023-11/E-Auto%20Guidebook.pdf

25 https://www.autocarpro.in/analysis-sales/electric-3-wheeler-sales-to-surpass-600000-units-in-fy2024-119443(accessed on January, 2024)

26 E-rickshaws drive EV penetration of 3Ws to over 50% in FY23, https://auto.economictimes.indiatimes.com/news/commercial-vehicle/e-rickshaws-drive-ev-penetration-of-3ws-to-over-50-in-fy23/99026538#:~:text=1%25%2C%20respectively.-,The%20unorganized%20e%2Drickshaws%20are%20now%20driving%20EV%20penetration%20in,of%20March%2026%2C%202023). (accessed on January, 2024)

27 NIUA, A Guidebook for Electrification of Auto-rickshaw Fleets in Indian Cities, October 2023. https://citiis.niua.in/web/sites/default/files/2023-11/E-Auto%20Guidebook.pdf

28 NIUA, A Guidebook for Electrification of Auto-rickshaw Fleets in Indian Cities, October 2023. https://citiis.niua.in/web/sites/default/files/2023-11/E-Auto%20Guidebook.pdf (accessed on January, 2024)

29 ITF, Life-Cycle Assessment of Passenger Transport, 2023. https://www.itf-oecd.org/sites/default/files/docs/life-cycle-assessment-passenger-transport-india.pdf (accessed on January, 2024)

30 Apte JS, Kirchstetter TW, Reich AH, Deshpande SJ, Kaushik G, Chel A, Marshall JD, and Nazaroff WW. 2011. Concentrations of fine, ultrafine, and black carbon particles in autorickshaws in New Delhi, India. Atmospheric Environment. Vol. 45 (26), p. 4470-4480

31 Ibid

32 CSE, Joshua S. Apt, Commuter Exposure to Vehicle Air Pollution in New Delhi, 2011, https://cdn.cseindia.org/attachments/0.62337100_1510641571_joshua_sapte.pdf (accessed on January, 2024)

33 https://www.ccacoalition.org/short-lived-climate-pollutants/black-carbon#:~:text=Black%20carbon%20is%20a%20component,toxic%20compounds%20into%20the%20bloodstream.

34 CSE, 2018, Three-wheeled devil on diesel, https://www.downtoearth.org.in/blog/air/three-wheeled-devil-on-diesel-62250

35 CSE, Strategy to Electrify Three-Wheeled Passenger and Goods Vehicles in Cities of Odisha, September 2022, https://www.cseindia.org/content/downloadreports/11411#:~:text=Willingness%20and%20awareness%20to%20shift,to%20Rs%2012%2C000%20per%20vehicle (accessed on January, 2024)

36 Ibid

37 Palak Thakur, Estimating vehicular emissions from auto rickshaws plying in Bengaluru, 2018. https://www.ijser.org/researchpaper/Estimating-vehicular-emissions-from-auto-rickshaws-plying-in-Bengaluru.pdf (accessed on January, 2024)

38 Palak Thakur, Estimating vehicular emissions from auto rickshaws plying in Bengaluru, 2018. https://www.ijser.org/researchpaper/Estimating-vehicular-emissions-from-auto-rickshaws-plying-in-Bengaluru.pdf (accessed on February, 2024)

39 Ibid

40 ibid

41 Ibid

42 Ibid

43 SIAM, Context paper ELC recycling status of circular economy in india, 2022, https://www.siam.in/uploads/filemanager/377ChakriytaContextPaper.pdf (accessed on January, 2024)

44 Stakeholder consultations with retrofit kit providers 'Zero 21',

45 Ibid

46 Ibid

47 Ibid

48 Stakeholder consultation with Auto drivers Union & Zero 21

49 Down to Earth, E-Retrofitment: India's Key to Fleet Electrification and Net Zero Emissions . https://www.downtoearth.org.in/news/renewable-energy/e-retrofitment-india-s-key-to-fleet-electrification-and-net-zero-emissions-89292 (accessed on January, 2024)

50 Switch Delhi, https://ev.delhi.gov.in/retro-fitment

51 ARAI, https://hmr.araiindia.com/Control/AIS/110201995755AM6_AIS_123_Part3_with_Amd_1and2_F.pdf (accessed on January, 2024)

52 Ibid

53 Down to Earth, E-Retrofitment: India's Key to Fleet Electrification and Net Zero Emissions. https://www.downtoearth.org.in/news/renewable-energy/e-retrofitment-india-s-key-to-fleet-electrification-and-net-zero-emissions-89292 (accessed on January, 2024)

54 Consultations with various retrofit kit providers

55 Down to Earth, E-Retrofitment: India's Key to Fleet Electrification and Net Zero Emissions. https://www.downtoearth.org.in/news/renewable-energy/e-retrofitment-india-s-key-to-fleet-electrification-and-net-zero-emissions-89292

56 Consultations with retrofit kit providers

57 Consultations with retrofit kit providers

58 Ibid

59 Switch Delhi portal, https://ev.delhi.gov.in/retro-fitment

60 Ibid

61 Ibid

62 Ibid

63 Ibid

64 Consultations with various government stakeholders

65 Regional Transport Office (RTO) Hyderabad

66 Vaibhav Pratap and Labanya Prakash Jena. 2018. "Financing for Low-Carbon Auto-Rickshaws." India Innovation Lab for Green Finance. https://www.climatefinancelab. OrgOrg/wp-content/uploads/2018/02/Financing-for-Low-Carbon-Auto-Rickshaws_Instrument-Analysis.pdf.

67 Ibid

68 Envirosmart, https://envirosmart.in/; ACEnergy . https://race.energy/aboutus; Zero 21 .https://zero21.autos/about/

69 Consultations with retrofit kit provider 'Zero 21'

70 Ibid

71 Truck Junction, https://trucks.tractorjunction.com/en/bajaj-truck/re-e-tec-90/price/hyderabad

72 Bajaj Finance ltd-af, https://www.bajajautofinance.com/three-wheeler-loan/bajaj-re-cng (accessed on April, 2024)

73 Bajaj Finance ltd-af, https://www.bajajautofinance.com/three-wheeler-loan/bajaj-re-petrol (accessed on April, 2024)

74 Bajaj Finance ltd-af, https://www.bajajautofinance.com/three-wheeler-loan/bajaj-re-diesel (accessed on April, 2024)

75 Government of Telangana, Transport Department portal, https://www.transport.telangana.gov.in/html/fees-registration.html (accessed on April, 2024)

76 Ibid

77 Consultations with 'Go Digit General Insurance Ltd'

78 Policymeter, Auto Rickshaw Insurance Price, April 2024. https://policymeter.com/commercial-vehicle-insurance/passenger-carrying-vehicle-insurance/auto-rickshaw-insurance/ (accessed on April, 2024)

79 Policymeter, Auto Rickshaw Insurance Price, April 2024. https://policymeter.com/commercial-vehicle-insurance/passenger-carrying-vehicle-insurance/auto-rickshaw-insurance/ (accessed on April, 2024)

80 Policybazaar, Auto Rickshaw Insurance Price, April 2024. https://www.policybazaar.com/motor-insurance/commercial-vehicle-insurance/bajaj-auto/re-maxima/ (accessed on April, 2024)

81 Policybazaar, Auto Rickshaw Insurance Price, April 2024. https://www.policybazaar.com/motor-insurance/commercial-vehicle-insurance/bajaj-auto/re-maxima/ (accessed on April, 2024)

82 Policybazaar, Auto Rickshaw Insurance Price, April 2024. https://www.policybazaar.com/motor-insurance/commercial-vehicle-insurance/bajaj-auto/re-maxima/ (accessed on April, 2024)

83 Based on AXIS bank vehicle loan EMI calculator.

84 Consultations with battery swapping stations in Hyderabad

85 NIUA, A Guidebook for Electrification of Auto-rickshaw Fleets in Indian Cities, October 2023. https://citiis.niua.in/web/sites/default/files/2023-11/E-Auto%20Guidebook.pdf (accessed on January, 2024)

86 Ibid

87 Ibid

88 Consultations with retrofit kit provider 'Zero 21'

89 Consultations with auto-drivers

90 Based on WRI TCO evaluator, https://www.wricitiesindia.org/content/tco-evaluator (accessed on April, 2024)

91 AEEE, Electrifying Last Mile Mobility: Overcoming Challenges and Boosting Adoption of Electric 3- Wheelers .https://aeee.in/electrifying-last-mile-mobility-overcoming-challenges-and-boosting-adoption-of-electric-3-wheelers/#:~:text=However%2C%203W%20electrification%20is%20facing,policies'%20role%20in%20E3W%20adoption (accessed on April, 2024)

92 Tamil Nadu EV Policy . https://investingintamilnadu.com/DIGIGOV/StaticAttachment?AttachmentFileName=/pdf/poli_noti/TN_Electric_Vehicles_Policy_2023.pdf (accessed on April, 2024)

93 Telangana EV Policy . https://tsredco.telangana.gov.in/Updates_2020/Telangana_EVES_policy_2020_30.pdf (accessed on April, 2024)

94 Rajasthan EV Policy .https://istart.rajasthan.gov.in/public/pdf/REVP_2022.pdf (accessed on February, 2024)

95 https://evreporter.com/wp-content/uploads/2022/01/Goa-EV-policy-2021.pdf (accessed on February, 2024)

96 Assam EV Policy. https://evreporter.com/assam-ev-policy-summary/#:~:text=The%20max%20amount%20of%20subsidy,3W%2C%204W%20for%205%20years.&text=%E2%80%93%20Retrofitment%20incentive%20at%2015%25%20upto,for%203%20seater%20auto%20rickshaws

97 Chandigarh EV Policy . https://www.chandigarh.gov.in/sites/default/files/jan2022/crest20-evpolicy22-2009.pdf

98 Primary survey with auto-rickshaw drivers

99 Ibid

100 Consultations with retrofit kit provider 'Zero 21'

101 Consultations with e-auto drivers

102 Ibid

103 h NIUA, A Guidebook for Electrification of Auto-rickshaw Fleets in Indian Cities, October 2023. https://citiis.niua.in/web/sites/default/files/2023-11/E-Auto%20Guidebook.pdf (accessed on February, 2024)

104 MoRTH (Ministry of Road Transport and Highways). 2018b. S.O. 5333€ Regarding Exemption to Battery Operated Transport Vehicles and Transport Vehicles Running on Ethanol and Methanol Fuels from Requirement of Permits. https://morth.nic. in/sites/default/files/notifications_document/Notification_no_S_O_5333E_dated_18_10_2018_regarding_exemption_to_Battery_Operated_Transport_Vehicles_and_Transport.pdf (accessed on February, 2024)

105 Ibid

106 Consultations with Insurance companies

107 Ibid

108 Ibid

109 Automotive Research Association of India (ARAI)

110 Vahan Sewa Portal, https://parivahan.gov.in/

111 Stakeholder consultations

112 NATRiP portal. http://www.natrip.in/

113 Ibid

114 Consultations with retrofit kit provider 'Zero21'

115 NIUA, A Guidebook for Electrification of Auto-rickshaw Fleets in Indian Cities, October 2023. https://citiis.niua.in/web/sites/default/files/2023-11/E-Auto%20Guidebook.pdf (accessed on February, 2024) "https://www.mudra.org."

116 Green Funds: Types, Strategies, Risks, and Future Trends." Carbon collective, https://www.carboncollective.co/sustainable-investing/green-fund

117 Source 1; Mudra - Micro Units Development & Refinance Agency Ltd.. Accessed June 11, 2024. https://www.mudra.org.in/ , Source 2; MoEF, https://moef.gov.in/wp-content/uploads/2019/05/NCAP_Report.pdf (accessed on February, 2024)

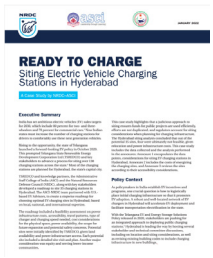
118 NIUA, A Guidebook for Electrification of Auto-rickshaw Fleets in Indian Cities, October 2023. https://citiis.niua.in/web/sites/default/files/2023-11/E-Auto%20Guidebook.pdf (accessed on February, 2024)

119 Ibid

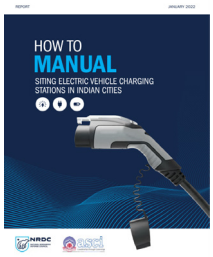
120 Ibid

121 SIAM, 2023, ELV Recycling, Status of Circular Economy in India. https://www.siam.in/uploads/filemanager/377ChakriytaContextPaper.pdf

Highlighted Reports



Ready to Charge Siting Electric Vehicle Charging Stations in Hyderabad



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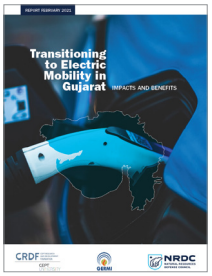

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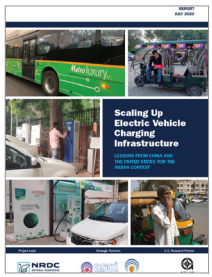
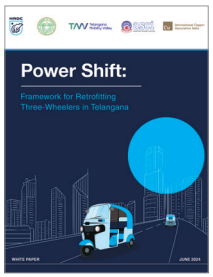
Energizing Freight: Policy Toolkit for Medium and Heavy-Duty Truck Electrification in India

Location Is Everything: Approaches to Siting Electric Vehicle Charging Infrastructure for the Indian Context - Issue Brief



Scaling up Electric Vehicle Charging Infrastructure - Report



Power Shift: Framework for Retrofitting Three-Wheelers in Telangana