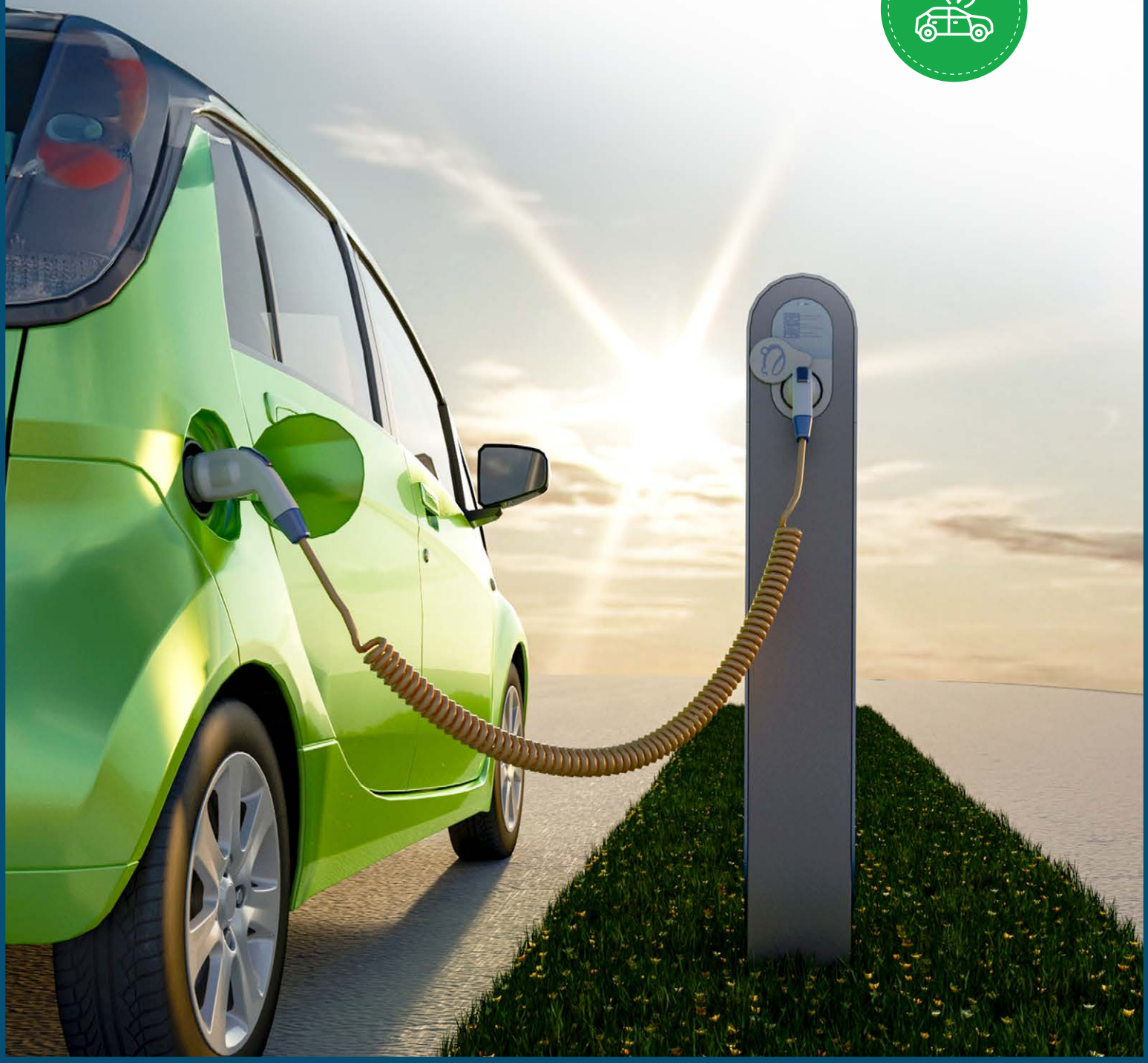
Alliance for an Energy Efficient Economy

ELECTRIFYING MEGHALAYA

Roadmap for Retrofitting ICE 4-Wheelers To EVs



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Roadmap for Retrofitting ICE 4-Wheelers To EVs

Prepared by: Alliance for an Energy Efficient Economy (AEEE).

AEEE PROJECT TEAM

Dr. Md Saddam Hussain, Senior Research Associate, AEEE
Dr. Vikas Nimesh, Principal Research Associate, AEEE
Anmol Jain, Research Associate, AEEE
Divyansh Khare, Intern, AEEE
Pramod Kumar Singh, Senior Director - Research & Programs, AEEE

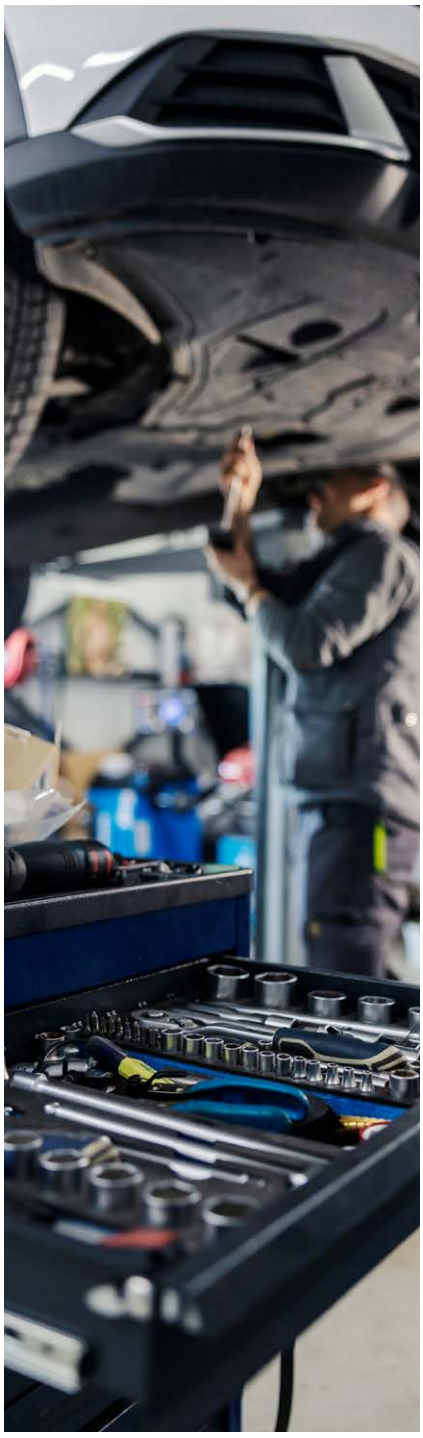
Suggested citation:

Hussain, M.S., Nimesh, V., Jain, A.; Khare, D., & Singh, P.K. (2024). Electrifying Meghalaya: Roadmap for Retrofitting ICE 4-Wheelers To EVs. New Delhi: Alliance for an Energy Efficient Economy

Disclaimer:

This report is based on the best available information in the public domain. Every attempt has been made to ensure the correctness of the data. However, AEEE does not accept responsibility for the consequences of using such data.

Acknowledgments



The authors would like to express their profound appreciation to Dr. Satish Kumar, President and Executive Director, AEEE, for providing invaluable guidance and feedback throughout the project. The authors extend their heartfelt gratitude to Ashwini Tiwary and Deepak Shukla Autobot India for their expert technical support and insightful feedback, which significantly contributed to the enhancement of this report.

Furthermore, the authors would like to extend their sincere thanks to the Meghalaya Transport Department for their unwavering support and invaluable contributions that have been instrumental in shaping this comprehensive and well-researched report. Throughout the project, their guidance and insights have provided us with the necessary foundation to address key issues in the field of energy efficiency. Additionally, our sincere appreciation goes to Don Bosco Technical School (DBTS), Shillong, for their collaboration in co-organizing the training program, which played a pivotal role in shaping this report. The feedback gathered during this event has been crucial in refining our findings and recommendations.

We also extend our appreciation to our local partner, Mr. Bibhudatta Sahu, for his pivotal role in connecting with the local community, rallying support for our cause, and facilitating participation in workshops and stakeholder consultations. His efforts have been crucial in the successful completion of this report.

Executive Summary

This report explores the transportation landscape in Meghalaya, emphasizing the imperative shift towards electric vehicles (EVs) through retrofitting. It begins by contextualizing Meghalaya's transportation scenario, highlighting the government's vision for electric mobility in alignment with national policies like the National Electric Mobility Mission Plan (NEMMP) 2020 and the FAME India scheme.

The concept and mechanics of ICE to EV retrofitting are explored in detail, presenting it as a transformative solution that extends vehicle lifespan while reducing emissions and operating costs. A Total Cost of Ownership (TCO) analysis underscores retrofitting, especially with leased batteries, as a cost-effective option over long-term ownership compared to buying new EVs.

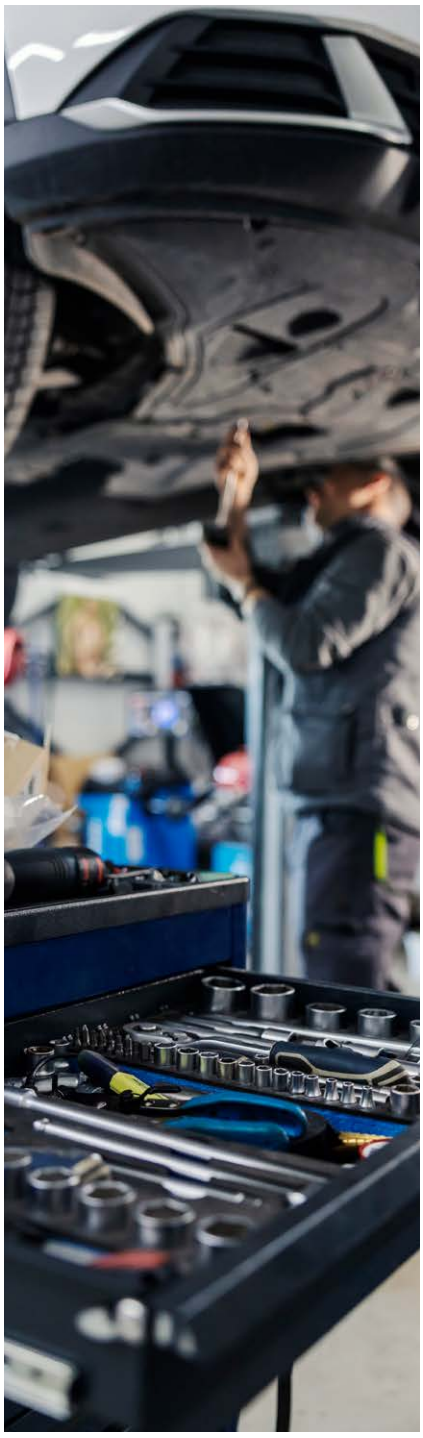
Consumer insights reveal perceptions, attitudes, and potential adoption rates for retrofitting, emphasizing the need to address consumer skepticism through education. Market potential and growth projections highlight the significant role retrofitting plays in the EV transition.

Policy and stakeholder engagement are identified as crucial facilitators for retrofitting, with recommendations for enhancing existing policies and incentives to foster collaboration among stakeholders. Technical considerations and challenges associated with retrofitting are discussed, and rigorous testing and adherence to safety and performance standards are advocated to ensure reliability.

The report concludes by positioning retrofitting as a cornerstone for Meghalaya's sustainable transportation future, calling for unified efforts across sectors to harness its full potential. Strategic recommendations for policy, infrastructure, and consumer engagement outline a comprehensive approach to scaling retrofitting initiatives in Meghalaya.

This executive summary encapsulates retrofitting as a viable, cost-effective, and sustainable solution for transitioning to electric mobility in Meghalaya, positioning it as essential for environmental sustainability and economic growth.

Acronyms



4W - Four-Wheeler

ARAI – Automotive Research Association of India

CAGR – Compound Annual Growth Rate

CMVR – Central Motor Vehicle Rules

EV – Electric Vehicles

E4W – Electric Four-Wheeler

FAME - Faster Adoption and Manufacturing of Hybrid & Electric Vehicles

GVW – Gross Vehicle Weight

ICE- Internal Combustion Engine

KM -Kilometer

KWh - Kilowatt-Hour

LCV – Light Commercial Vehicle

MoRTH – Ministry of Road Transport and Highway

NEMMP - National Electric Mobility Mission Plan

NH – National Highway

OEM – Original Equipment Manufacturer

R&D – Research and Development

RVSF - Registered Vehicle Scrapping Facilities

TCO -Total Cost of Ownership

Contents

01
Introduction

This report addresses the transportation challenges faced by Meghalaya, including pollution and congestion, and proposes the adoption of electric vehicles (EVs) as a cleaner, more sustainable mode of transport. Recent data indicates a modest uptake of EVs in the region, with a total of 574 units sold up to March 2024. Among these, only 42 are cars or SUVs, highlighting a significant opportunity to enhance environmental sustainability in the transportation sector through retrofitting.

Retrofitting involves converting conventional internal combustion engine vehicles to electric vehicles and is presented as a cost-effective approach to utilizing the existing vehicle fleet while advancing towards greener mobility. This method not only extends the life of existing vehicles but also reduces the environmental impact associated with the manufacturing of new vehicles. In Meghalaya, where the adoption of EVs, particularly cars and SUVs, remains low, retrofitting can serve as a vital bridge to a more sustainable future.

Implementing retrofitting initiatives in Meghalaya could substantially lower emissions and reduce dependence on fossil fuels. It offers an immediate solution to the region's air quality issues by decreasing the number of pollutants released from traditional vehicles. The analysis includes a Total Cost of Ownership (TCO) for retrofitting, comparing it against maintaining existing internal combustion engine vehicles or purchasing new EVs. Findings indicate that retrofitting, especially with leased batteries, offers significant cost advantages over long-term ownership, highlighting its economic viability alongside environmental benefits.

1.1 Public Transportation Landscape in Meghalaya

Meghalaya, situated in northeastern India, spans an area of 22,429 square kilometers and is home to a population of 3,120,576 as per the 2011 Census. Its capital is Shillong. The state shares its southern border with Bangladesh's Mymensingh and Sylhet regions and its western border with Bangladesh's Rangpur division. To the north and east, it is bordered by the Indian state of Assam. The state's proximity to Assam underscores the importance of railway connectivity.

In 1970, when Meghalaya attained autonomous statehood by separating from Assam, it inherited a combined road length of 2786.68 kilometers, including 174 kilometers of National Highways, with a road density of 12.42 kilometers per 100 square kilometers. Substantial progress has been made since then. By the end of the 12th Five-Year Plan, the total road length had significantly increased to 10,487.094 kilometers, comprising 7460.201 kilometers of surfaced roads and 3026.893 kilometers of unsurfaced roads. Although the road density still falls below the national average of 170 kilometers per 100 square kilometers, Meghalaya's current figure stands at 46.76 kilometers per 100 square kilometers (Government of Meghalaya). Furthermore, the state now boasts 6 National Highways covering a total length of 1124.39 kilometers, with 753.13 kilometers maintained by the State PWD, 214.56 kilometers by NHAI, and 156.70 kilometers by NHIDCL.

In Meghalaya, the modal share is dominated by private vehicles, totaling 21,626, primarily comprised of 4-wheelers (4W) and 2-wheelers (2W), making up approximately 80% of the total vehicles in the state. Following this, there are 2,521 public vehicles, including buses, electric rickshaws, three-wheelers, and other intermediate public vehicles, accounting for approximately 10% of the total registered vehicles. The remaining 10% comprises 2,782 freight vehicles, such as LCVs, road rollers, and cranes.

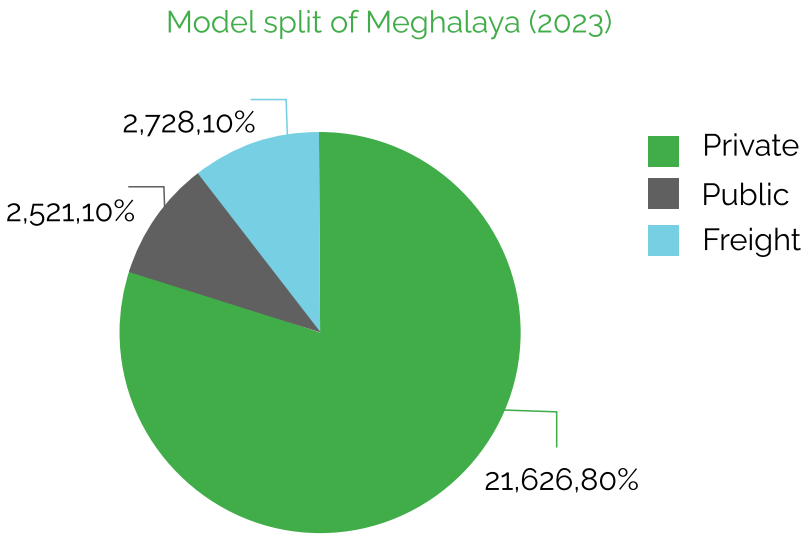


Figure 1: Modal Split of Meghalaya

Source: Vahan Dashboard

Table 1: Category wise registered Vehicles

Vehicle Category		Calendar Year								
		2023	2022	2021	2020	2019	2018	2017	2016	2015
1	Light Goods Vehicle	2,885	2,681	1,806	1,888	2,420	2,118	1,536	1,168	1,093
2	Light Motor Vehicle	11,064	11,071	8,559	8,211	9,480	10,016	9,096	7,714	7,190
3	Light Passenger Vehicle	3,133	2,031	1,072	1,318	2,198	1,767	1,684	1,644	1,554
4	Medium Goods Vehicle	187	97	43	75	251	58	107	149	83
5	Medium Motor Vehicle	3	7	7	6	13	12	9	4	1
6	Medium Passenger Vehicle	32	16	7	20	40	33	49	157	11

Source: Vahan Sewa Dashboard

1.2 Importance of Retrofitting in the Transition to Electric Vehicles

1 Significance of retrofitting

Retrofitting holds more significance for commercial vehicles than passenger cars due to the substantial reduction in carbon emissions and significant operational cost benefits for end-users. Commercial vehicle conversions, particularly in the 15-50 GVW range, can result in over 60% operating cost savings per kilometer and significant maintenance cost reductions due to fewer moving parts.

2 Urgency and Benefits of Retrofitting

The urgency for electric vehicle retrofitting in India stems from projections indicating a considerable increase in the number of buses and other public transport on the roads by 2030. Simply, adding more electric public vehicles to the existing fleet risks congestion on city roads. Hence, a more practical approach involves incorporating a limited number of electric vehicles while retrofitting existing ones to electric variants, effectively controlling vehicle counts and reducing vehicular emissions.

Retrofitting is particularly crucial in India due to a need for more indigenous technology to develop EV components suitable for the country's tropical climate. Additionally, EVs remain economically uncompetitive in India, and customers are reluctant to fully transition to electric fleets.

The advantages of retrofitting are manifold. From the customer's perspective, it reduces vehicle running costs, extends vehicle life, and fosters a sense of pride in contributing to sustainability. Societally, electric/hybrid vehicles promote public health and mitigate harm to the global climate. From the government's standpoint, retrofitting decreases crude oil consumption, vehicular emissions, and expenditure on oil imports.

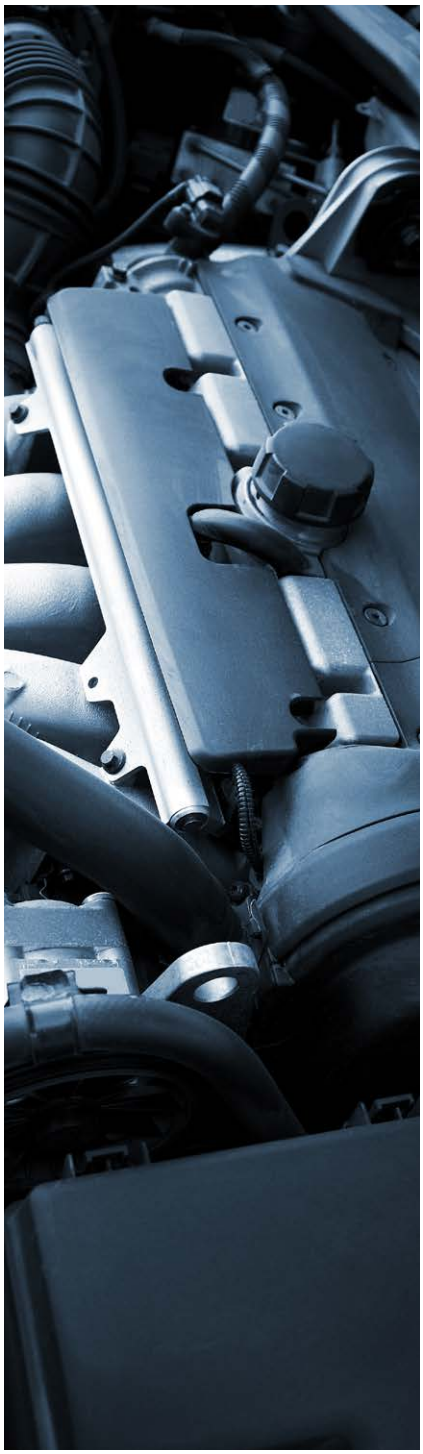
In India's emerging electrification market, where the lack of charging infrastructure poses a significant barrier to EV adoption, retrofitted EVs can serve as pioneers by stimulating demand for charging infrastructure, localized components and batteries, service infrastructure, and understanding usage patterns, among other factors. [1]

1.3 Vision-Missions

The Government of India has set an ambitious target for electric vehicles (EV), alongside plans to significantly reduce carbon emissions from diesel and petrol engines by 2030. Given this, the country is taking steps towards switching to electric vehicles. However, the pace of this transition can't be dramatic. Thus, to realize its dream of reducing its carbon footprint, the country must focus on converting the existing ICE vehicles into electric ones. Retrofitting increases the useful life span of existing vehicles by 5-7 years and would also not fall into the new scrappage policy.

The Government of India initiated the National Electric Mobility Mission Plan (NEMMP) 2020 in 2013 to bolster national fuel security by promoting hybrid and electric vehicles (EVs). The plan set an ambitious target of achieving 6-7 million annual sales of hybrid and electric vehicles starting from 2020 onwards. Fiscal and monetary incentives were planned to incentivize adoption, aiming to kickstart this emerging technology. With government support, cumulative sales were projected to reach 15-16 million by 2020, resulting in an estimated savings of 9500 million liters of crude oil, equivalent to Rs. 62000 crores. The Faster Adoption and Manufacturing of Hybrid & Electric Vehicles (FAME India) scheme, launched under NEMMP 2020 with an initial outlay of Rs. 75 crores in the Union Budget for 2015-16, aimed to accelerate the adoption and market creation of hybrid and electric vehicles. The scheme sought to position hybrid and electric vehicles as the preferred choice for consumers, thereby reducing liquid fuel consumption in the automobile sector. It was anticipated that early market creation through demand incentives, technology development, and domestic production would lead to self-sufficient economies of scale by 2020. By 2012-13, approximately 42,000 electric vehicles were sold, predominantly electric low-speed scooters, with nearly 20,000 hybrid and electric vehicles sold in 2013-14. The introduction of the FAME scheme was expected to stimulate the market for hybrid and electric vehicles across all vehicle segments, including 2-wheelers, 3-wheelers, 4W, LCVs, and buses. The scheme aimed to incentivize buyers through monetary support, with the Department of Heavy Industry finalizing details such as the incentive amount per vehicle-technology segment. The incentive would be administered through an electronic mechanism/portal, with manufacturers reducing the purchase price of hybrid and electric vehicles for buyers, reimbursed by the government. [2]

02
Understanding Retrofitting



2.1 Concept and Mechanism of ICE to EV Retrofitting

Retrofitting refers to a mechanical process involving the removal of the petrol/diesel engine and fuel tank from an Internal Combustion Engine (ICE) vehicle, which are then substituted with an electric motor and battery, effectively transforming the vehicle into an electric one. The electric motor utilized in this process has the capability to operate either directly from a battery or indirectly through a fuel cell, such as hydrogen, providing flexibility in power sources for the electric vehicle [3].

Steps Involved in Vehicle Retrofitting

a. Vehicle Assessment

Before commencing the retrofitting process, evaluating your vehicle to determine its suitability for conversion is crucial. Key factors to consider include the vehicle's age, condition, weight, and the availability of replacement parts.

b. Retrofitting Planning

Once the vehicle assessment confirms its viability for conversion, the next step involves meticulous planning for the retrofit. This includes selecting the suitable electric motor and battery pack and determining the optimal placement of these components.

c. Removing the Conventional Engine

Subsequently, the conventional engine and associated parts, such as the fuel tank and exhaust system, must be carefully removed. This step can be intricate and may necessitate the expertise of a professional mechanic.

d. Installing the Electric Components for the Electric Vehicle Retrofitting Conversion Process

With the conventional engine removed, the electric motor, controller, and other essential components are installed. This phase also demands precision and may require the assistance of a skilled electric vehicle technician.

e. Wiring and Control Systems

After installing electric components, the wiring and control systems must be configured. This entails connecting the battery pack, motor, and controller while ensuring the system is optimized for performance.

f. Battery Installation for Electric Vehicle Retrofitting Conversion Process

The battery pack plays a pivotal role in the conversion of electric vehicles. Selecting a high-quality battery pack that matches the vehicle's size and weight is imperative. The battery should be securely installed in an easily accessible location for maintenance.

g. Testing and Fine-tuning

Upon retrofit completion, thorough testing and fine-tuning are essential to ensure optimal performance. This involves evaluating acceleration, braking, handling, and monitoring battery life and range.

h. Certification and Registration

Finally, certifying and registering the electric vehicle retrofit with the relevant government agencies is imperative. This may entail obtaining specialized licensing or certification to ensure compliance with regulations. [1,4]

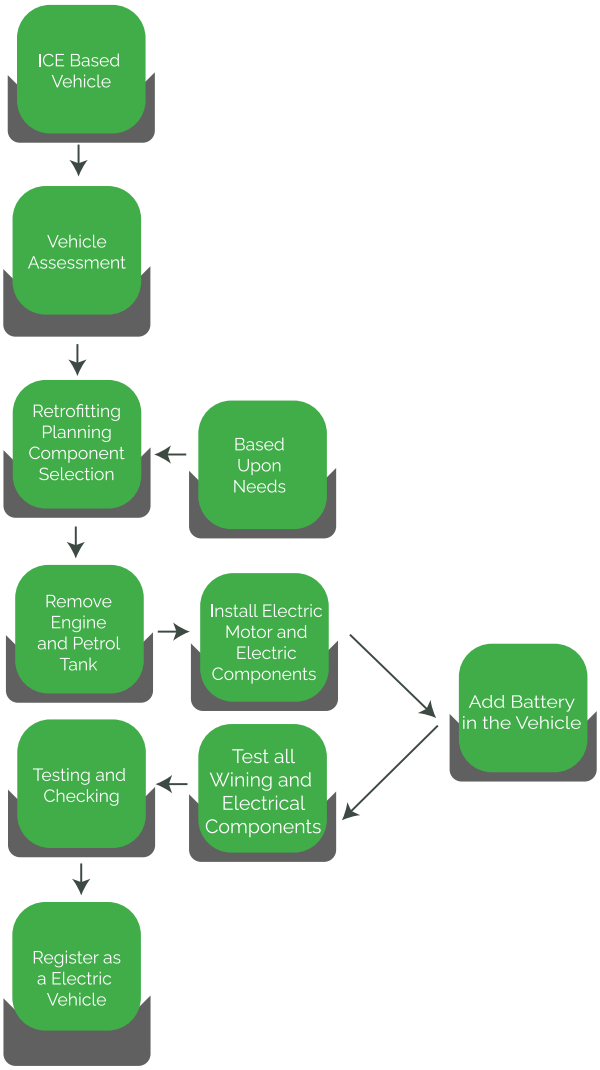


Figure 2: Retrofitting Process

Source: Author Generated

2.2 Total Cost of Ownership (TCO) Analysis for Retrofitting

Converting traditional internal combustion engine (ICE) vehicles into electric vehicles (EVs) is being viewed as a viable solution to meet the demand for decarbonization without imposing excessive costs on the public. However, the transition process must be gradual. Therefore, retrofitting current ICE vehicles is deemed necessary alongside the integration of new EVs. [5]

The Total Cost of Ownership (TCO) offers a method for accurately assessing and comparing the expenses associated with owning and operating a vehicle throughout its lifespan. It encompasses various factors, including initial purchase price, ongoing expenses like fueling/charging and maintenance, and financing costs. Given that these costs vary depending on the technologies involved, TCO analysis aims to assist users in comprehending the trade-offs involved and making well-informed decisions when selecting a vehicle to purchase.

2.2.1 Scenario-01

Here, a detailed Total Cost of Ownership (TCO) analysis was conducted for three different options. In the first option, operators continued to use their existing ICE vehicle after the 10th year. Operators retrofit their 4W into an E4W and purchase the battery in the second option. In the third and final option, operators install a retrofitment kit into their 4W but do not purchase the battery. Instead, they opt to lease the battery and utilize battery swapping stations.

Various factors were considered in analyzing the Total Cost of Ownership (TCO) for the three cases mentioned above. Fixed components included the battery cost, retrofitment kit, and government incentives. Operational cost components encompass annual maintenance, battery capacity, insurance per year, mileage (measured in kilometers per liter or kilowatt-hour), and the cost of refueling, recharging, or battery swapping. A discount and resale rate of 10% was factored in the CAPEX cost, while a 5% growth rate is considered for Fuel, electricity, and maintenance costs.

Table 2: Considered Values for the calculation of TCO

S.No	Factors	ICE	Retrofitted (Owned Battery)	Retrofitted (Leased Battery)
1.	Battery Cost	0	300000	0
2	Retrofitting Kit Cost	0	250000	250000
3	Tax	0	0	0
4	Insurance Cost/Yr	5000	7500	7500
5	Financial Incentives	0	50000	20000
6	Annual Maintenance	8000	5000	4000
7	Battery Capacity	0	21.50 KWh	21.50 KWh
8	Mileage	15 KMPL	8 KM/KWh	8 KM/KWh
9	Fuel/Electricity Cost	98.66/ Litre	10/KWh	20/Kwh

Source: Author Generated

It is observed that if the operator drives the vehicle 180 KM per day for 5 years, the TCO for the ICE 4W stands at Rs.7.48/KM, indicating its higher cost over the specified period. In contrast, the Retrofitted (Owned Battery) E4W demonstrates a slightly lower TCO of Rs.5.47/KM, suggesting less cost expenses compared to the ICE variant. Moreover, the Retrofitted (Leased Battery) E4W exhibits the lowest TCO of Rs.4.65/KM, indicating a moderate decrease in cost compared to the owned battery electric and ICE versions.

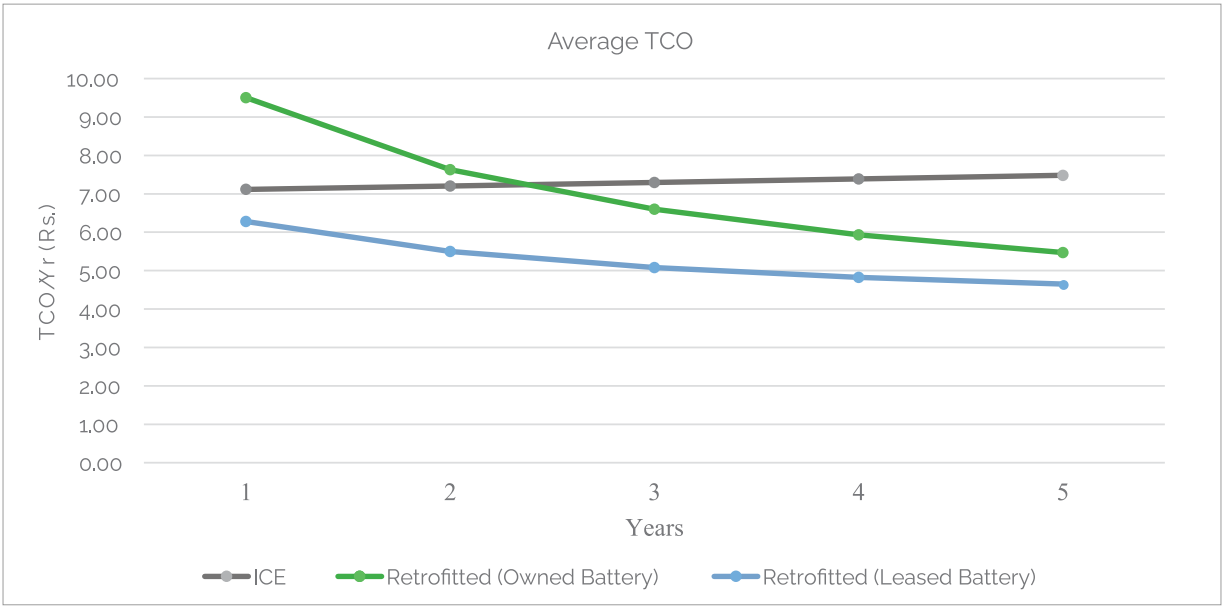


Figure 3: Average TCO value

Source: Author Generated

At the end of the 5th year, the TCO further emphasizes the economic advantage of electric vehicles, with the Retrofitted (Owned Battery) E4W showing the lowest TCO of Rs.3.61/KM, followed by the Retrofitted (Leased) E4W with a TCO of Rs.3.96/KM. In contrast, the TCO for the ICE vehicle stands at Rs.7.86/KM. This data underscores the potential financial benefits of transitioning to electric vehicles, especially considering long-term ownership costs.

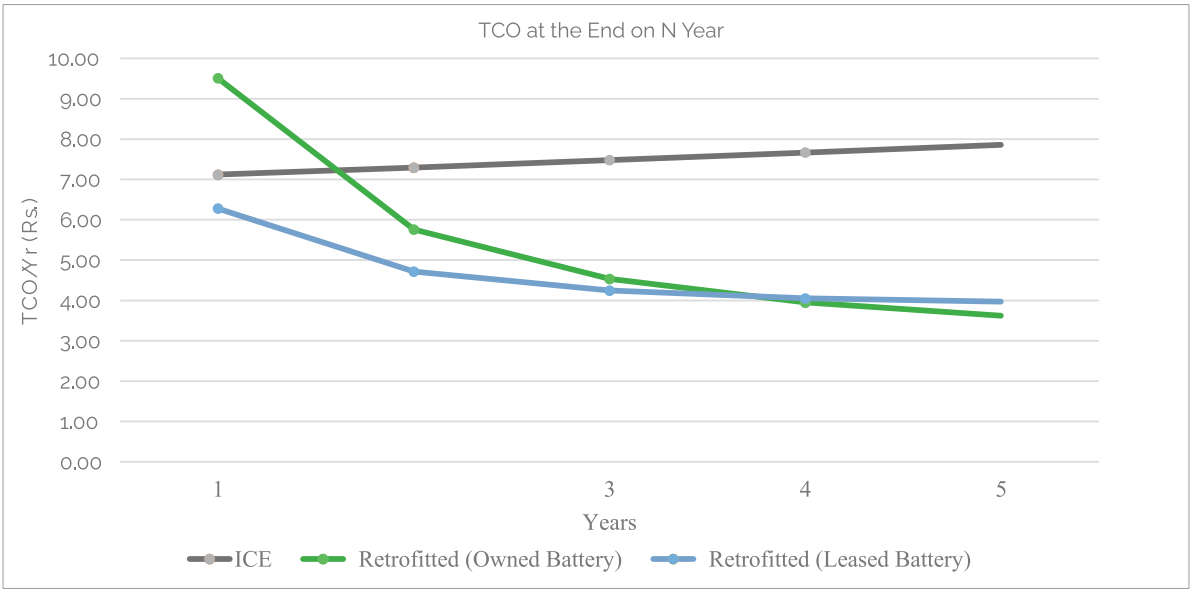


Figure 4: TCO value at the end of each year

Source: Author Generated

2.2.2 Scenario-02

Here, a detailed Total Cost of Ownership (TCO) analysis was conducted for four different options. The first option is for operators to buy a new ICE vehicle after the 10th year. Operators retrofit their 4W into an E4W and purchase the battery in the second option. In the third option, the operator switches to a new E4W, and in the fourth and last option, operators install a retrofitment kit into their 4W but do not purchase the battery. Instead, they opt to lease the battery and utilize battery swapping stations.

Various factors were considered in analyzing the Total Cost of Ownership (TCO) for the abovementioned cases. Fixed components included the battery cost, Retrofitment kit, and government incentives. Operational cost components encompassed annual maintenance, battery capacity, insurance per year, mileage (measured in kilometers per liter or kilometers per kilowatt-hour), and the cost of refueling, recharging, or battery swapping and battery change as well (After the first 5 years). A discount and resale rate of 10% was factored in the CAPEX cost, while a 5% growth rate is considered for Fuel, electricity, and maintenance costs.

Table 3: Considered Values for the calculation of TCO

S. No	Factors	ICE	Retrofitted (Owned Battery)	New EV 4W	Retrofitted (Leased Battery)
1.	Battery Cost	0	300000	0	0
2	Retrofitting Kit Cost/ Vehicle Cost	550000	250000	1000000 (Includes Battery)	250000
3	Tax	40000	0	70000	0
4	Insurance Cost/Yr	7500	7500	10000	7500
5	Financial Incentives	0	20000	50000	5000
6	Annual Maintenance	15000	5000	5000	4000
7	Battery Capacity	0	21.50KWh	22KWh	21.50KWh
8	Mileage	15 KMPL	8 KM/KWh	8 KM/KWh	8 KM/KWh
9	Fuel/Electricity Cost	98.66/Litre	10/KWh	10/KWh	20/Kwh
10	New Battery Cost	0	300000	400000	0

Source: Author Generated

If the operator drives the vehicle 180 km per day for 10 years, the TCO for the New ICE 4W stands at Rs.13.43/KM, indicating its higher cost over the specified period. In contrast, the Retrofitted (Owned Battery) E4W demonstrates a significantly lower TCO of Rs.7.35/KM, while the average TCO for New E4W stands at Rs.10.67/KM. Moreover, the Retrofitted (Leased Battery) E4W exhibits the lowest TCO of Rs.4.32/KM, indicating a significant decrease in cost compared to the owned battery electric version.

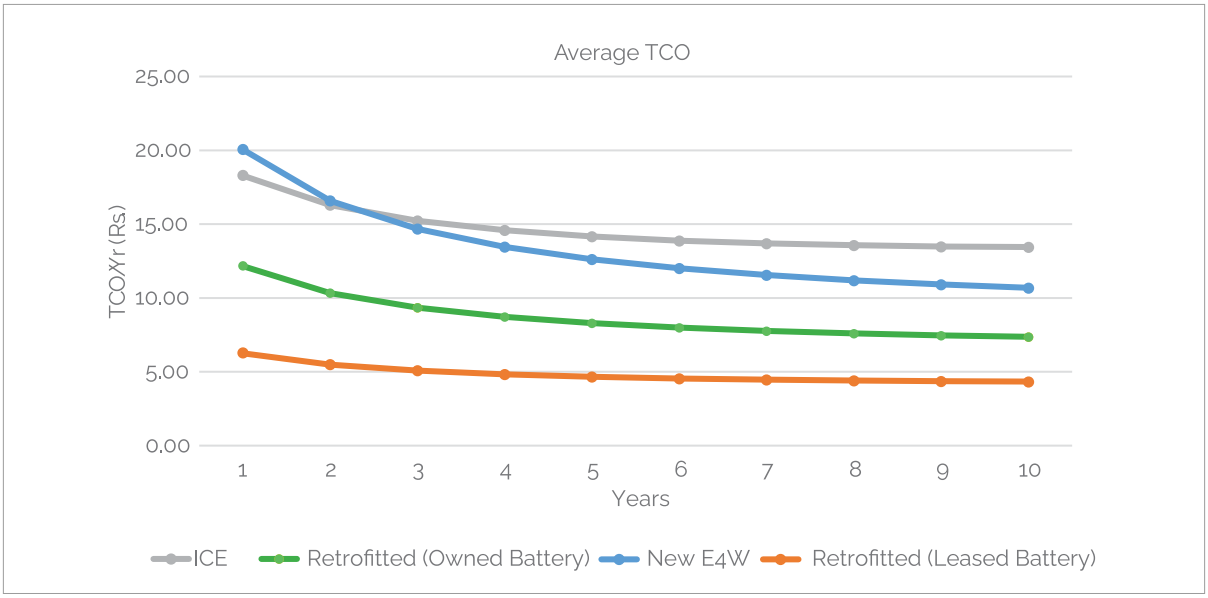


Figure 5: Average TCO value

Source: Author Generated

At the end of the 10th year, the TCO further emphasizes the economic advantage of electric vehicles, with the Retrofitted (Leased Battery) E4W showing the lowest TCO of Rs.4.07/KM, followed by the Retrofitted (Owned Battery) E4W with a TCO of Rs.6.47/KM, and for new ICE vehicle it is Rs.13.05/KM. In contrast, the TCO value for New E4W at the end of the 10th year stands at Rs.8.46/KM. This data underscores the potential financial benefits of transitioning to electric vehicles, especially considering long-term ownership costs.

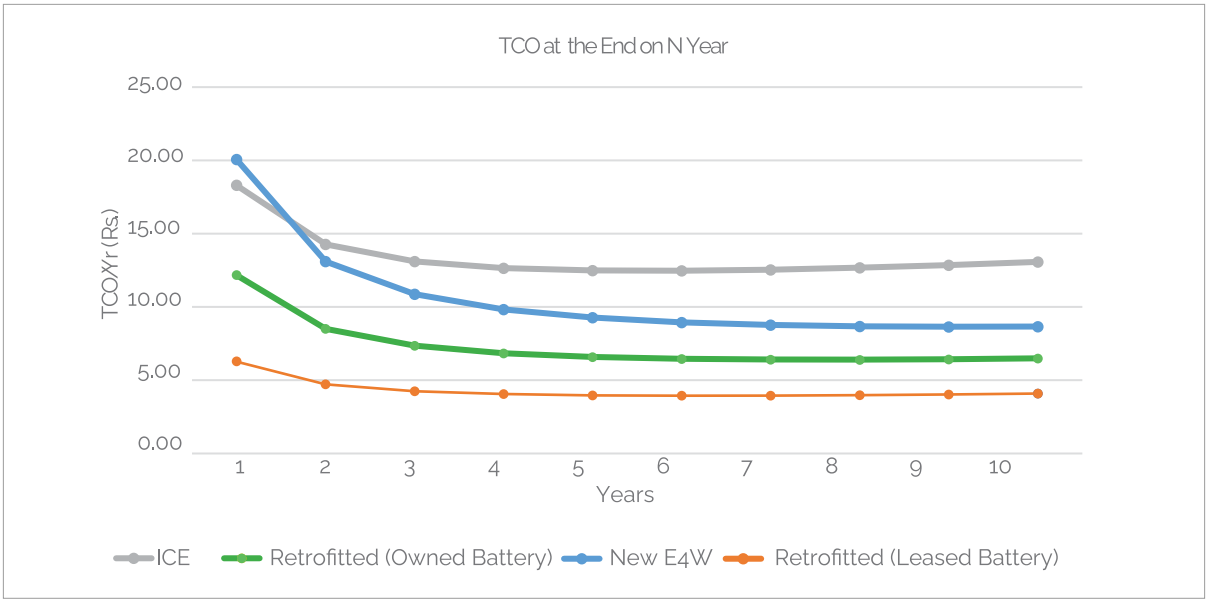


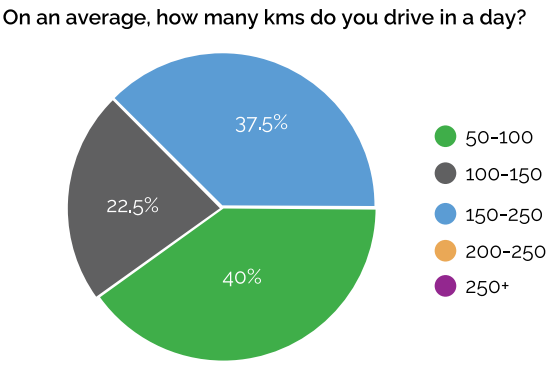
Figure 6: TCO value at the end of each year.

Source: Author Generated

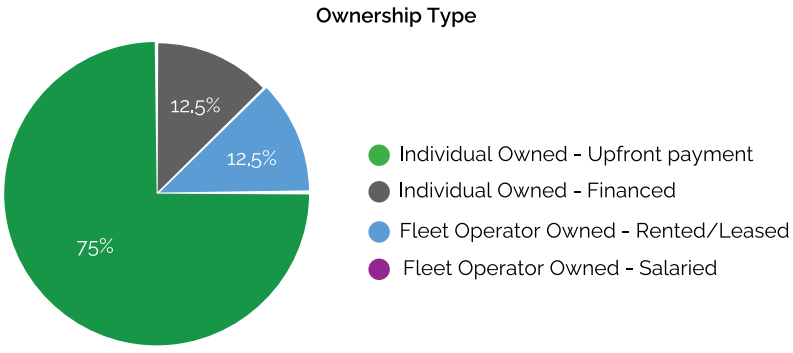
03
Consumer Insights

Attracting skeptical consumers and fostering their acceptance of retrofitted electric vehicles (EVs) is essential for increasing market adoption. Educating consumers about the benefits of retrofitting, addressing their concerns, and building confidence in the available retrofitting solutions are key strategies in this process.

To better understand the target audience's perspective, we surveyed approximately 50 taxi drivers in Shillong. These drivers primarily operate Maruti Suzuki Alto 800s that run on petrol as fuel. These taxis, which typically have a passenger capacity of four to five per trip, are mostly owned individually and were acquired through upfront payments. This information is crucial in tailoring strategies that resonate with drivers' specific needs and concerns, facilitating a smoother transition to retrofitted EVs.



(a)



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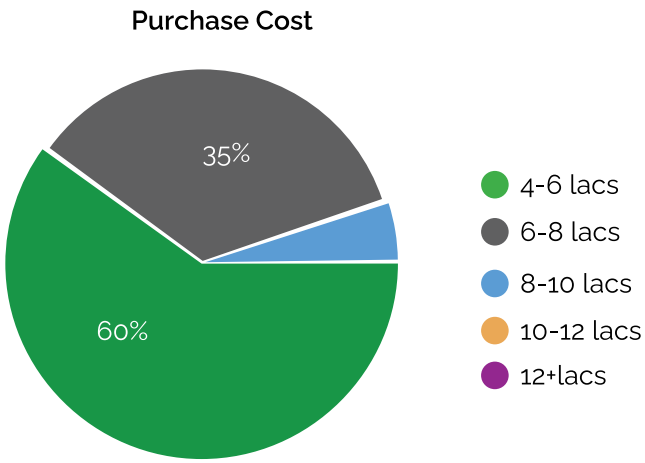


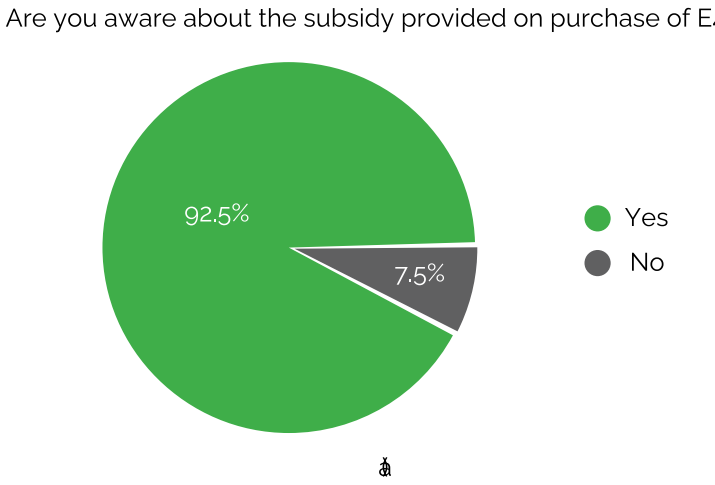
(c)

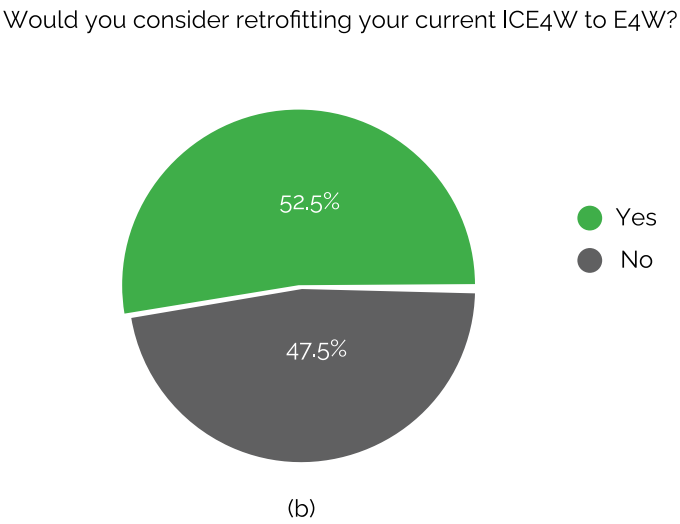
Figure 7: Descriptive Analysis for (a) On an average, how many kms do you drive in a day? (b) Ownership Type (c) Purchase Cost

3.1 Perceptions and Attitudes Towards Retrofitting

Understanding consumer attitudes towards ICE to EV retrofitting is crucial for shaping perceptions of E-mobility. Initial perceptions often revolve around concerns such as insufficient EV range and the assumption that EVs are primarily suitable for urban areas. Moreover, perceptions of retrofitting tend to be negative initially, met with skepticism primarily due to perceived high costs and insufficient knowledge about the process.

One significant barrier to acceptance among taxi drivers is the lack of awareness regarding available subsidies for retrofitting costs. This highlights the need for targeted awareness programs. Interestingly, 47.5% of taxi drivers have shown a willingness to transition their vehicles from ICE to electric, recognizing the benefits of EVs over traditional vehicles, including potential increases in vehicle lifespan. However, the upfront cost of retrofitting remains a significant obstacle, necessitating innovative business models and financing options to make retrofitting more accessible.





(b)

Figure 8: Descriptive Analysis for (a) Are you aware about the subsidy provided on purchase of E4W? (b) Would you consider retrofitting your current ICE4W to E4W?

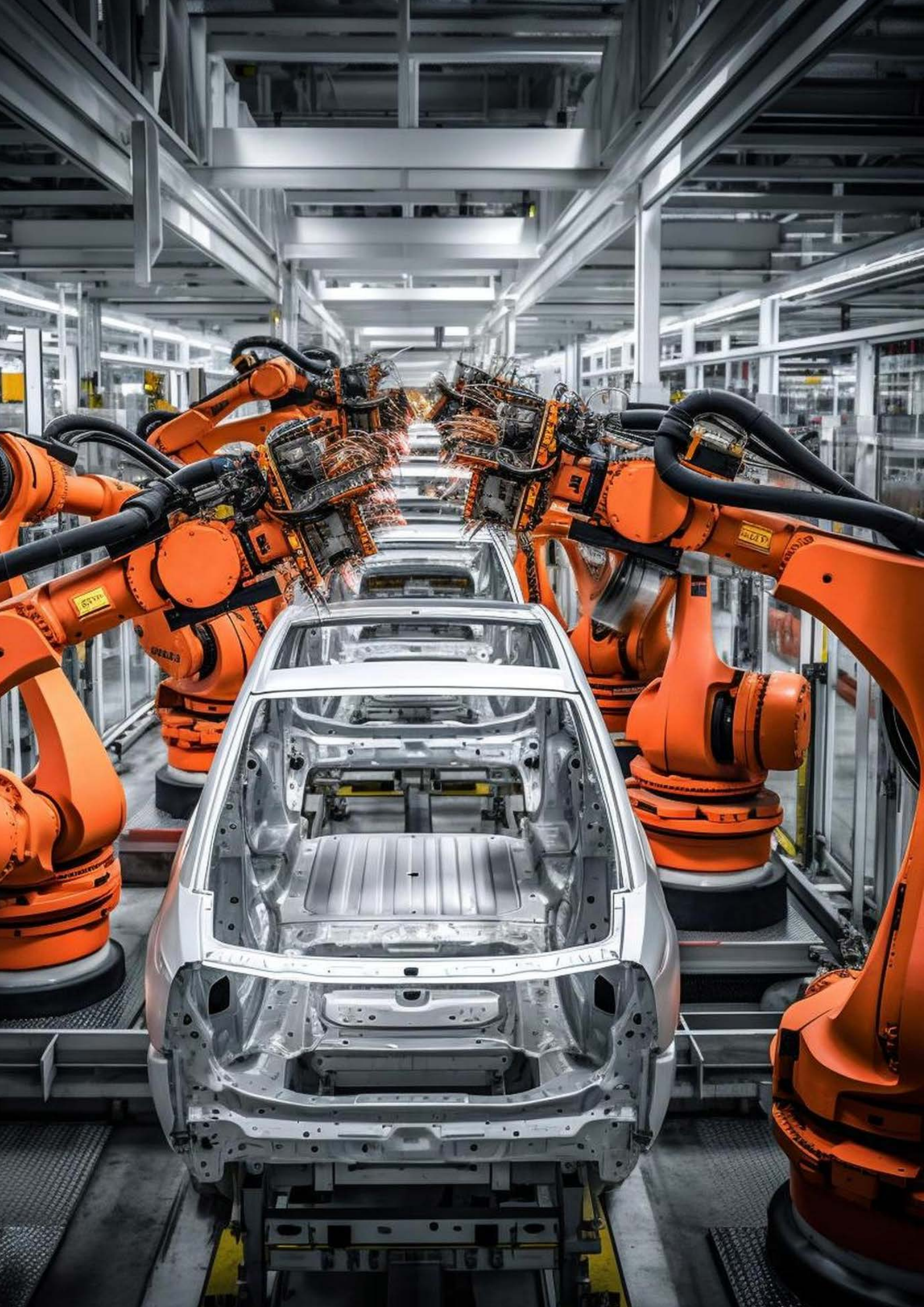
The availability of more public charging stations (PCS) could address concerns about range and waiting times. Moreover, drivers are motivated to consider retrofitting because of the environmental advantages of lower emissions, the potential for enhanced acceleration, reduced operating and maintenance costs, and the prospect of extending their vehicle's service life. Additionally, a growing interest in EV technology among drivers in Meghalaya points to an increasing readiness to explore retrofitting options, signaling a positive shift in attitudes towards E-mobility.

3.2 Demand Analysis and Potential Adoption Rates

While market analysis suggests that the retro-fitting sector is still in its early stages, it exhibits significant potential for growth due to its technological simplicity and accessibility. As of 2023, the global retrofit vehicle market is estimated to be valued at USD 65.94 billion, with projections indicating a growth to USD 125.37 billion by 2032 at a notable CAGR of 7.40%. Notably, the Asia-Pacific region commands a dominant share of 62.5%, driven by substantial investments in clean transportation and robust R&D efforts primarily led by countries such as India, China, Japan, and South Korea.

Moreover, the sector presents promising opportunities for continuous expansion driven by increasing consumer demand and stricter emission regulations. In the next decade, anticipated shifts from commercial to passenger vehicles and two-wheelers further bolster prospects. Retrofitted vehicles reportedly boast longer lifespans and superior power delivery. EV retrofitting also emerges as a vital asset in decarbonizing transportation systems, highlighting its role in sustaining high-cost vehicles that might otherwise face scrappage. [6]

In India, this concept has gained substantial traction, backed not only by legal frameworks but also regarded as an upgrade to the existing vehicular system.



04

Policy and Stakeholder Engagement

Integrating EV conversion into national legislative frameworks is essential to advance EV retrofitting and solidify its position in the transportation sector. Policies should explicitly acknowledge retrofitted vehicles within existing EV incentives, enhancing their appeal and adoption. This inclusive approach facilitates comprehensive monitoring and regulation, transitioning retrofitting from a niche alternative to a mainstream solution in the electrification agenda.

4.1 Government Policies Supporting EV Retrofitting

Government subsidies and incentives can play a pivotal role in enhancing the economic viability of retrofitting. In a significant move, the 2021 Delhi Government policy allowed vehicles over ten years old, which would usually violate the National Green Tribunal's ban, to keep running if they're retrofitted with an Electric Vehicle (EV) kit. This proactive decision has led to the growth of an industry focused on converting older Internal Combustion Engine (ICE) vehicles into cleaner EVs, creating a path for older vehicles to contribute to the vision of 'Cities of Tomorrow.'

Additionally, various states are introducing EV policies, some of which offer incentives for retrofitting. These actions show a commitment to promoting sustainable transportation and speeding up the shift to electric mobility

Table 4: State EV Policies and Vehicle Retrofitting Initiatives

S. No.	State / UT	Policy and Year	Retrofitting Policy
1	Rajasthan	Rajasthan EV Policy 2022	Eligible retrofit kits will be incentivized; 15% of the retrofit kit cost (including taxes) up to INR 15,000 per vehicle. Retrofit kits eligible for incentives under this policy include kits for conversion from ICE to battery-operated Electric Vehicles and shall be approved by a competent agency under Rule 126 of CMVR, 1989, or notified by the Transport Department, Government of Rajasthan.
2	Tripura	Tripura EV Policy 2022	During the policy period, 25% of the on-road vehicles will be targeted for conversion by retrofitting into EV vehicles from ICE vehicles.
3	Chhattisgarh	Chhattisgarh State EV Policy 2022	To promote replacing existing ICE installations with electric kits in the vehicles. This may also be taken up at AVSF centers set up in the State. This shall also include converting existing ICE vehicles to hybrid vehicles with ICE and electric kit provisions.

Source: Author Generated

To further enhance the transition from traditional internal combustion engine (ICE) vehicles to electric vehicles (EVs), it is imperative to establish a comprehensive and incentivizing policy scheme. Central to this framework is the introduction of robust incentives designed to support retrofitting existing vehicles into EVs.

4.2 Roles and Responsibilities of Key Stakeholders

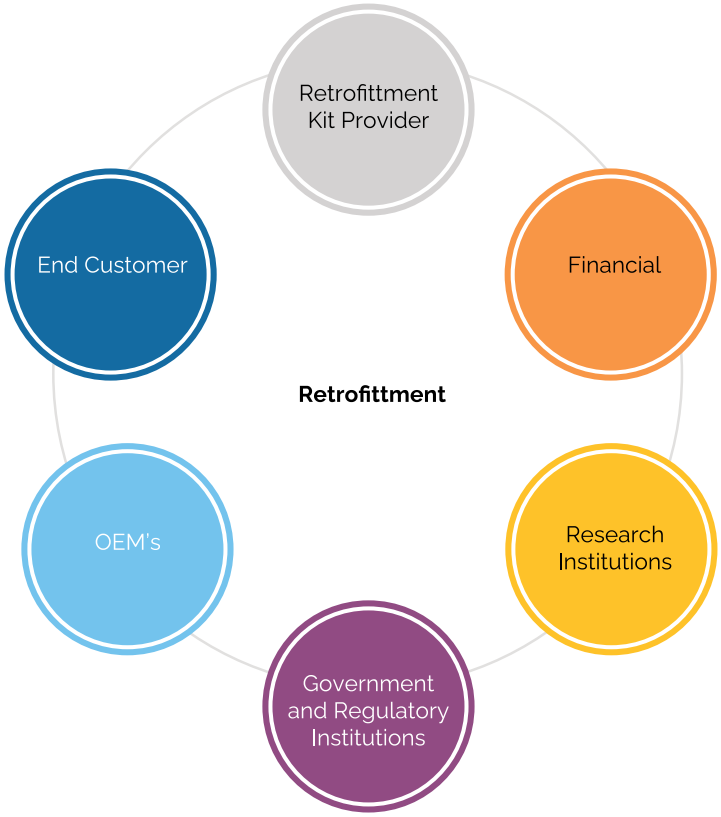


Figure 9: Involved Stakeholders

Source: Author Generated

In the retrofitting industry for converting ICE four-wheelers to E-wheelers, several key stakeholders are involved, each with their specific roles and responsibilities:

- Retrofitting Kit Providers: These entities are crucial for supplying the essential components required for the conversion process. They manage business operations, coordinate various stakeholders' activities, and ensure certified retrofitting kits are available. Moreover, they are responsible for providing trained specialists to install these kits and set up service points for end customers. Retrofitting Kit Providers also establish infrastructure for vehicle conversions, execute installations, and offer post-conversion servicing and maintenance.
- Financial Institutions (Venture Capital Partners/ Banks): Venture capital firms and banks are pivotal in supplying the capital necessary for initiating and scaling the retrofitting processes. They invest in retrofitting projects, facilitating these ventures to expand their operations and access broader markets. Additionally, these financial institutions also play a role in offering loans and financing options to end customers, enabling them to afford the conversion of their vehicles into E-wheelers. This financial support is vital for both the growth of retrofitting businesses and adopting E-wheelers.
- Research Institutions: These institutions support the technical development of electrification solutions for four-wheelers. Their involvement fosters innovation and drives advancements in E-wheeler technology. Depending on their contribution, they may receive financial remuneration.
- Government and Regulatory Institutions: Governmental and regulatory agencies provide critical support through grants, subsidies, and policy frameworks to encourage the adoption of electric vehicles (EVs). They offer financial incentives to both retrofitting businesses for research and development and to end customers for purchasing E-wheelers. Furthermore, they are responsible for ensuring that retrofitting practices comply with safety standards and environmental regulations, overseeing vehicle registrations, fitness tests, and the certification of retrofitting kits.
- Original Equipment Manufacturer (OEMs): OEMs supply the high-quality components and parts necessary for retrofitting 4W into electric vehicles. Their role is essential in maintaining the reliability and performance standards of the converted vehicles.
- End Customers: The end customers are the final and key stakeholders in the retrofitting process. They are the recipients of the conversion service, transforming their 4W into a more sustainable E-vehicle. Customer satisfaction and feedback are critical for the continuous improvement and success of the retrofitting industry, influencing service standards and the development of new solutions.

By integrating these stakeholders and highlighting their roles, we can appreciate the complexity and collaborative nature of the retrofitting industry's ecosystem. This interconnected network is essential for the successful conversion of ICE 4W to electric vehicles, supporting the transition towards more sustainable modes of transportation.

4.3 Current Regulatory Framework for EVs and Retrofitted EVs in India

A collaborative partnership between the government and industry stakeholders is essential to mitigate the potential risks associated with retrofitting. Establishing a robust regulatory framework becomes imperative to uphold strict quality standards for both retrofitting kits and processes. [7]

Table 5: Regulatory Frameworks

Regulatory Sections Reference	Sections 41(7), 41(10), 56, and 59 of the Motor Vehicle Act, alongside Rule 62 and Rule 189 of the CMVR, constitute the regulatory backbone for EVs and retrofitted EVs under the oversight of MoRTH.
Registered Vehicle Scrapping Facilities (RVSFs)	Section 8 of the RVSFs guidelines is pivotal in the context of EVs and Retrofitted EVs, contributing to the comprehensive governance of these vehicle categories in India.
Governing Bodies	Ministry of Road Transport and Highways (MoRTH) oversees the implementation and interpretation of the Central Motor Vehicles Rules (CMVR) and Motor Vehicle Act, which provide the legal framework for registration, fitness, and lifespan of transport vehicles, including EVs and retrofitted EVs in India.
Registration Renewal	As per Rule 62 of the CMVR, and Sections 41(7) and 41(10) of the Motor Vehicle Act, the current regulations permit the renewal of registration for retrofitted EVs akin to other conventional vehicles. This provision applies to both private and commercial entities.
Fitness Tests	Rule 189 of the CMVR delineates three additional fitness tests, specifically for EVs, pertinent to retrofitted EVs. Upon passing these tests, the initial registration of 15 years can be renewed.
Scrappage Policy	The existing laws do not mandate a scrappage requirement for EVs and retrofitted EVs. Any scrapping activity by private players is conducted voluntarily.
Vehicle Lifespan	The prescribed lifespan for these categories of vehicles is set at 15 years. However, a provision for 5-year extensions exists, subject to the vehicle passing requisite fitness tests and provided the chassis remains in a fit condition.

Source: Author Generated

4.4 Impact of Financial Incentives and Subsidies

The primary hurdle lies in the economic feasibility of retrofitting, particularly considering the significant expenses associated with procuring and installing retrofit kits. With the decreasing costs of new EVs, there's growing skepticism regarding the financial prudence of opting for retrofitting. This doubt intensifies as battery expenses are anticipated to reduce in the future, prompting questions about the long-term viability of retrofitting as a sound investment decision. [8]

However, financial incentives and subsidies present a crucial opportunity for overcoming these economic challenges and encouraging a shift towards retrofitting. By offering financial support and incentives, governments can help offset the upfront costs associated with retrofitting, making it a more attractive option for vehicle owners.

05

Technical Considerations and Challenges:

While retrofitting offers various benefits, it also poses specific challenges and risks that require careful consideration. This chapter explores the detailed landscape of risks linked with Electric Vehicle (EV) retrofitting, recognizing the complexities involved in such endeavors.

5.1 Technical Consideration and Challenges

A primary concern revolves around the technical and performance limitations. Retrofitting might need to consistently achieve the same efficiency and performance as vehicles originally designed as EVs. The conversion process can be complex, requiring specialized knowledge and expertise. This disparity can lead to differing performance levels, potential technical malfunctions, and challenges with weight distribution.

Depending on a wide range of suppliers for specialized components introduces inherent vulnerabilities within the supply chain. Disruptions in the procurement process or component quality inconsistencies can slow project timelines and increase costs, posing operational risks to retrofitting initiatives.

Furthermore, swift advancements in EV technology may make retrofitted vehicles vulnerable to early obsolescence. Balancing the integration of state-of-the-art innovations with long-term sustainability is essential to reduce the risk of technological redundancy. [6]

5.2 Safety Standards and Certification Processes

Thorough testing and calibration are imperative when retrofitting vehicles for electric propulsion, ensuring seamless integration and functionality of all system components. This involves meticulous motor controller calibration, charging functionality validation, and rigorous safety checks to identify and address potential hazards. Safety considerations are paramount throughout the retrofit process, necessitating compliance

with established safety standards and regulations. It is essential to guarantee that high-voltage components are adequately insulated, properly grounded, and equipped with safety features such as cutoff switches and emergency shutdown procedures.

Moreover, legal and regulatory compliance is non-negotiable, mandating adherence to local, regional, and national regulations governing vehicle modifications, emissions, and safety standards, along with obtaining requisite permits and approvals. Documentation plays a crucial role in maintaining comprehensive records detailing component specifications, wiring diagrams, and implemented safety measures. Certification may also be required for certain aspects of the retrofit to ensure adherence to industry standards. Finally, a meticulous final inspection conducted by a qualified technician is essential before the retrofitted electric vehicle (EV) is put into regular use, verifying compliance with safety and performance standards to guarantee the reliability and safety of the converted vehicle.

06

Way Forward

6.1 Strategic Recommendations for Policy, Infrastructure, and Consumer Engagement

Public-private partnerships have the potential to cultivate collaboration between government bodies and private companies specializing in EV technologies. These partnerships support joint ventures aimed at developing and distributing retrofitting kits, thereby advancing the adoption of retrofitting solutions.

After analyzing the total cost of ownership (TCO) across various scenarios, it becomes evident that there is an immediate need to introduce multiple new business models in the market to promote the battery leasing sector in the region. This move would not only yield substantial profits for operators but also incentivize them to retrofit their vehicles after 10 years. Additionally, implementing a scrappage policy initially in urban areas and gradually extending it statewide would foster electric vehicle adoption and retrofitting the current fleet.

Anticipating advancements in battery technology, which would lower battery costs and increase energy density, is key to enhancing vehicle range. Providing financial support to early adopters is a critical step toward establishing a self-sustainable model within the state. Furthermore, offering fiscal and non-fiscal incentives for charging stations and battery-swapping facilities will encourage investors to develop the necessary infrastructure in the region. [9]

6.2 Scheme for Scaling Retrofitting Initiatives in Meghalaya.

To develop a scheme for retrofitting 4-wheeler ICE vehicles to EVs in Meghalaya with an initial focus on 4W taxis like the Maruti 800 and Alto involves a multi-faceted approach; it's essential to address several policy, infrastructure, and financial aspects. Here's a comprehensive approach to such a scheme:

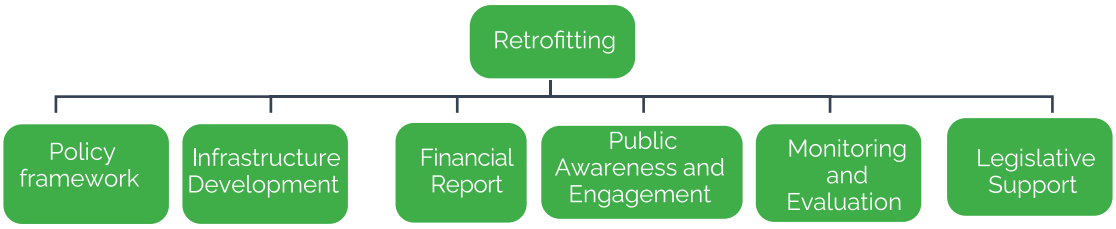


Figure 10: Retrofitting Scheme

a. Policy Framework

Incentivization and Regulatory Support

- **RTO Fee Exemption:** Eliminate Regional Transport Office (RTO) fees for EV retrofitting, including charges for Registration Certificate renewal, retrofitting permissions, vehicle evaluation, and fitness certification.
- **Road Tax Exemption:** Introduce a road tax exemption for retrofitted EVs to lower operational costs and enhance the economic appeal of EVs.
- **Equal Treatment:** Ensure that retrofitted EVs receive the same benefits and are subject to the same regulations as newly manufactured EVs, especially in commercial applications.
- **Extended Vehicle Life:** Amend scrapping policies to extend the operational life of vehicles by 10 years post-retrofit, contingent on receiving a new EV fitness certificate.

b. Infrastructure Development

Retrofitting Facilities

- **Capital Subsidies:** Offer financial support to existing garages to upgrade their EV retrofitting facilities or establish new authorized retrofitting centers.
- **Technical Training:** Provide training programs for technicians on EV technologies and retrofitting procedures to ensure high-quality conversions.

Inspection and Certification Centers

- **Single-Window Compliance:** Develop a streamlined Advance Passenger Information (API) for all RTO-related activities to facilitate faster processing and minimize bureaucratic hurdles.
- **Inspection and Certification Infrastructure:** Establish dedicated Inspection and Certification (I&C) centers that can handle the specific needs of retrofitted EVs, ensuring compliance with safety and performance standards.

c Financial Support

Subsidies and Grants

- **Direct Subsidies:** Offer direct financial incentives to vehicle owners and retrofitting companies to cover a portion of the retrofitting costs.
- **Tax Incentives:** Provide tax breaks or credits to retrofitting service providers and vehicle owners who choose to convert their vehicles to electric.

Low-Cost Financing

- **Green Loans:** Collaborate with financial institutions to offer low-interest loans for retrofitting projects for both individual vehicle owners and businesses engaged in retrofitting services.

e. Public Awareness and Engagement

Education and Outreach

- **Awareness Campaigns:** Launch state-wide informational campaigns to educate the public on EVs' benefits and the available retrofitting incentives.
- **Stakeholder Workshops:** Conduct workshops for vehicle owners, service providers, and local government units to discuss the retrofitting process, benefits, and regulatory changes.

f. Demonstrations and Pilot Projects

- **Pilot Retrofitting Project:** Implement a pilot project in select cities within Meghalaya to demonstrate the feasibility and advantages of vehicle retrofitting, adjusting the program based on feedback and results.

f. Monitoring and Evaluation

Data Collection and Analysis

- **Performance Tracking:** Establish a system to monitor the performance of retrofitted vehicles and the utilization of retrofitting centers, gathering data to improve the scheme continuously.
- **Feedback Mechanism:** Set up channels for participants to provide feedback on the retrofitting process and the effectiveness of the incentives and support provided.

g. Legislative Support

Legal Framework

- **Modify Existing Laws:** Amend transportation and environmental regulations to support the integration of retrofitted EVs into the transportation system and ensure compliance with environmental standards.
- **Protection Policies:** Enact policies to protect consumers and ensure that retrofitting services meet strict quality and safety standards.

By implementing these strategic steps, Meghalaya can effectively scale its retrofitting initiatives, paving the way for a more sustainable transportation system while contributing to the broader goals of environmental conservation and economic development.

07
Conclusion

7.1 Summary of Findings

The retrofitting of internal combustion engine (ICE) vehicles to electric vehicles (EVs) represents a significant step forward in accelerating the transition to more sustainable transportation practices. This approach offers a viable and environmentally friendly solution capable of transforming many ICE vehicles into EVs, thereby mitigating emissions. A comprehensive examination of the significance, market potential, and policy landscape surrounding EV retrofitting underscores its crucial role in reducing emissions and optimizing resource utilization within the automotive sector. By facilitating this transition, EV retrofitting becomes instrumental in addressing pressing environmental concerns.

While EV retrofitting holds immense promise, it confronts various challenges, ranging from technical intricacies to safety considerations, financial constraints, and regulatory complexities. Addressing these challenges necessitates strategic solutions to ensure retrofitting initiatives' effective implementation and scalability. Collaborative efforts between governments and industry stakeholders are paramount in devising and executing strategies that foster widespread acceptance of EV retrofitting as a viable alternative to vehicle replacement or scrappage. This entails the implementation of tailored awareness campaigns, vocational training programs, and robust research and development endeavors.

Furthermore, innovative business models are essential in making retrofitting economically feasible and accessible. By exploring creative approaches to financing, such as leasing or subscription-based models, and incentivizing aftermarket retrofitting services, businesses can expand the reach of retrofitting solutions to a broader market. Additionally, strategic partnerships between automotive manufacturers, technology providers, and service providers can drive innovation and efficiency in the retrofitting process. These collaborative ventures can leverage policy incentives, such as tax reliefs and economic subsidies, to streamline retrofitting and stimulate growth in related industries. Ultimately, a balanced regulatory framework is essential to ensure that

technological advancements in retrofitting align with consumer safety, environmental sustainability, and economic viability, thereby paving the way for a more sustainable transportation landscape.

7.2 Final Thoughts and Future Outlook

The potential of retrofitting to drive the widespread adoption of electric vehicles (EVs) is not only undeniable but also pivotal in shaping the future of transportation toward sustainability. By prioritizing this approach, we have the opportunity to propel advancements in EV technologies, resulting in transformative changes that align with global efforts to reduce carbon emissions and achieve ecological sustainability. Retrofitting, rather than being a temporary solution, stands as a significant step towards sustainable mobility, offering a pathway to mitigate the environmental impact of transportation.

The potential impact of effective retrofitting extends beyond individual vehicles; it has the power to reshape entire transportation systems and patterns. By enabling the conversion of a significant portion of the existing vehicle fleet to electric power, retrofitting can potentially revolutionize how people commute, travel, and transport goods. This shift towards electric mobility not only reduces emissions but also opens doors to new modes of transportation and innovative business models centered around sustainable mobility solutions.

However, achieving effective retrofitting requires more than just technological advancements; it necessitates informed decision-making, strategic planning, and collaborative efforts across various sectors. Policymakers, industry players, and the public must work together to develop and implement clear action plans that promote the widespread adoption of EV retrofitting. This report serves as a comprehensive guide, offering insights and recommendations to navigate the complexities of retrofitting and steer toward a sustainable future. It emphasizes the urgency of turning the concept of EV retrofitting into a widespread reality, emphasizing its critical role in shaping the future of transportation and safeguarding the planet for future generations.

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Alliance for an Energy-Efficient Economy
37, Link Road, Ground Floor, Lajpat Nagar III,
New Delhi 110024

+91-11-4123 5600 info@aeee.in www.aeee.in