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Enabling Europe India Collaboration

RETROFIT FOR A GREENER FUTURE

ACCELERATING ELECTRIC VEHICLE ADOPTION

JANUARY 2024

FOREWORD

MR. DAVINDER SANDHU

CHAIRPERSON & CO-FOUNDER
PRIMUS PARTNERS

The adoption of electric vehicles (EVs) is accelerating across India and the policy framework aiding this transition continues to evolve with resolute focus and vision. The forthcoming EV policy is set to further bolster this progress.

The Ministry of Road Transport and Highways and Ministry of Heavy Industries have been instrumental in driving the narrative for effective and large-scale market development for EVs and emission reductions. National endeavours such as the FAME Scheme have democratized the access to electric vehicles, making them a viable option for citizens across economic strata.

Global examples confirm retrofitting as a glide path that ensures a smooth transition to an EV-based future, underscoring the necessity for conducive policy formulations, regulatory incentives, and the creation of a supportive e-mobility ecosystem to transition. Retrofitting is an actionable pathway to electrify buses and public utility fleets—essential elements in the transition to a resilient, energy-efficient transport sector.

Retrofitting enhances vehicle longevity, adds the essential elements of recycle and re-use, and optimizes operating costs. It has significant potential to scale the EV landscape and will bridge the gap between current state and ambitious national EV targets. It brings the promise of ground-breaking EV products, creating local manufacturing champions, and demonstrating the role of innovation and sustainability in meeting the demands of modern consumers.

The enclosed report synthesizes these perspectives, providing a comprehensive outlook on the role of retrofitting in India's green future. It offers a pragmatic examination of appropriate regulatory facilitation, cost implications, and incentives that will underpin retrofitting's place in our EV adoption strategy. The document encapsulates the contributions and insights from policymakers, industry leaders, and regional stakeholders, united in the commitment to forging an electrified road ahead.

FOREWORD

MR. VAIBHAV DANGE

MEMBER OF BOARD OF DIRECTORS EUROPEAN BUSINESS AND TECHNOLOGY CENTRE (EBTC)

I am delighted to present the "Retrofit for a Greener Future: Accelerating Electric Vehicle Adoption" report. This comprehensive document marks another significant milestone in our commitment to fostering sustainable development and technology transfer between Europe and India.

The urgency to combat climate change has clearly become a global priority. India's growing automotive sector and its transition towards electric vehicles (EVs) holds a pivotal role in this narrative. Retrofitting, the process of transforming existing internal combustion engine (ICE) vehicles into electric ones, stands out as an innovative solution, a natural evolutionary step on the way to widespread EV adoption. It is both a bridge towards a cleaner environment and a testament to human ingenuity.

This innovative practice gains even more relevance against the backdrop of recent landmark decisions in the European Union, wherein it is stipulated that by 2035, the majority of all new vehicles sold will be zero CO2 emissions, allowing a few exceptions. India, marching in step with this vision, is taking rapid strides towards achieving its ambitious target of a 30% EV market share by 2030. It is clear that the transition from ICE to EV will be instrumental in shaping the future of the automotive sector.

This report is a tribute to the collaborative spirit of policymakers, industry leaders, and regional stakeholders who have joined forces to enable the transition to a low-carbon economy. It serves as a reminder that technology is a tool for progress, reflecting both India's and Europe's dedication to environmental awareness and acknowledging India's role as a significant player in the global effort to achieve sustainability.

Our dedication at European Business and Technology Centre (EBTC) is to create pathways for cleaner technology and facilitate dialogues that encourage breakthroughs. It is encouraging to see this report consolidate key insights, financial analyses, and policy recommendations that can empower stakeholders across the automotive sector. We hope that the knowledge shared here will catalyse meaningful actions and reinforce the commitment to fuelling an EV revolution in India.

I invite our counterparts in industry and government to immerse themselves in the findings of this report. Let us commit to the ethos of retrofitting - a symbol of adaptation and progress - and embrace the opportunities it provides. Together, we can forge a greener and more resilient future through sustainable transport solutions that benefit not only the present but also the generations to come.

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ELECTRIC VEHICLE

PREFACE

MR. ANURAG SINGH

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The report titled "Retrofit for a Greener Future: Accelerating Electric Vehicle Adoption" takes a hard look at how retrofitting can significantly impact the adoption of electric vehicles (EVs) and contribute to a more sustainable future.

Retrofitting, the process of adapting existing vehicles to electric power, offers a practical route to decrease carbon emissions from the transportation sector. It delves into the nuts and bolts of retrofitting, examining its economic viability, environmental benefits, and the policies that can either drive its adoption.

Written at a time when the switch to EVs is becoming not just preferable but necessary, the report argues for retrofitting as a key strategy in our transition to electric mobility. It presents findings from recent research, market analysis, and policy studies to build a case for retrofitting as a means to extend the life of current vehicles while reducing overall emissions.

It discusses the potential of retrofitting to cut down our reliance on new vehicle production and shows how it can bring down the barriers to EV adoption for many vehicle owners. The report also outlines the challenges this approach faces, such as technical limitations and safety regulations, and suggests how these can be addressed.

In essence, the report serves as both a comprehensive guide and a call to action for policymakers, industry leaders, and consumers to consider retrofitting as a significant contributor to green transportation. By providing this information, the aim is to support informed decisions about the future of our vehicle fleets and their environmental impact.

EXECUTIVE SUMMARY

Electric Vehicle (EV) retrofitting is emerging as a pivotal solution in the transition towards sustainable urban transportation. Amid global efforts to mitigate climate change and reduce vehicular emissions, this report delves into the growing EV retrofitting market, underscoring its crucial role in "repairing the past" and making existing vehicles future-proof, alongside building a more sustainable future.

The global EV retrofitting sector, valued at USD 65.94 billion in 2023, is projected to reach USD 125.37 billion by 2032. This growth trajectory is fueled by technological innovation and increasing consumer demand, with retrofitting offering a pragmatic opportunity to convert existing petrol and diesel vehicles into environmentally friendly, electrically powered alternatives.

India's adoption of EV retrofitting is notably rapid, driven by policy initiatives like those in Delhi, where older diesel and petrol vehicles are legally transitioning to electric through retrofitting.

This approach aligns with India's commitment to climate action, fostering technological advancements and capacity building in the EV sector. Retrofitting stands out not only as a complementary strategy to new EV production but also as an economical alternative, offering a quick return on investment and low total cost of ownership across various vehicle segments.

The economic analysis within this report highlights the fiscal benefits of retrofitting, showcasing operational cost reductions and fuel savings. These financial advantages position retrofitting as a feasible and resource-efficient pathway, contributing to a circular economy.

Despite its advantages, retrofitting faces challenges including technical complexities, safety issues, financing difficulties, and changing regulatory frameworks. To navigate these obstacles, the report recommends a comprehensive strategy involving government-industry cooperation, quality assurance, subsidies, incentives, and public-private partnerships.

State-level policies that resonate with EV incentives and effective monitoring are essential for the widespread adoption and standardization of retrofitting. The report advocates for nationwide pilot programs, targeting 10 million green kilometres, to showcase retrofitting's potential in urban trucking applications such as garbage collection, water tanker operations, and logistics.

Urban municipalities are pivotal in leading the retrofitting movement, setting sustainable urban transportation benchmarks. Case studies like Waste Management New Zealand's EV fleet transition illustrate the real-world impact and feasibility of retrofitting in urban logistics.

To further propel the retrofitting sector, significant investment in research and development, coupled with targeted public awareness campaigns, is vital.

The report concludes that EV retrofitting aligns with the Paris Agreement and India's NDCs, representing not just an immediate solution for reduced emissions and sustainable living, but also a long-term commitment to environmental stewardship.

1 BASICS OF RETROFITTING

1.1 SETTING THE CONTEXT

Amidst the increasing perils of global warming and vehicular emissions, global efforts in climate action have gained widespread acceptance across various sectors. Recognizing their significant role in Green House Gas (GHG) emissions, the transportation industry is predominantly focusing on establishing sustainable solutions and transitioning from traditional petrol and diesel vehicles to more eco-friendly options, such as Electric Vehicles (EVs).

National governments have taken significant steps in advancing their policies and have embraced the electrification of transportation to enhance global energy efficiency in line with Sustainable Development Goal 7, which focuses on ensuring access to affordable, reliable, sustainable, and modern energy for all. Simultaneously, Original Equipment Manufacturers (OEMs) are directing substantial investments into this sector due to its increasing popularity among consumers.

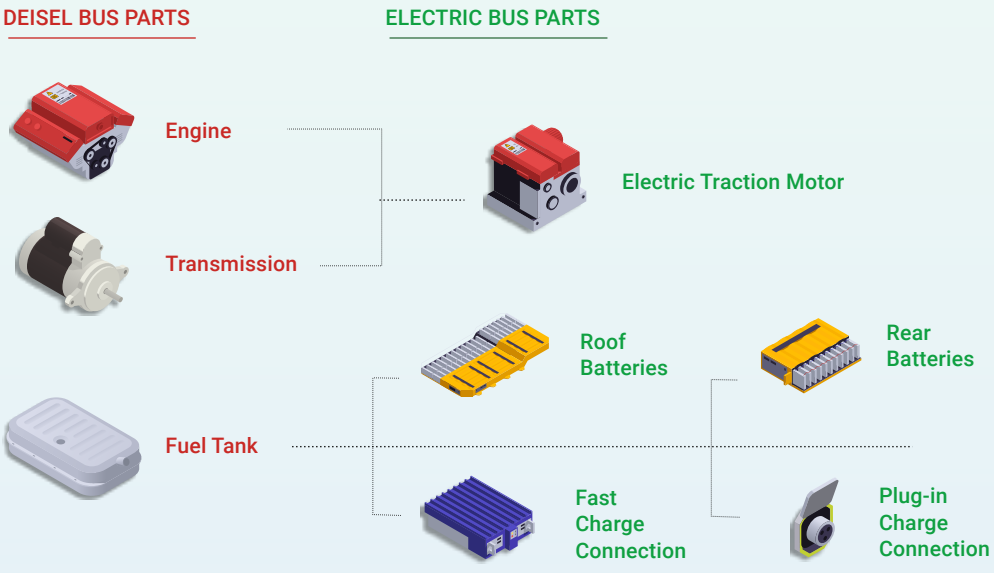
1.2

RETROFITTING AS A SMARTER ALTERNATIVE

Despite technological advancement's role in decreasing emissions per individual vehicle, aggregate pollution levels continue to rise due to the ever-increasing number of vehicles on the road. Given this context, retrofitting to EVs emerges as a cost-efficient, fast and adaptable solution that opens up the possibility of replacing conventional internal combustion engines with cleaner and more efficient electricity battery-powered units. Retrofitting stands out as a viable option that strikes the balance in the ongoing shift toward electrification of the transportation ecosystem.

THE PROCESS: SWAPPING ESSENTIAL COMPONENTS

Retrofitting involves the process of substituting essential components in a petrol or diesel vehicle with the necessary elements for electric propulsion. In this transformation, the vehicle undergoes the removal of its internal combustion engine, transmission, gas tank, exhaust system, and gearbox, and is replaced by an electric motor, controller, battery, inverter, high-voltage cables, and upgraded instrumentation. [1]



[1] "What is Retrofitment?" https://ev.delhi.gov.in/retro-fitment

1.3

MARKET SCENARIO

Although the market analysis suggests that the retro-fitting sector is currently in its infancy, it exhibits significant potential for expansion due to techno-logical simplicity and accessibility.

As of 2023, the global retrofit vehicle market is estimated to be valued at USD 65.94 billion and projected to reach USD 125.37 billion by 2032 with a noteworthy CAGR of 7.40%.

Asia-Pacific region stands out with a dominant share of 62.5%, attributing to substantial investments in clean transportation and robust R&D efforts led by countries like India, China, Japan and South Korea. [2]

The sector shows promising signs and opportunities for continuous expansion due to increasing consumer demand and stricter emission regulations, with a retrofitting transition from commercial into passenger vehicles and two-wheelers in the coming decade. The longevity of retrofitted vehicles is reportedly higher, and they tend to deliver superior power. Additionally, EV retrofitting is an asset for decarbonization of transportation systems Thus, retrofitting presents a promising way to continue utilizing high-cost vehicles that might otherwise require scrapping.

In India, this concept has gained traction, where it not only holds legal backing but is also considered an upgrade to the existing vehicular system.

Global Retrofit Vehicle Market (2023)

USD 65.94 bn

Projected Market Size (2032)

USD 125.37 bn

Compound Annual Growth Rate (CAGR)

7.40%

The Delhi Government, recognizing the potential of retrofitting, has been pro-active in facilitating this transition towards electric mobility. As of 14 January 2022, the Delhi Government allows the con-version of 10-year-old diesel vehicles and 15-year-old petrol vehicles to electric, through retrofitting technology.

This initiative is further bolstered by the forthcoming EV Policy 2.0, which aims to promote the adoption of electric vehicles (EVs) through retro-fitment. [3]

[2] "Global Retrofitment Scenario" https://gggi.org/gggi-publishes-technical-report-on-ev-retrofitting/

[3] "EV Policy 2.0" https://economictimes.indiatimes.com/industry/renewables/ev-policy-2-0-here-is-delhi-governments-new-plan-to-boost-electric-vehicles/articleshow/103603640.cms

1.4

RETROFITTING: CATALYST FOR EV

As the nation tackles the challenges of urban pollution and climate change, retrofitting offers a pragmatic solution to accelerate the transition to electric mobility. It not only lays the groundwork for a robust EV ecosystem but also cultivates a culture of technological innovation and skill development in the EV sector.

By converting existing ICE vehicles to electric, retrofitting not only aligns with India's climate action goals but also serves as a real-world prototype, fostering awareness and acceptance of EVs among the public.

1.4.1 CLIMATE ACTION

Ever since the acknowledgement of transport's role in sustainable development, from the 1990's Agenda 21 to today's focus on green mobility as a prescriptive and preventive option, climate action has taken a paramount centre stage. Aligned with the Paris Agreement, the immediate imperative is to limit global temperature rise by reducing GHG emissions and thereby attaining net-zero emissions, paving the way for a low-carbon future by mid-century.

India, as the world's third largest polluter heavily reliant on coal for 70% of its power generation, is actively striving to lead the global march against climate change. To spearhead this initiative, India is committed to a significant reduction in the emission intensity of its GDP by 33-35% by 2030 compared to 2005 levels. [4]

However, while the Indian government's ambitious target of converting 30% of all vehicles into EVs by 2030 to reach carbon neutrality by 2070 [5] reflects a major commitment towards India's e-mobility future, this journey encounters several roadblocks. It includes the slow growth of EV infrastructure, range anxiety among potential EV adopters, and the absence of standardization in EV technologies.

These challenges underscore the need for a reassessment of policy measures and targets, shedding light on the imperative need for exploring alternate sustainability pathways such as retrofitting.

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4 "Why the Climate Fight will Fail Without India" https://www.scientificamerican.com/article/why-the-climate-fight-will-fail-without-india/

5 "India EV Economy" https://www.investindia.gov.in/team-india-blogs/indias-ev-economy-future-automotive-transportation

1.4.2 AWARENESS

Public awareness is another key piece to the puzzle. In many parts of the country, knowledge about electric vehicles remains rudimentary. Prospective buyers often fail to understand the evolution, potential and practical benefits of EVs, which significantly hampers their adoption.

Despite the higher initial cost of EVs or retrofitting, a vital point of consideration lies in the long-term operational expenses. In comparison to a diesel-powered vehicle, an electric vehicle exhibits a reduction of nearly 2/3rd in operational expenditures. [6]

This reduction creates a compelling case for govern-ment entities and fleet operators. They can leverage retrofitting to enhance their existing fleet's lifespan, strengthen their resolve for EV adoption and most importantly, showcase their resolve to achieve their green goals.

[6] Secondary Research

CASE STUDY

PERCEPTION MEETS REALITY: UNDERSTANDING CONSUMER ATTITUDES TOWARDS ICE TO EV RETROFITTING IN GERMANY

INTERNAL COMBUSTION ENGINE TO ELECTRIC VEHICLE RETROFITTING: POTENTIAL CUSTOMER'S NEEDS, PUBLIC PERCEPTION, AND BUSINESS MODEL IMPLICATIONS [7]

FABIAN HOEFT, 2020

A study was conducted in Germany to understand the customer perception towards retrofitting, and the implications of the same on ICE to EV retrofitting business model. It explores public perceptions in terms of how people perceive retrofitting as a sustainable opportunity, and the willingness to choose retrofitted vehicles.

Key Findings:

1. Vehicle purchase decisions are purely rational. Social status associated with the vehicle is most relevant to customers while buying a vehicle, followed by brand and appearance.
2. Perceptions on electromobility – insufficient EV range, assumption that EVs are suitable for urban areas
3. Perceptions on retrofitting – initial perceptions are negative and are met with scepticism due to costs involved, insufficient knowledge
4. Motivators for retrofitting – environmental benefits, improved acceleration, lower operating and maintenance costs, extending the vehicle lifetime and enthusiasm for EV technology
5. Key success factors for retrofitting business models which customers expect – ability to charge vehicle at home, exemption from ICE vehicle restrictions, availability of alternative solutions for long-distance travel, retrofit safety guarantee, neat vehicle design, further vehicle feature upgrades
6. The study identified a target customer segment of users of passenger cars, focus on sub-urban areas, customers travelling 50-250 km a day.

[7] "Fabian Hoeft, 2020" https://www.sciencedirect.com/science/article/pii/S2590198221000373

1.4.3 EV ECOSYSTEM

A fundamental element paving the road to widespread EV adoption is the development and establishment of a robust charging infrastructure, and retrofitting vehicles plays a pivotal role in catalyzing this development. Charger availability is a significant influencing factor for potential EV buyers. While the current standpoints - a ratio of 135 electric vehicles to a solitary charging station in India, naturally cause apprehension, retrofitting can stimulate solution-oriented initiatives. [8]

The prospect of converting a considerable chunk of existing vehicles to electric under retrofitting initiatives effectively means demanding a rise in accessible charging stations.

This resultant demand could potentially prompt the government and private entities to invest significantly in infrastructure development nationwide, thereby reducing "range anxiety" amongst current and potential EV owners.

Furthermore, as more vehicles are retrofitted and become reliant on this growing network of charging stations, it will drive continual usage and maintenance of this infrastructure, ensuring its viability and sustained development. A comprehensive charging network will ease the transition from conventional to electric vehicles by providing people with the confidence of straightforward vehicle charging similar to traditional refuelling.

[8] "EV Infrastructure in India" https://bolt.earth/blog/indian-ev-charging-infrastructure-by-2030

1.4.4 CAPACITY BUILDING

Retrofitting serves as a conduit for technologically advancing India's prowess in EVs, extending beyond merely converting traditional vehicles to electric. It encompasses a spectrum of technological improvements important for broader electric vehicle adoption. The success of India's transition to EVs hinges significantly on the evolution and standardization of the Electric Vehicle Ancillary Industry. This transition would be led by creation of ancillary clusters in cities. Currently, a majority of parts, including electronic components, are imported mainly from China and European countries. [9] To foster a sustainable and lucrative domestic EV ancillary sector, India needs to bolster local manufacturing of EV parts and components, aligning with the "Make In India" initiative.

The growing retrofitment industry in India presents a fertile ground for startups offering retrofitment kits, catering to consumers keen on converting their ICE vehicles to EVs rather than scrapping them. Although the industry remains largely unregulated, the central government has established regulations for vehicle and retrofitment kit certification, indicating a structured pathway toward standardization. This need for skilled professionals could stimulate the educational sector, inspiring curriculums tailored toward EV technology and maintenance. Simultaneously, the demand for expansive manufacturing and distribution networks could spur growth in propelling both and employment these areas, entrepreneurial opportunities.

Through retrofitting, a real-world testing platform emerges, enabling the iterative application enhancements of new technical. By modifying existing vehicles, experts can experiment with a real-life model, optimizing technologies for enhanced performance and cost efficiency before their integration into new EVs.

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[9] "100% Made in India electric vehicles a long distance away" https://www.moneycontrol.com/news/technology/auto/100-made-in-india-electric-vehicles-a-long-distance-away-industry-7412721.html

2 ECONOMICS OF RETROFITTING

2.1 INTRODUCTION

Retrofitting EV has been considered as an option to accommodate the decarbonization demand while maintaining accessible costs for the population. However, the pace of this transition cannot be dramatic and thus, to complement the addition of new EVs, retrofitting existing ICE vehicles is a given requirement.

Retrofitting increases the useful life span of existing vehicles by 8 to 10 years and allows them to be exempted from the scrappage policy. [10] This is essential to note when dealing with vehicles owned by public entities which fall under the ambit of the scrappage policy.

[10] "Delhi Switch Policy" https://ev.delhi.gov.in/retro-fitment

2.2

FINANCIAL ANALYSIS OF RETROFITTING EVs

Financial analysis reveals that retrofitting an ICE two-wheeler may cost between INR 50,000 to 1 lakh, [11] whereas the purchase of a comparable new electric two-wheeler might require up to INR 1.5 lakh. Retrofitting is also economically advantageous in terms of fuel savings, which could be substantial—around INR 50,000 to 60,000 annually for a petrol two-wheeler. In contrast, the annual expense for charging an electric two-wheeler would likely not exceed INR 10,000.

An examination by the International Copper Association-India has revealed that an electric retrofit for three-wheelers (3W) can yield annual savings of INR 2.16 lakh compared to petrol three-wheelers, INR 1.96 lakh in comparison with diesel three-wheelers, and INR 1.62 lakh against CNG three-wheelers. [12]

For four-wheelers and light commercial vehicles, the retrofitting costs, including the price of the conversion kit, can reach up to INR 8 lakh. Comparatively, a new electric four-wheeler costs around INR 15 lakh, making retrofitting an appealing proposition for owners, who would only have to spend approximately INR 4-5 lakh for the conversion. [13]

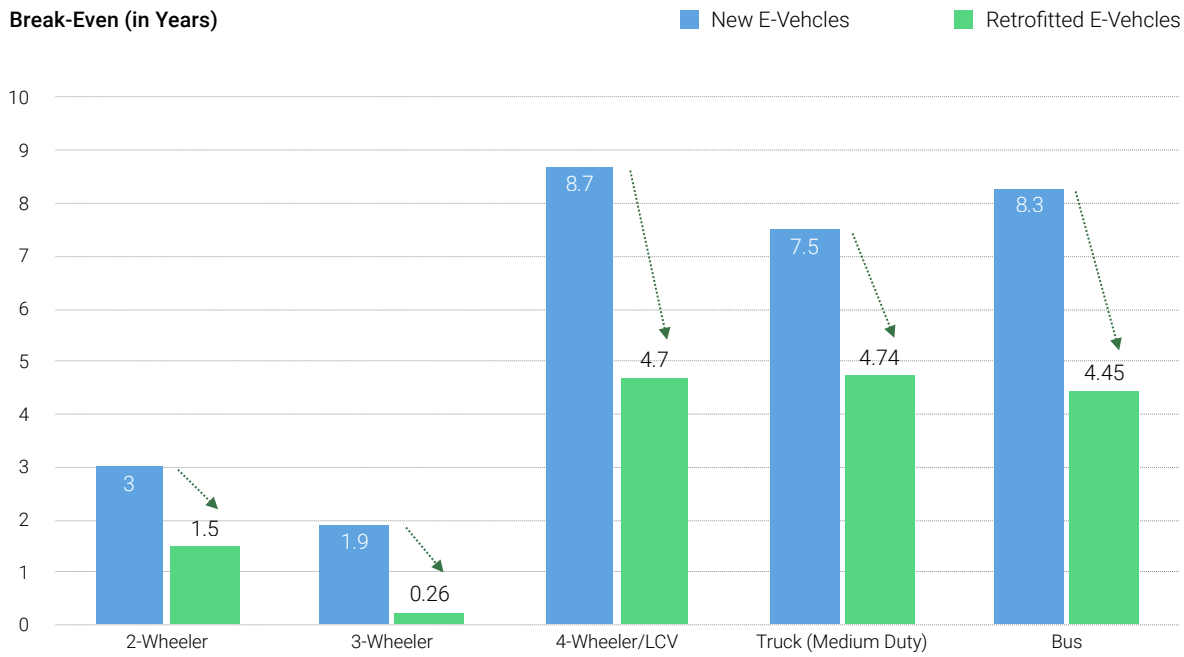
[11] "JMK Research" https://jmkresearch.com/how-electric-vehicle-retrofitting-can-be-a-viable-solution-to-limiting-vehicular-emissions-in-india

[12] Electric Retrofitting of autos is need of the hour" https://www.thehansindia.com/business/electric-retrofitting-of-autos-need-of-the-hour-812267

[13] Retro-fitment: How to convert a petrol, diesel, or CNG car into an electric one." https://economictimes.indiatimes.com/industry/renewables/retro-fitment-how-to-convert-a-petrol-diesel-or-cng-car-into-an-electric-one-rules-and-process/articleshow/103625270.cms

ANNUAL FUEL SAVINGS AND ROI

Vehicle Type	Retrofitting Cost (in INR)	New EV Cost (excluding incentives) (in INR)	Annual Fuel Savings (in INR)	ROI (in yrs) Retrofit	ROI (in yrs) New
2-Wheeler	₹ 75,000	₹ 1,50,000	₹ 45,000	1.5	3
3-Wheeler	₹ 50,000	₹ 3,60,000	₹ 1,89,000	0.26	1.9
4-Wheeler/LCV	₹ 8,00,000	₹ 15,00,000	₹ 1,71,168	4.7	8.7
Truck (Medium Duty)	₹ 37,00,000 - ₹ 45,00,000	₹ 65,00,000	₹ 8,64,000	4.74	7.5
Bus	₹ 60,00,000 - ₹ 85,00,000	₹ 1,40,00,000	₹ 16,84,000	4.45	8.3



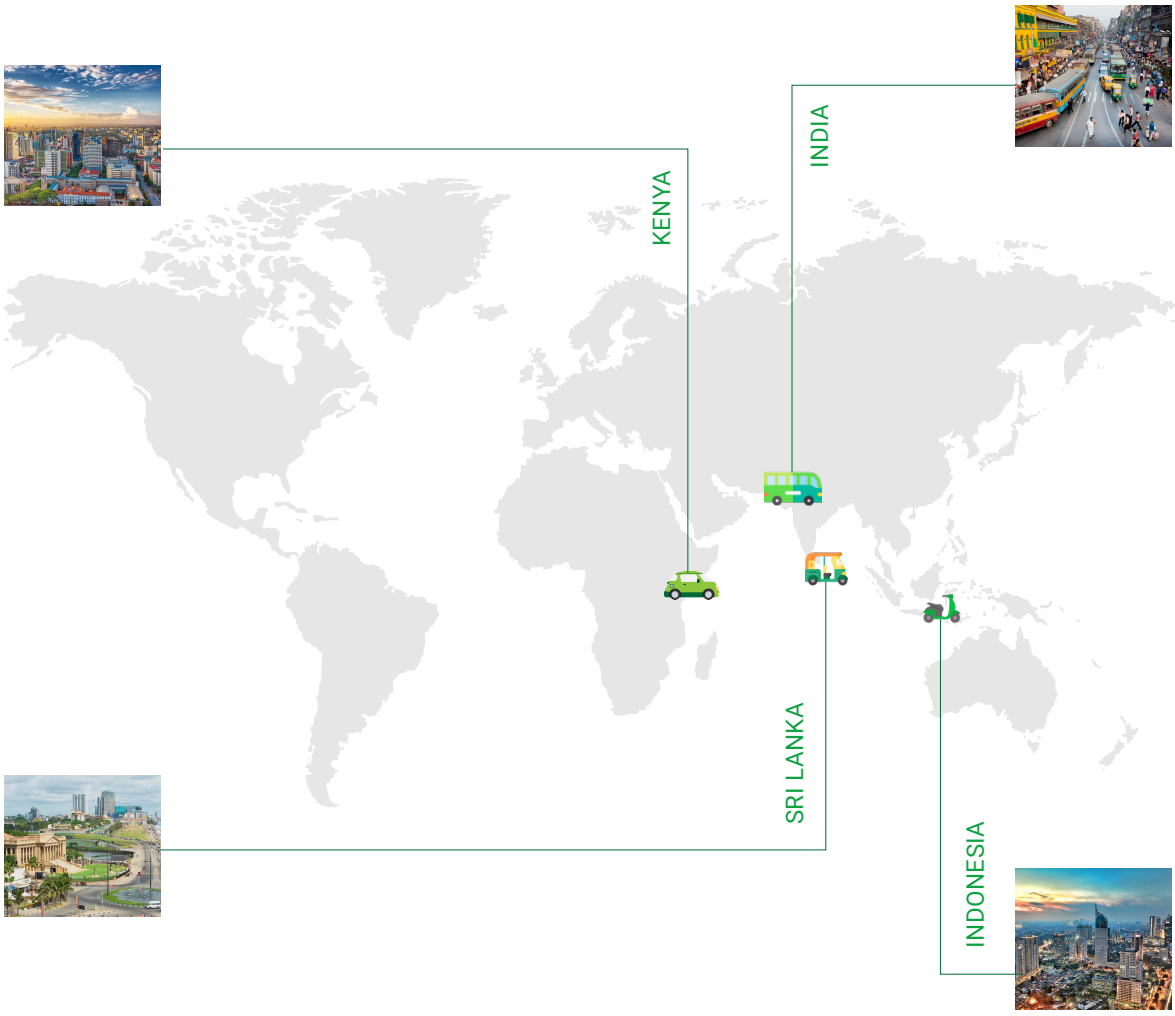
Considering the retrofitting process, key factors include the vehicle's age, remaining lifespan, and financing availability. For small cars, retrofit kits cost around INR 3 to 4 lakhs. Despite the benefits of purchasing new EVs, which include warranties and reliability, retrofitting is economically sensible, particularly in the commercial sector, as it revitalizes the performance of vehicles used in logistics.

2.3

ANALYSIS AND CASE STUDIES

The transition to EVs is gaining momentum worldwide as a pivotal strategy to combat climate change and minimize reliance on fossil fuels. This shift is also driven by the urgency to tackle environmental concerns and the economic challenges associated with traditional internal combustion engine vehicles.

The case studies from Kenya, Sri Lanka, and Indonesia, as delineated in the GGGI Technical Report No. 29, [14] alongside an independent analysis of Maharashtra, India, offer a persuasive account of EV retrofitting adoption.



[14] "GGGI Technical Report No.29" https://gggi.org/wp-content/uploads/2023/09/GGGI_Tech-Report29_EVRetrofitting.pdf

2.3.1 CASE STUDY INDONESIA

With the urgency to mitigate GHG emissions, the Indonesian government has been proactive in crafting legal frameworks and introducing tax incentives to boost EV uptake, with a notable focus on electric two-wheelers (E2Ws). The data in GGGI's Technical Report on retrofitting shows:

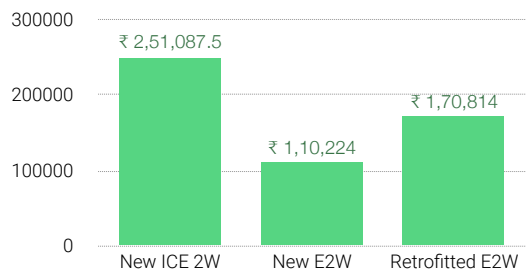
Parameters	New ICE 2W	New E2W	Retrofitted E2W*
CAPEX			
Vehicle Cost	₹ 98,569.14	₹ 1,06,052.4	₹ 1,58,883.6
Battery Replacement Cost	-	₹ 12,390.24	₹ 12,390.24
Subsidy	-	₹ 39,093	₹ 39,093
OPEX			
Fuel Cost per year	₹ 13,297.43	₹ 2,397.87	₹ 2,397.87
Annual Maintenance cost	₹ 672.3	₹ 395.08	₹ 395.08
Annual Insurance	1.5% of vehicle price	1.5% of vehicle price	1.5% of vehicle price
Interest Rate	5.75%	5.75%	5.75%

* Cost of retrofitted E2W: Used ICE vehicle cost + conversion kit+ service fee (calculated from data available by Afraah et al, 2021) [15]
** Lifespan of 15 years

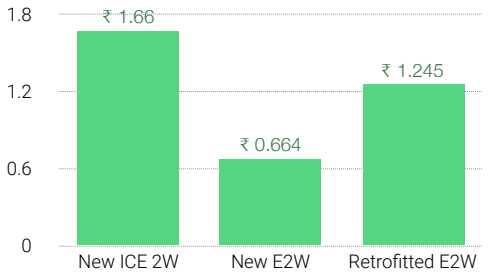
	New ICE 2W	New E2W	Retrofitted E2W
TCO	₹ 2,51,087.5	₹ 1,10,224	₹ 1,70,814
Travel Cost per Km	₹ 1.66	₹ 0.664	₹ 1.245

*** Distance taken as 10,220 km/year

TCO Comparison (in ₹)



Travel Cost per Km Comparison (in ₹)



[15] "Afrah et al, 2021" https://ejournal.umm.ac.id/index.php/industri/article/view/16717

2.3.2 CASE STUDY
SRI LANKA

In Sri Lanka, the integration of EVs into the transport sector is not just a climate action measure but a critical response to the country's recent fuel crises. The proliferation of mobile taxi applications has embedded the three-wheeler as a staple in Sri Lankan urban mobility, creating a growing opportunity for the retrofitting industry.

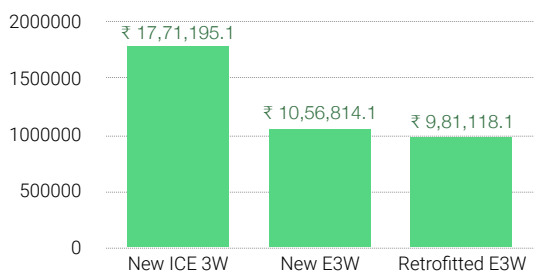
Parameters	New ICE 3W	New E3W	Retrofitted E3W*
CAPEX			
Vehicle Cost	₹ 2,70,497	₹ 3,78,646	₹ 3,02,950
Battery Replacement Cost	-	₹ 1,24,500	₹ 1,24,500
Subsidy	-	-	-
OPEX			
Fuel Cost per year	₹ 2,87,527.8	₹ 1,00,396.8	₹ 1,00,396.8
Annual Maintenance cost	₹ 17208.39	₹ 12,032.51	₹ 12,032.51
Annual Insurance	-	-	-
Interest Rate	15.5%	15.5%	15.5%

* Retrieved from the financial-economic analysis on Tuktuk done by the UNDP
** Lifespan of 10 years

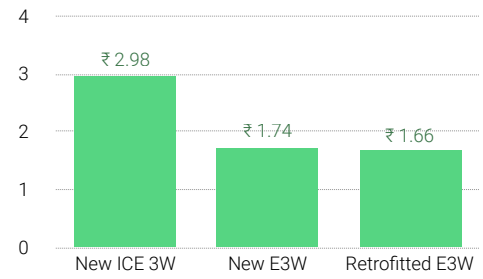
	New ICE 3W	New E3W	Retrofitted E3W
TCO	₹ 17,71,195.1	₹ 10,56,814.1	₹ 9,81,118.1
Travel Cost per Km	₹ 2.98	₹ 1.74	₹ 1.66

*** Distance taken as 58,765 km/year

TCO Comparison (in ₹)



Travel Cost per Km Comparison (in ₹)



2.3.3 CASE STUDY
KENYA

To reduce and as a means to sidestep the immediate necessity for complete shifts to newly manufactured EVs. GGGI Technical Report on Retrofitting has leveraged the 2019 GIZ report for transportation data in Kenya and incorporates additional data from Roam Electric, a leading entity in the EV retrofitting industry. The baseline internal combustion engine (ICE) passenger vehicle Landcruiser 70 Series 2023 is considered.

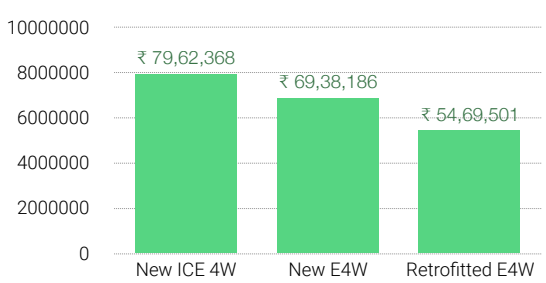
Parameters	New ICE 4W	New E4W	Retrofitted E4W*
CAPEX			
Vehicle Cost	₹ 37,65,129	₹ 47,80,385	₹ 33,11,700
Battery Replacement Cost	-	₹ 1,76,914.5	₹ 1,76,914.5
Subsidy	-	-	-
OPEX			
Fuel Cost per year	₹ 2,45,670.9	₹ 98,730.99	₹ 98,730.99
Annual Maintenance cost	₹ 2,90,500	₹ 1,03,569.1	₹ 1,03,569.1
Annual Insurance	-	-	-
Interest Rate	9.5%	9.5%	9.5%

* Cost of retrofitted E4W: Used ICE vehicle cost + conversion kit +service fee
** Lifespan of 15 years

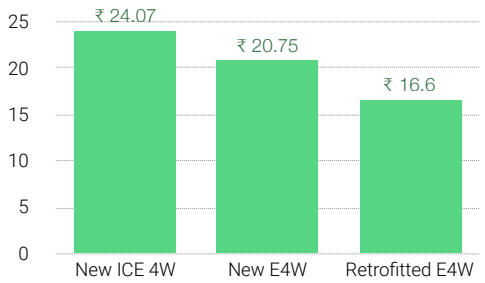
	New ICE 4W	New E4W	Retrofitted E4W
TCO	₹ 79,62,368	₹ 69,38,186	₹ 54,69,501
Travel Cost per Km	₹ 24.07	₹ 20.75	₹ 16.6

*** Distance taken as 22,223 km/year

TCO Comparison (in ₹)



Travel Cost per Km Comparison (in ₹)



2.3.4 CASE STUDY
INDIA

A. TRUCKS

In Maharashtra, a series of pilot studies were initiated to assess the feasibility of retrofitted trucks and buses compared to new ICE trucks and new Electric Trucks and buses respectively. A comprehensive comparative analysis was conducted, examining new ICE trucks, new Electric Trucks, and retrofitted Electric Trucks over a 10-year operational lifespan, drawing insights from primary research data.

Parameters	New ICE Truck	New E Truck	Retrofitted E Truck*
CAPEX			
Vehicle Cost	₹ 20,00,000	₹ 65,00,000	₹ 37,00,000 - ₹ 45,00,000
Battery Replacement Cost	-	₹ 16,00,000	₹ 16,00,000
Subsidy	-	-	-
OPEX			
Fuel Cost per year	₹ 12,24,000	₹ 3,60,000	₹ 3,60,000
Annual Maintenance cost	₹ 2,16,000	₹ 1,42,000	₹ 1,42,000
Annual Insurance	5% of vehicle price	5% of vehicle price	5% of vehicle price
Interest Rate	11%	11%	11%

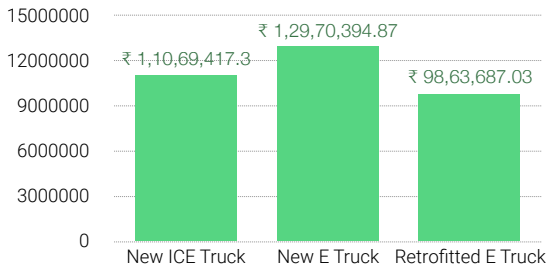
* Cost of Retrofitted Truck: Used ICE Vehicle Cost + Conversion Kit + Service Fee

** Lifespan of 10 years

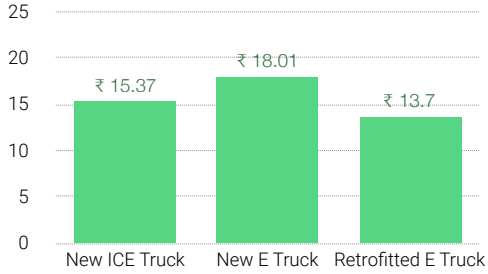
	New ICE Truck	New E Truck	Retrofitted E Truck
TCO	₹ 1,10,69,417.30	₹ 1,29,70,394.87	₹ 98,63,687.03
Travel Cost per Km	₹ 15.37	₹ 18.01	₹ 13.70

*** Distance taken as 72,000 km/year

TCO Comparison (in ₹)



Travel Cost per Km Comparison (in ₹)



B. BUSES

India's e-bus sector has rapidly ascended to become the second largest globally, boasting an impressive annual production range of 14,000-20,000 e-buses. Forecasts paint an optimistic picture, projecting an increase in e-bus market penetration from the current 3% to an anticipated 20% by the financial year 2026. [16] Retrofitting is poised to assume a pivotal function in this transition: State Road Transport Undertakings (SRTUs) are likely to opt for refurbishing and updating existing fleets to electric models, rather than disposing of them. The analysis below takes a cue from the abovementioned pilots, examining the retrofit potential across three distinct bus categories.

Parameters	New ICE Bus	New E Bus	Retrofitted E Bus*
CAPEX			
Vehicle Cost	₹ 45,00,000	₹ 1,40,00,000	₹ 60,00,000 - ₹ 85,00,000
Battery Replacement Cost	-	₹ 48,00,000	₹ 32,00,000
Subsidy	-	-	-
OPEX			
Fuel Cost per year	₹ 33,94,285.7	₹ 11,18,800	₹ 11,18,800
Annual Maintenance cost	₹ 9,50,400	₹ 5,94,000	₹ 5,94,000
Annual Insurance	-	-	-
Interest Rate	11%	11%	11%

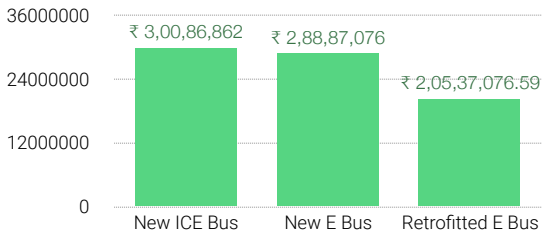
* Cost of Retrofitted Bus: Used ICE Vehicle Cost + Conversion Kit + Service Fee

** Lifespan of 10 years

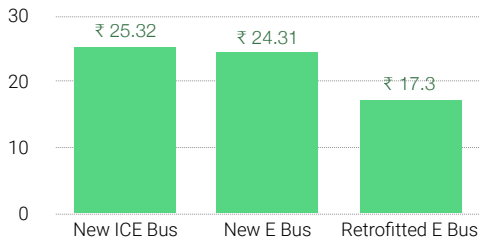
	New ICE Bus	New E Bus	Retrofitted E Bus
TCO	₹ 3,00,86,862	₹ 2,88,87,076	₹ 2,05,37,076.59
Travel Cost per Km	₹ 25.32	₹ 24.31	₹ 17.3

*** Distance taken as 1,18,800 km/year

TCO Comparison (in ₹)



Travel Cost per Km Comparison (in ₹)



[16] "E-bus penetration to grow to very high levels in 5-7 years" https://www.thehindubusinessline.com/companies/economies-of-scale-e-bus-penetration-to-grow-to-very-high-levels-in-5-7-years/article67241307.ece

2.4

CASE FOR COMMERCIAL VEHICLES

India has more than 2.8 million trucks that run over 100 billion kilometres per year. While they comprise only about 2% on-road vehicles, these trucks are responsible for about 40% of emissions and fuel consumption from road transport.

Daily, a truck covers an average distance of approximately 350 kilometres, which starkly contrasts with the mere 35 kilometres travelled by an individual vehicle. Research by the International Council on Clean Transportation suggests a substantial increase in heavy-duty truck activity, potentially quadrupling by 2050 to exceed 400 billion kilometres annually. [17]

Electric commercial vehicles are still on the cusp of widespread adoption across different markets, but the introduction of retrofitting solutions holds the potential to be an important development. This is because retrofitting technology can be tailored to meet the specific demands of consumers. Therefore, the consideration of retrofitting in commercial vehicles is advised for several reasons:

Maximized Distance Efficiency

Commercial vehicles, particularly trucks and buses, traverse far greater distances daily than personal vehicles. Retrofitting these vehicles can achieve significant emission reductions, matching the impact of numerous personal vehicles.

Financial Viability for Fleets

Fleet owners can reap substantial economic benefits from retrofitting. This process significantly lowers maintenance and fuel expenses compared to ICE vehicles, making it a financially sound choice, especially for vehicles with high intrinsic value.

Enhanced Public Health Benefits

Buses and trucks contribute notably to greenhouse gas emissions. Transitioning them from ICE to electric powertrains will lead to improved air quality, offering health benefits in both rural and urban settings.

Government Incentives and Strategic Benefits

Retrofitting presents a cost-effective alternative that aligns with government incentives. This strategy not only reduces capital expenses for fleet owners but also supports broader goals like emission reduction, reduced crude oil consumption, and decreased reliance on oil imports.

[17] "Where Are India's Electric Trucks?" https://thewire.in/economy/where-are-indias-electric-trucks

3

CO_2 EMISSION REDUCTION AND GREEN ECONOMY

3.1

INTRODUCTION

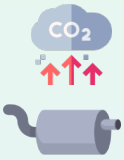
As India strides forward in its commitment to the Paris Agreement and its own nationally determined contributions (NDCs), fostering a robust EV retro-fitting ecosystem becomes pivotal. This not only aids in reducing the country's dependence on fossil fuels but also paves the way for cleaner air and a more sustainable urban environment. The subsequent sections of this chapter delve into a detailed analysis of CO2 emissions across various vehicle segments and the significant role retrofitting can play in achieving India's climate goals.

In September 2023, Delhi had achieved integating 800 electric buses into its public transport fleet exemplifying the substantial environmental impact electric vehicles can have. These electric buses alone are expected to save approximately 45,000 tons of CO2 emissions annually, contributing to a greener and cleaner Delhi. Over their 12-year lifespan, they are estimated to save a total of 5.4 lakh tonnes of CO2. [18]

[18] "Delhi aims to double its EV adoption this financial year" https://www.hindustantimes.com/cities/delhi-news/delhi-aims-to-double-its-ev-adoption-this-financial-year-101694714795895.html

3.2

UNDERSTANDING CO_2 EMISSION FACTORS



Tailpipe CO_2 Emission Factor:

This metric specifically measures the CO_2 emissions that are directly released from a vehicle's exhaust when burning petrol (or diesel). These emissions are the direct result of fuel combustion in internal combustion engine vehicles. The calculation considers the amount of CO_2 produced per unit of fuel consumed. [19]

Electricity CO_2 Emissions Factor:

In contrast, this factor relates to electric vehicles (EVs) and measures the indirect CO_2 emissions. These emissions are not produced by the vehicle itself but are a result of generating the electricity used to charge the EV. In India, where electricity generation is still heavily reliant on coal and other fossil fuels, this factor is crucial for understanding the overall environmental impact of using an electric vehicle. [20]

	2W (Petrol)	3W (Petrol)	4W (Petrol)	Truck (Diesel) [21]	Bus (Diesel)
CO2 emissions factor (g/km) [22]	39.04	113.5	179.94	1000	1000
Electricity CO2 emissions factor (g/kWh) [23]	632	632	632	632	632

The CO2 emissions factors are taken into account when calculating the total emissions in the vehicle segments discussed below.

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[19] "Greenhouse Gas Emissions from a Typical Passenger Vehicle", https://www.epa.gov/greenvehicles/greenhouse-gas-emissions-typical-passenger-vehicle

[20] Carbon Dioxide Emissions from Electricity", https://world-nuclear.org/information-library/energy-and-the-environment/carbon-dioxide-emissions-from-electricity.aspx.

[21] Primary Research

[22] "E-Amrit CO2 Calculator" https://e-amrit.niti.gov.in/co2-calculator

[23] "Carbon Intensity Map" https://ourworldindata.org/grapher/carbon-intensity-electricity

3.3

CO_2 EMISSION ANALYSIS ACROSS VEHICLE SEGMENTS

The comparative analysis focuses on demonstrating the CO2 emission reductions achievable through retrofitting petrol vehicles to electric in the two-wheeler, three-wheeler, and four-wheeler segments.

Two-Wheelers (2W): Petrol to Electric

Parameter	Petrol Two-Wheeler	Electric Retrofitted Two-Wheeler
Annual CO2 Emissions	0.71 ton	0.34 ton
Annual Emissions Savings	-	0.37 ton
Lifecycle Emission Reductions (10 years)	-	3.7 tons

Three-Wheelers (3W): Petrol to Electric

Parameter	Petrol Three-Wheeler	Electric Retrofitted Three-Wheeler
Annual CO2 Emissions	4.14 ton	1.87 ton
Annual Emissions Savings	-	1.9 ton
Lifecycle Emission Reductions (10 years)	-	19 tons

Four-Wheelers (4W): Petrol to Electric

Parameter	Petrol Four-Wheeler	Electric Retrofitted Four-Wheeler
Annual CO2 Emissions	6.56 ton	3.69 ton
Annual Emissions Savings	-	2.87 ton
Lifecycle Emission Reductions (10 years)	-	28.7 tons

In the broader context of reducing carbon emissions in the transportation sector, the electrification of heavy-duty vehicles, such as diesel trucks, emerges as a critical area of focus. The analysis examines the potential carbon emissions reduction achievable by transitioning from diesel trucks to electric alternatives. Utilizing data specific to diesel trucks and buses, the study illustrates the substantial environmental benefits of this transition.

CARBON EMISSION ANALYSIS FOR DIESEL TRUCKS AND BUSES

The electrification of heavy-duty vehicles like diesel trucks and buses is key to reducing carbon emissions in the transportation sector. The transition to electric variants offers a significant opportunity to cut emissions, considering their high mileage and substantial emissions per vehicle.

Trucks: Diesel to Electric

Parameter	Diesel Truck	Electric Retrofitted Truck
Annual CO2 Emissions	72 tons	36.4 tons
Annual Emissions Savings	-	35.6 tons
Lifecycle Emission Reductions (10 years)	-	356 tons

Buses: Diesel to Electric

Parameter	Diesel Bus	Electric Retrofitted Bus
Annual CO2 Emissions	108 tons	81.9 tons
Annual Emissions Savings	-	26.1 tons
Lifecycle Emission Reductions (10 years)	-	261 tons

Each diesel truck contributes approximately 72 tons of CO2 annually, based on an average daily operation covering significant distances.

Scaling this up to a fleet size of 1000 trucks results in an overwhelming 35,600 tons of CO2 emissions per year.

Similarly, diesel buses, essential in urban and inter-city transportation, contribute 108 tons of CO2 emissions annually. [24]

[24] Primary Research

3.4

KEY INSIGHTS AND IMPLICATIONS

These findings underscore the importance of retrofitting initiatives across different vehicle segments as a viable pathway to achieving significant reductions in carbon emissions. It highlights the need for supportive policy frameworks, financial incentives, and widespread public awareness to facilitate a transition towards cleaner, more sustainable transportation methods.

The CO2 emission reductions demonstrated through EV retrofitting represent a critical component in the global fight against climate change. This approach offers an opportunity to not only reduce emissions but also to preserve and extend the utility of existing vehicles in a more environmentally responsible manner.

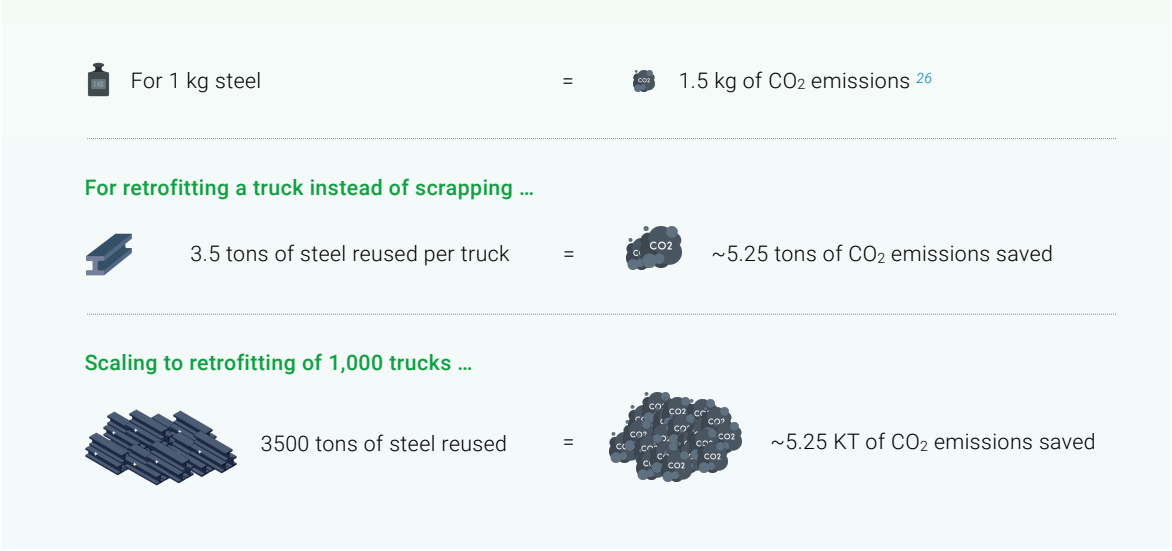
Shifting from diesel to electric trucks and buses in the heavy transportation domain is more than a technological transition; it's a leap towards sustainable transportation. Electrification in these segments can dramatically decrease CO2 emissions, as evidenced by the potential savings calculated above. Electric retrofitting not only offers immediate emission reductions but also sets a precedent for future sustainable practices in heavy-duty vehicle operations.

3.5

CIRCULAR ECONOMY & VEHICLE SCRAPPAGE POLICY

The concept of retrofitting aligns well with the principles of a circular economy, which emphasizes on resource efficiency and waste reduction. Unlike the linear model of 'take-make-dispose,' a circular economy advocates for 'reduce, reuse, and recycle,' which can be embodied through EV retrofitting. By converting existing vehicles to electric, we preserve the embodied energy and materials that went into their manufacturing, while significantly extending their operational life. Moreover, retrofitting can stimulate local economies by creating job opportunities in the retrofitting service sector, spurring innovation in EV technology, and fostering a market for recycled EV batteries and components.

On the other hand, India's Vehicle Scrappage Policy introduced by the government is aimed at phasing out old and unfit vehicles and replacing them with newer, more environmentally friendly ones. [25] This policy is governed by various factors including the fitness and emission levels of vehicles rather than solely their age. Commercial vehicles over 15 years and passenger vehicles over 20 years of age are subjected to increased re-registration fees or scrapping under this policy.



Instead of scrapping old vehicles, the government could provide incentives or support initiatives to retrofit these vehicle s to run on electric power. This way, the lifespan of existing vehicles is extended. Moreover, retrofitting could also offer a pathway to modernizing the existing vehicle fleet, while simultaneously reducing emissions and aligning with the broader sustainability goals of a circular economy.

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[25] "Motor Vehicles (Registration and Functions of Vehicle Scrapping Facility) Rules, 2021" https://morth.nic.in/gsr-653e-regarding-motor-vehicles-registration-and-functions-vehicle-scrapping-facility-rules-2021

[26] Primary Research

4 RISKS AND MITIGATION IN EV RETRO-FITTING

4.1 INTRODUCTION

While the retrofitting approach offers numerous benefits, it also comes with its own set of challenges and risks.

This chapter aims to explore these risks associated with EV retrofitting and propose comprehensive mitigation strategies.

4.2

RISKS IN EV RETROFITTING

Technical Complexities

One of the primary concerns is the technical and performance limitations. Retrofitting may not always match the efficiency and performance of vehicles designed as EVs from scratch. The conversion process too can be intricate, demanding specialized knowledge and expertise. This mismatch can result in varied performance levels, potential technical failures, and issues with weight distribution. [27]

Safety and Compliance

Retrofitting involves major changes to a vehicle's core systems, which can raise concerns about electrical safety, battery integrity, and overall vehicle stability. Meeting evolving safety standards and regulations is crucial for the successful implementation of retrofit projects as more and more EV penetration takes place. The market's skepticism about the viability and reliability of retrofitted vehicles cannot be overlooked. Concerns about the quality of retrofit kits, particularly those not manufactured by original equipment manufacturers (OEMs), and the potential lack of support and warranty are considerable. [28]

Financial Challenge

Another major challenge is the economic viability of retrofitting, given the substantial costs involved in purchasing and installing retrofit kits. Comparatively, new EVs are becoming more affordable, raising doubts about whether retrofitting is a financially sound decision as battery costs go down in the future.

Regulatory and Legal Challenges

Regulatory and legal challenges due to the evolving nature of regulations surrounding EVs and retrofitting can pose significant hurdles. Retrofit projects must comply with current and future policies, and any legislative changes could impact their feasibility.

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[27] "G.S.R. 653(E) regarding the Motor Vehicles (Registration and Functions of Vehicle Scrapping Facility) Rules, 2021",0020 https://morth.nic.in/sites/default/files/notifications_document/GSR%20653.pdf.

[28] "Autocar India" https://www.autocarindia.com/advice/can-i-convert-my-ice-car-to-an-ev-429441

4.3

MITIGATION STRATEGIES

To counter the potential risks associated with retrofitting, a collaborative effort between the government and the industry players is imperative. It begins with developing comprehensive testing and quality assurance processes for retrofitted vehicles. Government subsidies and incentives can play a crucial role in making retrofitting economically viable. A robust regulatory framework is needed to enforce stringent quality standards for retrofitting kits and processes. Public-private partnerships can foster collaboration between government bodies and private companies specializing in EV technologies, supporting joint ventures for the development and distribution of retrofitting kits.

GOVERNMENT POLICY INTERVENTION

Government Subsidies and Incentives

- Implement subsidies and financial incentives for retrofitting diesel vehicles to EV.
- Offer GST and tax rebates, reduced registration fees and other non-financial incentives for retrofitted electric vehicles.

Initiatives at State Level

- Advocate for introduction of dedicated state policies with integrated retrofitting standards and compliances, aligning with the Central schemes and initiatives.
- Encourage state-specific incentives, in addition to central incentives, offering subsidies on capital investments, financial and non-financial incentives, tax exemptions, creation of special EV zones, and support for start-ups.

GOVERNMENT POLICY INTERVENTION

CONTD.

Regulatory Framework and Standards

- Develop and enforce stringent quality standards for retrofitting kits and processes.

Infrastructure Development

- Government-led initiatives and projects to expand the network of EV charging stations.
- Invest in developing maintenance facilities equipped to handle retrofitted electric vehicles.

Awareness and Outreach Campaigns

- Launch awareness programs to educate the public about the benefits of EV retrofitting.
- Organize workshops and seminars to address concerns and misconceptions.

Research and Development Support

- Fund research projects focused on improving retrofitting technologies and reducing costs.
- Encourage innovation through grants and awards for breakthroughs in retrofitting.

Training and Skill Development

- Develop training programs for technicians in EV retrofitting processes.
- Introduce certification courses in educational institutions focusing on EV technology.

INDUSTRY COLLABORATION

OEMs specializing in EV technologies should actively participate in the retrofitting framework.

Collaborate with government bodies so as to facilitate the retrofitting transition.

Invest in research and development to advance retrofitting technologies and reduce associated costs.

Engage in the development of training programs for technicians in EV retrofitting processes.

4.4

WAY FORWARD

In conclusion, transitioning ICE vehicles to EVs through retrofitting presents a spectrum of challenges. However, with a coordinated approach involving government initiatives, industry collaboration, and public engagement, these challenges can be effectively addressed and overcome.

The forthcoming chapter will delve into the policy frameworks and market enablers that the government can implement to expedite the development of the retrofitting industry in India, thereby catalyzing this crucial transition in the automotive sector.

5 POLICY AND MARKET ENABLERS

5.1 INTRODUCTION

With the advent of the 2023 G20 Indian Presidency's 'Principles on Financing Cities of Tomorrow,' [29] a global spotlight has been cast on urban centres as engines of economic prosperity. In alignment with this vision, an emphasis has been placed on reimagining urban landscapes through citizen-focused, evidence-based governance – a concept that is increasingly crucial as we navigate the principles of sustainable urban development.

[29] "Principles of Financing Cities of Tomorrow" https://dea.gov.in/sites/default/files/G20_Principles_for_IWG.pdf

5.2

ADDRESSING CRUDE OIL DEPENDENCY

As the fifth-largest automobile market, India faces a dual challenge: addressing its substantial crude oil dependency, which accounts for a staggering 80% of its transport fossil fuel requirements costing upwards of $100 billion annually and tackling the corresponding environmental implications of ICE vehicles. [30]

This consumption not only bleeds the public exchequer but amplifies urban pollution, signalling an urgent need to pivot towards greener alternatives.

5.3

CURRENT POLICY RESPONSE VIS-A-VIS RETROFITTING

The policy response from local governments indicates a recognition of these challenges and an innovative approach to addressing them. In a groundbreaking initiative, the 2021 Delhi Government policy allowed vehicles over ten years old, which would ordinarily fall foul of the National Green Tribunal's ban, to remain operational if retrofitted with an Electric Vehicle (EV) kit. [31] This proactive policy decision has catalysed the formation of a growing industry focussed on converting aged ICE vehicles to cleaner EVs – carving out a pathway for legacy vehicles to become part of the 'Cities of Tomorrow.'

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[30] "Electrifying Indian Mobility Report" https://assets.ey.com/content/dam/ey-sites/ey-com/en_in/topics/automotive-and-transportation/2022/ey-electrifying-indian-mobility-report.pdf

[31] "Here's how you can bypass the NGT ban in Delhi" https://timesofindia.indiatimes.com/business/india-business/is-your-diesel-car-older-than-10-years-heres-how-you-can-bypass-the-ngt-ban-in-delhi/articleshow/87864138.cms

CURRENT REGULATORY FRAMEWORK FOR EVS AND RETROFITTED EVS IN INDIA [32]

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.

32 Secondary Research

... CONTD.

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, which are also 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 on a voluntary basis.

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.

GST Rates

The GST framework for EVs and retrofitted EVs in India presents a varied rate structure. New fully built EV buses benefit from a lower GST rate of 5%. There is no provision for an EV Retro fitment kit in GST. Spare batteries and essential components for EVs are levied with an 18% GST.

A multi-pronged approach to address the challenges in the transition from EVs is imperative for the government to establish a robust regulatory framework.

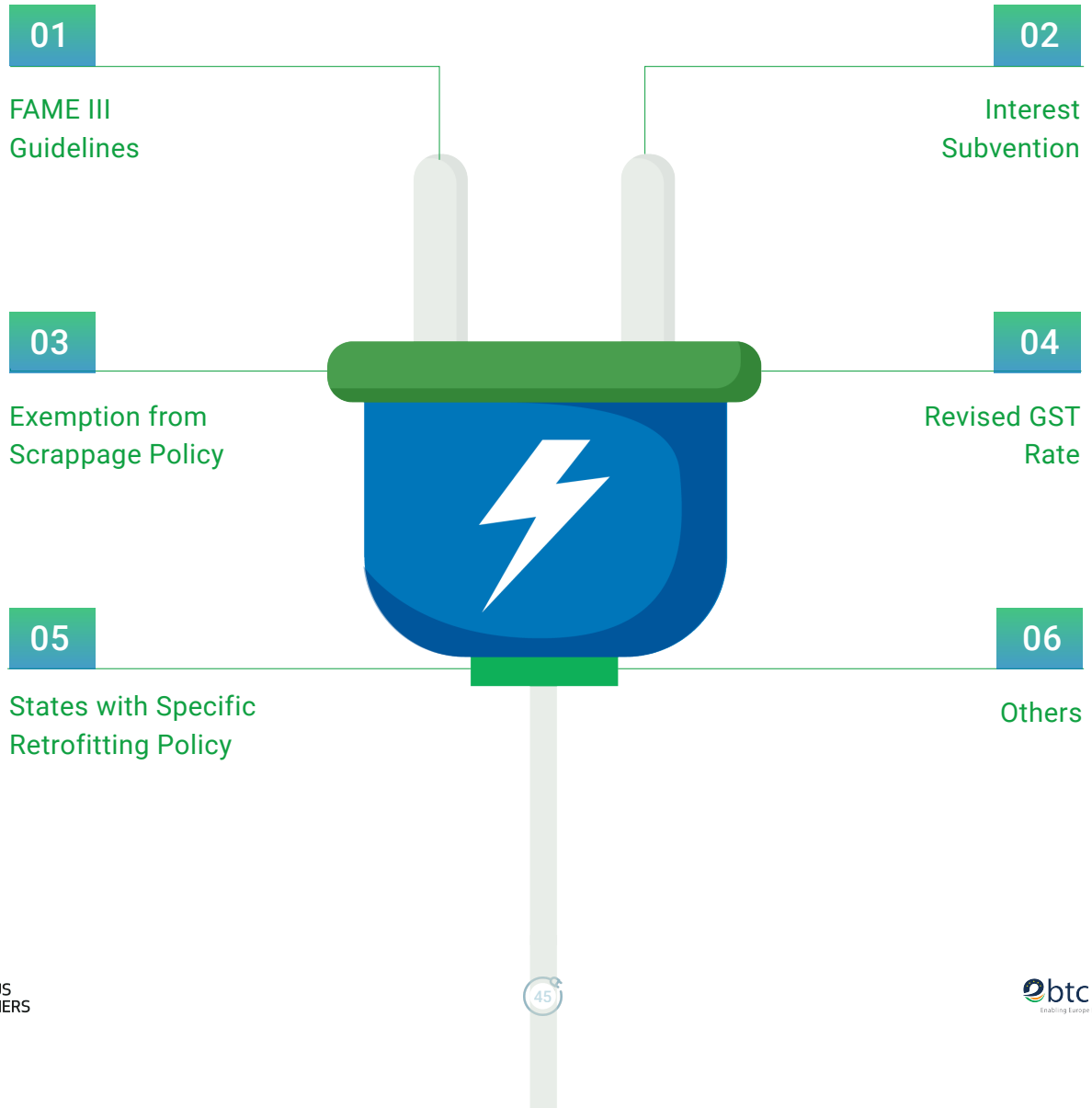
5.4

POLICY RECOMMENDATIONS

To harness the full potential of the EV retrofitting market, concerted policy efforts must be directed at bolstering decarbonization strategies and industry innovation. As a cost-effective and flexible solution, retrofitting stands as a complementary process to the electrification of the transportation system, gradually gaining recognition across the globe.

To propel the advancement of EV retrofitting and solidify its position within the transportation sector, it is critical to integrate EV conversion within the nation's legislative framework. To enhance the appeal and adoption of retrofitting, it is essential for policies to explicitly recognize retrofitted vehicles within the existing framework of EV incentives. Such an inclusive approach will enable comprehensive monitoring and regulation, propelling the practice from a niche alternative to a mainstream solution in the electrification endeavour.

The report proposes the following recommendations:



5.4.1 FAME III RECOMMENDATIONS

- As the FAME II scheme nears its end, it is essential to turn attention towards the upcoming FAME III. It is critical that FAME III explicitly includes retrofitted vehicles to continue the momentum towards electric mobility and make sure all forms of EVs are supported by this important policy.

Table 1 | Proposed FAME III Guidelines

Categories	Incentives/ Subsidies (per kWh)	Approximate Battery Size	Ex-Factory Price Limit	Cap per Cost of Vehicle
E-Retrofitted Buses	INR 20,000	200 kWh	1,00,00,000	40%
E-Retrofitted Trucks	INR 13,300	150 kWh	50,00,000	40%

- Purchase subsidies for retrofitted vehicles in the next phase of the Faster Adoption and Manufacturing of Electric Vehicles (FAME) scheme. For the third phase of FAME, there could be a provision of a subsidy of up to 40 lakhs per retrofitted truck, with eligibility based on satisfying Domestic Value Add (DVA) criteria. The DVA assessment could incorporate elements such as locally assembled battery packs to encourage domestic manufacturing.

- A suggested policy intervention includes securing a 20 lakh INR subsidy per retrofitted bus under FAME III. This subsidy would be contingent upon DVA criteria, providing financial relief for the retrofitting industry.

- A similar approach can be followed in the 2W,3W and 4W segments for their retrofitted counterparts.

5.4.2 INTEREST SUBVENTION

- Address financing challenges by implementing favourable loan interest rates, specifically "5 to 6%," which should extend to the establishment of charging infrastructure for retrofitted vehicles.

5.4.3 EXEMPTION FROM SCRAPPAGE POLICY

- Section 8 of the Motor Vehicles (Registration and Functions of Vehicle Scrapping Facility) Rules, 2021 - "Criteria for scrapping of vehicles" mandates scrapping of government vehicles which are older than 15 years. Mandatory scrapping should not be applicable for government vehicles that are retrofitted. Introduction of an exception for vehicles retrofitted with electric powertrain systems, recognizing their extended lifespan.

5.4.4 REVISED GST RATE

- The GST framework for EVs and retrofitted EVs in India presents a varied rate structure. Fully built EV buses benefit from a lower GST rate of 5%. There is no provision for an EV Retro fitment kit in GST.

- Spare batteries and essential components for EVs are levied with an 18% GST. [33] It is proposed that when a retro fitment EV kit is purchased, it should be charged at 5% to lower the cost of conversion in line with EV vehicle purchase to accelerate the adoption of electric mobility solutions.

5.4.5 STATES WITH SPECIFIC RETROFITTING POLICY

- Building on the Delhi Government's initiative that allows older petrol and diesel two-wheelers, three-wheelers, and four-wheelers to continue operating post NGT's age restrictions (10 years for diesel and 15 for petrol) if retrofitted with EV kits, it is imperative for other states to establish their guidelines.

- These should detail the process for re-registering retrofitted vehicles and accrediting retrofitters.

[33] "GST Rates" https://cbic-gst.gov.in/gst-goods-services-rates.html

5.4.5 STATES WITH SPECIFIC RETROFITTING POLICY (CONTD.)

- The Delhi Government is well-positioned to expand its progressive policy framework to encompass commercial vehicles, such as trucks and buses. By doing so, it can serve as a pioneering example for other states, establishing a replicable model for retrofitting policies at a pan-India level.

- The State government of Telangana took a major initiative by converting traditional auto-rickshaws into Electric-Rikshaws. All those auto-rikshaws that have been on the road for more than ten years and emit significant amounts of pollution into electric vehicles were to be processed into the electric auto-rikshaw. Around 5,000 outdated auto-rickshaws, including 500 in Hyderabad alone, were retrofitted with electric engines as part of Phase 1 of the initiative. [34]

5.4.6 OTHER RECOMMENDATIONS

- Exemptions for retrofitted vehicles from plying and parking restrictions will likely generate significant private sector interest, mimicking the success seen in the e-LCV segment.

- Proposals also extend to recommendations for excusing retrofitted vehicles from the Environmental Compensation Charge (if applicable), municipal taxes, and parking fees. As the current numbers of retrofitted vehicles are modest, these exemptions are projected to have minimal impact on revenue streams.

- Incentivizing the deployment of DC high-power charging solutions is critical to support the rapid incorporation of retrofitted vehicles in a diverse range of applications.

- Allow retrofitted commercial vehicles to operate round the clock in urban areas.

[34] "Telangana govt to offer Rs 15,000 for converting auto-rickshaws into electric vehicles" https://www.newindianexpress.com/states/telangana/2021/dec/10/telangana-govt-to-offer-rs-15000for-converting-auto-rickshaws-into-electric-vehicles-2393815.html

5.5
MARKET ENABLERS

5.5.1 URBAN APPLICATIONS AND LEADERSHIP IN RETROFITTING E-VEHICLES

Municipalities can play a pivotal role in this transition, demonstrating leadership in reducing urban air pollution and promoting a shift to zero-emission trucking. By prioritizing the retrofitting of these specific categories, municipalities can set a precedent for sustainable intra city transportation. This approach not only addresses immediate air quality concerns but also paves the way for broader adoption of clean transportation technologies across various sectors and can be a signal to urban citizens that their local governments are taking significant steps to sustainable living.

The transition towards sustainable urban transportation through the adoption of retrofitted E-Vehicles can begin with specific urban applications characterized by predictable and manageable duty cycles. [35] Key areas where retrofitted E-Vehicles can make a significant impact include:

Garbage Collection: Retrofitting garbage trucks can dramatically reduce emissions in daily waste management operations.

Water Tankers: These vehicles are prime candidates for retrofitting, given their consistent range requirements and operational patterns.

Construction & Demolition Waste Transport: Retrofitting trucks in this category can significantly reduce emissions associated with construction-related activities.

Delivery and Logistics: Using retrofitted E-Trucks in delivery & logistics can enhance sustainability of urban freight operations.

Horticulture and Essential Goods Transport: Trucks used for transporting horticulture products, fruits, vegetables, and dairy are ideal for retrofitting due to their predictable routes and power needs.

[35] "Support Battery Electric Trucks in the Delhi EV Policy 2.0" https://theicct.org/wp-content/uploads/2023/06/Delhi-EV-2.0_brief_FINAL_2.pdf

CASE STUDY

RETROFITTING BY WASTE MANAGEMENT BY NEW ZEALAND

Waste Management®

A practical example of retrofitting in action can be found with Waste Management New Zealand (WMNZ). [36]

This company's truck fleet, essential for its operations and previously reliant on significant diesel consumption, embarked on a transformational journey towards electric vehicles. The move was driven by both environmental and operational considerations.

One of the central challenges addressed was 'range anxiety', particularly pertinent for WMNZ's collection trucks that travel an average of 200km per day. The nature of these vehicles' operation – frequent stops for bin collection, up to 1200 times per day – made them ideal candidates for electric conversion. Each stop generates regenerative energy, recharging the onboard batteries, thus efficiently utilizing the energy that would otherwise be lost in diesel vehicles.

WMNZ's electric collection truck pilot, initiated in mid-2016 in collaboration with Netherlands based EMOSS, marked the beginning of this transformative journey. The first converted box-body truck arrived in New Zealand in late 2016 and has since covered approximately 80,000km in various collection activities around Auckland. This retrofitting pilot has been a cornerstone in WMNZ's transition to an EV fleet, having already converted 12 trucks to electric and continuing to support the operational teams in this transition.

The WMNZ case highlights the practicality and benefits of retrofitting, particularly in urban logistics and waste management. It underscores the capability of retrofitted electric trucks to handle the rigorous demands of daily urban operations while contributing significantly to reducing emissions and operational costs. This example serves as an inspiring model for other cities and municipalities, demonstrating the tangible benefits of adopting retrofitted electric vehicles in their fleets.

Note to Government: State and local governments should take note of such successful pilots, providing opportunities for similar scaled initiatives to private players for buses or trucks. These real-world examples can serve as robust Proof of Concept, underlining the effectiveness of retrofitting in sustainable urban transportation and logistics.

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36 "Case Study: Leading the EV Transition for New Zealand" https://www.wastemanagement.co.nz/news-and-media/cs-fleet-conversion/

5.5.2 SCALED PILOT FRAMEWORK FOR EV RETROFITTING

This pilot is envisioned to bridge the gap between theoretical promise and practical application, systematically testing and showcasing the viability of retrofitting existing internal combustion engine vehicles to electric powertrains within urban environments. It would aim to address prevalent concerns, demonstrate benefits, and fine-tune the process through a data-driven approach. The involvement of international financing, support from key governmental bodies, and collaboration with industry stakeholders are key to ensuring the pilot's success.

Funding and Financial Structuring

Source:

International Finance Corporation (IFC) or World Bank

Amount: INR 100 Crores

Leadership and Oversight

Primary Agencies:

NITI Aayog, Ministry of Road Transport and Highways (MoRTH), and Ministry of Heavy Industries (MHI)

Pilot Scale and Use Cases

Total Scope:

200 buses

10 million kilometers

Demonstration Requirements:

50,000 kilometres annually for each bus

Application Models:

- Cross Circuit
- Hub and Spoke

Use Cases:

Urban applications with easy-to-electrify duty cycles

Timelines and Phases

Project Duration: 2 years

Selection of Implementation Agency

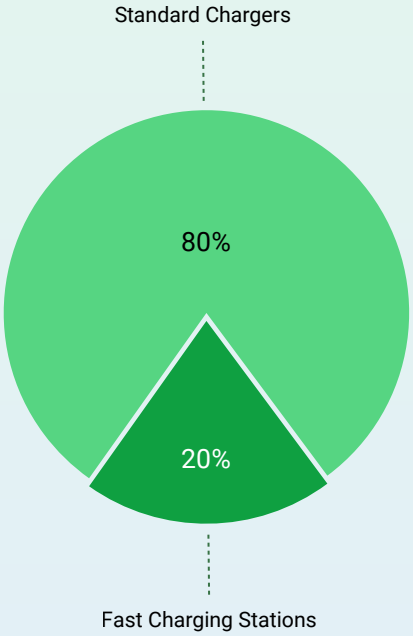
Procurement Method:

Open Tender to ensure fair and competitive selection

Infrastructure Requirements

Charging Network

Creation of dedicated circuits for Enroute charging



Expected Outcomes and Measures

Key Performance Indicators:

- Cost Savings
- Reduction in Emissions
- User Acceptance
- Availability
- Range
- Payload
- Safety

Reporting Standards:

Documentation of findings and results in line with international best practices for transparency and replication purposes.

Note: The implementation of the pilot will adhere to pre-agreed benchmarks and KPIs to assess the viability and impact of EV retrofitting within the defined use cases. Engagements will be periodically reviewed, with findings disseminated among stakeholders to inform further scaling and policy formulation.

With the structured framework in place for the Scaled Pilot for EV Retrofitting, the stage is set to embark on a transformative journey. State and local governments, in collaboration with private players, are primed to demonstrate the practicality and benefits of retrofitting initiatives. The success of these pilots will serve as a testament to the effectiveness of retrofitting, creating a ripple effect for adoption across the urban transportation landscape.

Investing in R&D will be the driving force behind innovation in EV retrofitting technology, while awareness building will pave the way for public acceptance and enthusiasm. Together, these components will play a decisive role in shaping the future of electric mobility.

5.6

RESEARCH & DEVELOPMENT (R&D) AND AWARENESS BUILDING:

5.6.1 NEED FOR RESEARCH AND DEVELOPMENT

Investment in Research and Development (R&D) is a critical pillar for the advancement and popularization of EV retrofitting technology. The EV retrofitting market is in its infancy, and the primary actors have been start-ups and specialized technicians. For this industry to evolve and for retrofitting to become a viable solution in clean transportation, substantial investments are requisite in powertrain technology, engineering adaptation solutions of popular vehicles, and cost reduction of essential parts for retrofitting, notably lithium-ion batteries.

The challenges faced by the retrofitting market share a common ground with the broader EV industry, hence, R&D investments in EV retrofitting can be synergized with the ongoing or future electrification strategies of major automobile OEMs.

5.6.2 EMPOWERING LOCAL INITIATIVES

Recent announcements from global automobile giants Stellantis, [37] which owns Peugeot, Fiat, Citroen and other global car brands, Ford, GM, and Toyota regarding the development of solutions aligned for the retrofitting sector hint at a positive outlook. However, the onus also lies on the government and public actors to foster an environment conducive for R&D in EV retrofitting.

This is a sector closely intertwined with adapting to the real transportation needs of the population and should not be solely driven by major international players. Local capacity-building and technology development are essential for market expansion.

[37] "Car giant to offer diesel-to-electric conversions in vans" https://www.drive.com.au/news/car-giant-to-offer-diesel-to-electric-conversions-in-vans/

5.6.3 FOSTERING PUBLIC-PRIVATE PARTNERSHIPS

Moreover, engagement with local and state governments, as well as local players in the retrofitting sector, is essential to promote EV retrofitting solutions tailored to the real mobility needs of the population.

The example of earmarked EV retrofitting R&D investments, as seen in France's EUR 20 million investment (see Case Study: *France's approach to EV Retrofitting: Simplified Regulations and Government Support)* in scaling up industrial solutions for EV retrofitting kits, serves as a model in signalling active engagement of the private sector in the industry.

By combining R&D investments with adaptations to national legislation, a strong signal is sent regarding the country's strategy of expansion, thereby creating a pathway for the comprehensive adoption and growth of the EV retrofitting sector in India.

CASE STUDY

FRANCE'S APPROACH TO EV RETROFITTING: SIMPLIFIED REGULATIONS AND GOVERNMENT SUPPORT [38]

Background

France as a country had always had strict laws for vehicular tuning and modifications, requiring any sort of modification to be officially registered and changed in the vehicle's documentation.

Retrofitting of ICE to EV also followed a similar process, which required vehicle owners to re-register their vehicles, and checked by certified specialists before given any authorization for circulation. This was a time-consuming process.

[38] "Relating to the conditions of transformation of vehicles for thermal motorisation into electric motorisation with batteries or fuel cells" https://www.legifrance.gouv.fr/jorf/id/JORFTEXT000041780558

CASE STUDY

CONTD.

Solution

France modified its legislation in 2020, which allowed the process to be much simpler compared to the old regime. Rather than focusing on the certification of vehicles, the new legislation allowed for homologation of EV kits by model. The EV kits were to be submitted to the authorities for technical verification, and after approval can be installed in the vehicles that fulfill the following requirements:

- ✓ Vehicles should be well maintained and roadworthy.
- ✓ Vehicle should be registered in France.
- ✓ Vehicle should be over 5 years old.
- ✓ Consumers must seek government-certified technicians for installing the government approved EV conversion kits.

Benefits

Converted EVs were not only registered as EVs but as completely new vehicles under insurance companies, which allowed old vehicles to be given greater benefits for insurance after conversion.

Additionally, converted EVs were treated the same as a normal EV as there was no distinction between them which allowed vehicle owners to benefit from government incentives for EV acquisition and ownership such as France's EV rebate scheme which made EV vehicles eligible for rebates of EUR 1,100 for two- and three-wheelers, EUR 2,500 to 5,000 for four-wheelers, and EUR 5,000 to 9,000 for HDVs.

Conclusion

France's strategy in regularizing the EV conversion process aligns with the national objective of decarbonizing the transportation system in the country. EV retrofitting was seen as a complementary solution to new EVs, and start-up companies are focused on developing and homologating the EV retrofit kits for popular French vehicle models, with plans to expand to other European Markets.

France's government is committed to the sector which is noticeable by seeing the change brought in the legislation for EV retrofitting. **The government has also announced an investment of EUR 20 million to assist the retrofitting professionals to scale up their technology and reduce unit cost of EV conversion kits.**

As cities worldwide endeavour to shape a sustainable future, the integral role of the EV retrofitting market becomes unmistakably apparent. By fostering an environment that enables the growth of retrofitting solutions, we can dramatically accelerate the transition to electric mobility, mitigate pollution, and drive economic resilience in tandem with environmental stewardship.

The careful calibration of policy measures and market enablers is critical in galvanizing this shift, creating a conducive ecosystem for innovation, adoption, and scale. The success of this transition will not only redefine India's automotive landscape but will also offer a blueprint for sustainable urban development.

6 WAY FORWARD

The focus of this report has been on EV retrofitting and its critical role in shaping a sustainable transportation future. Retrofitting emerges as a viable, environmentally friendly solution, capable of transforming numerous internal combustion engine (ICE) vehicles into electric ones and thereby reducing emissions. The significance, market potential, and policy landscape of EV retrofitting are thoroughly examined. This process is essential for lowering emissions and optimizing resource usage in the automotive sector.

The analysis highlights that although EV retrofitting is still developing, it shows great potential. It faces several challenges, including technical, safety, financial, and regulatory issues, which require strategic solutions.

Collaboration between governments and industry is key to developing effective strategies.

To promote and achieve widespread acceptance of EV retrofitting as an alternative to replacing or scrapping vehicles, tailored awareness campaigns, vocational training, and research and development are necessary.

These efforts, combined with policy incentives like tax reliefs and economic incentives, as well as public-private partnerships, can streamline the retrofitting process and boost related industries.

A balanced regulatory framework is essential to ensure technological advancement, consumer safety, environmental sustainability, and economic feasibility.

Looking forward, retrofitting's potential to drive widespread adoption of EVs is undeniable. Focusing on this approach can advance EV technologies, leading to significant changes in transportation that align with global carbon reduction and ecological goals.

The ambitious goal of retrofitting a significant number of vehicles to electric reflects the broader aim of a carbon-conscious economy and collective climate initiatives.

In conclusion, retrofitting is more than a temporary solution; it's a significant step towards sustainable mobility. It fosters technological innovation and demonstrates a commitment to environmental stewardship, potentially changing vehicle usage. Effective retrofitting requires informed decision-making and a clear action plan. This report offers comprehensive insights to guide policymakers, industry players, and the public towards a sustainable future. It underscores the need to turn the concept of EV retrofitting into widespread reality.

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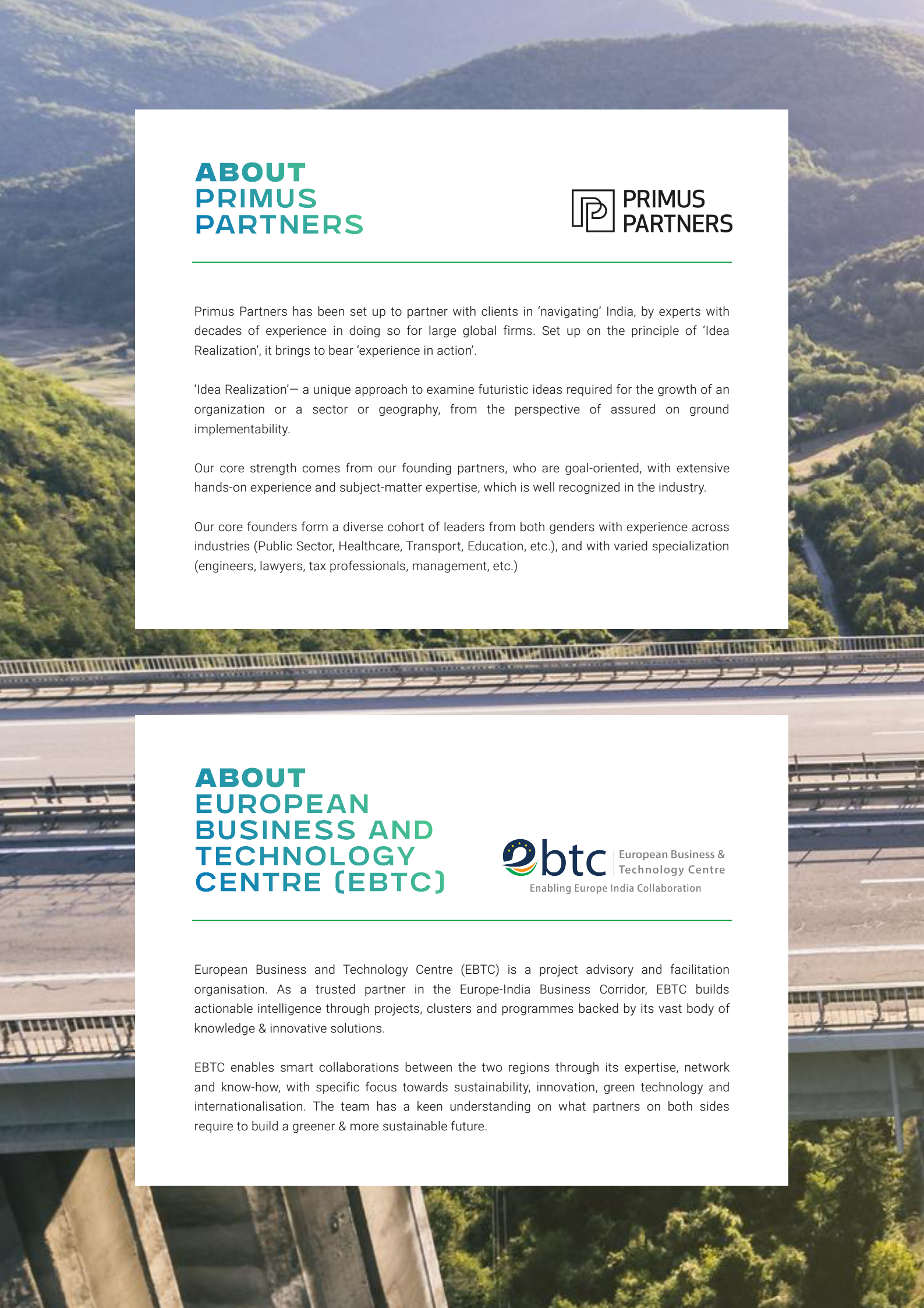

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