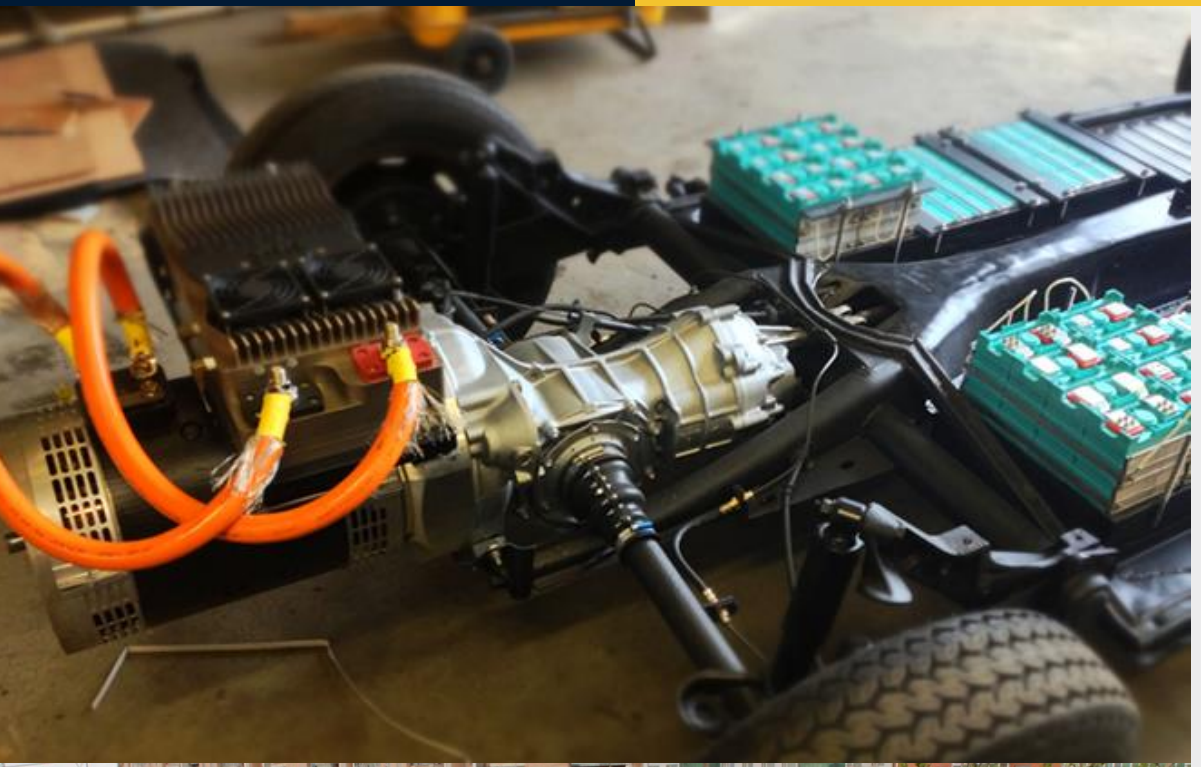

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Affordable e-Mobility options for LMICs

Assessment of Used EV Imports & ICEV to EV Retrofitting

Acknowledgement

This report is authored by **Mr. Rahul Bagdia, CMD-pManifold**. The analysis is contributed by members including **Mr. Akshay Gattu, Mr. Kunjan Bagdia** and **Mr. Vikrant Vaidya** from pManifold e-Mobility team. The report has been reviewed by the **Sustainable Mobility Unit of the United Nations Environment Programme (UNEP).**

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UN environment
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Background

This report was developed within the framework of UNEP's Global Electric Mobility Programme. The Global Electric Mobility Programme supports member states, especially low and middle-income countries (LMICs) with the introduction of electric mobility to reduce air pollution and mitigate climate change. The Programme is currently working with partners to actively support the shift to electric mobility in more than 60 LMICs, implementing grants close to US$ 130 million. The Programme is active on the global, regional and country levels, combining technical assistance, outreach and awareness campaigns and investment.

This report focuses on identifying and analyzing affordable options for e-Mobility in LMICs including the topics of used electric vehicle (EV) imports and Internal Combustion Engine Vehicle (ICEV) to EV retrofitting.

Abbreviations

AC	Alternate Current
AIS	Automotive Industry Standards
BEV	Battery Eectric Vehicle
CAGR	Compound Annual Growth Rate
CAPEX	Capital Expenditure
CARS	Consumer Assistance to Recycle and Save
CC	Cubic Capacity
COVID	COronaVIrus Disease
DC	Direct Current
ECE	Economic Commission for Europe
EECCA	Eastern Europe, Caucasus & Central Asia
ELV	End-of-Life Vehicles
EMC	Electromagnetic compatibility
EOL	End-Of-Life
EU	European Union
EV	Electric Vehicle
GBT	Guojia Biaozhun / Chinese
GDP	Gross Domestic Product
GHG	Green House Gas
GNI	Gross National Income
GVW	Gross Vehicle Weight

GVW	Gross Vehicle Weight
HCV	Heavy Commercial Vehicle
HV	High Voltage
ICEV	Internal Combustion Engine Vehicle
JEVIC	Japan Export Vehicle Inspection Centre
LAC	Latin America and Caribbean
LCV	Latin America & Caribbean
LDV	Light-Duty Vehicle
LMIC	Low- and Middle- Income Country
MPWT	Ministry of Public Works and Transport
NDC	Nationally Determined Contributions
OBD	On-Board Diagnostics
OEM	Original Equipment Manufacturer
OICA	International Organization of Motor Vehicle Manufacturers
OPEX	Operational Expense
PHEV	Plug-in Hybrid Electric Vehicle
PPP	Public-Private Partnership
REESS	Rechargeable Energy Storage System
REM	Rwanda Electric Motors
ROI	Return on Investment
RWF	Rwandan Franc

RWF	Rwandan Franc
SOH	State of Health
SOP	Standard Operating Procedure
TCO	Total Cost of Ownership
UAE	United Arab Emirates
ULW	Unladen Weight
UN	United Nations
USA	Unites States of America
USD	United States Dollar
USITA	United States International Trade Administration
VAT	Value Added Tax

Glossary

Key definitions of terms used in the report:

LMICs

LMICs stands for **Low- and Middle- Income Countries** i.e., countries having Gross National Income (GNI) per capita less than $13,845 as per statistics of year 2022 (World Bank). **Total no. of LMICs are 134.** The analysis of countries within report is majorly focused on ones with no local automobile manufacturing since these countries are more dependent on used vehicle imports.

ICEVs

ICEVs include all vehicles which are primarily powered by petrol or diesel based Internal Combustion Engines (ICE) which include **pure ICE based vehicles and hybrids which are powered by combination of ICE and electric motor(s).**

EVs

EVs include all vehicles that can plug in with an external source of power for charging the on-board batteries. These include **Plug-in Hybrid Electric Vehicles (PHEVs) and pure Battery-operated Electric Vehicles (BEVs).**

Battery Replacement

Battery replacement refers to the process of replacing the depleted batteries with new batteries

EV Refurbishing

Refurbishing of EVs refers to making the imported used EVs roadworthy by making necessary repairs including battery replacement, cleaning and painting

Key assumptions in the report:

Assumptions

- The ‘used vehicle’ flow analysis is done for 4 wheelers and not for 2 and 3 wheelers because of unavailability of data for 2 and 3 wheelers across all the exporting countries.
- The exporting countries analyzed in this study include EU, Japan, USA and South Korea. More than 90% of used vehicles traded globally are exported from these three countries.
- Flow of used vehicles within the EU countries is not considered in the analysis.

Glossary

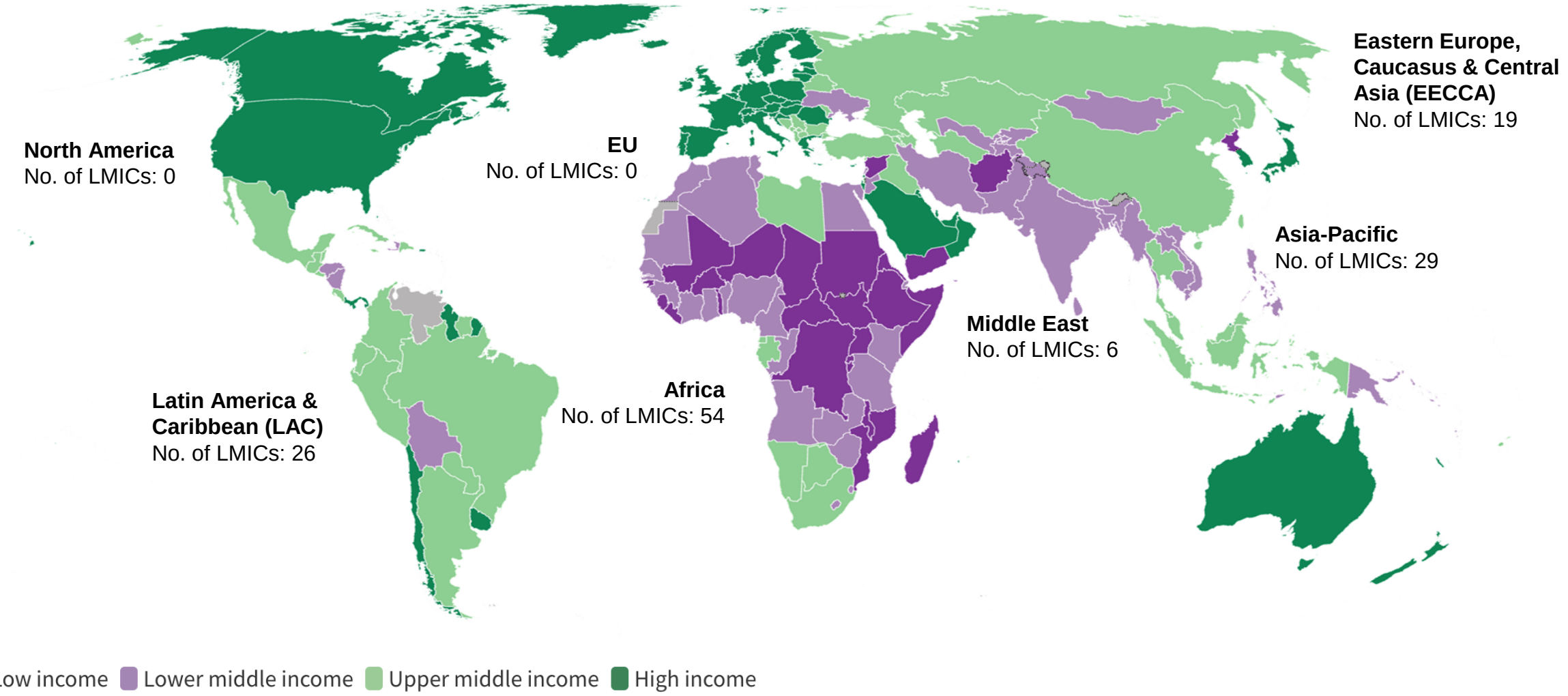
HSN codes for used EVs (4Ws) in trade statistics of different countries:

Country	Used Hybrid	Used PHEV	Used BEV
USA	8703.40.0090 (Petrol hybrid) 8703.50.0050 (Diesel hybrid) 8703.50.0090 (Diesel hybrid)	8703.60.0045 (Petrol PHEV) 8703.60.0090 (Petrol PHEV) 8703.70.0050 (Diesel PHEV) 8703.70.0090 (Diesel PHEV)	8703.80.0090
Japan	8703.40.100 (Petrol hybrid) 8703.50.100 (Diesel hybrid)	8703.60.100 (Petrol PHEV) 8703.70.100 (Diesel PHEV)	8703.80.100
EU	8703.40.90	8703.60.90	8703.80.90

Limitations of study:

Limitations
▪ The export data of secondary flow of used vehicles is not captured in the research. For example, Ukraine imports the used vehicles from EU/ USA through ports of neighboring countries like Poland, which is not captured in the current study. ▪ The current used vehicle flow data of USA shows no exports of BEVs. ▪ Given the fast development of electric mobility and in many cases irregularities or incompleteness in official data, figures shall be taken as approximation only.

Regional Categorization of Countries



Source: World Bank, https://datatopics.worldbank.org/world-development-indicators/the-world-by-income-and-region.html

Executive Summary

Transport Sector Overview in Low and Middle Income Countries (LMICs)

- Motor vehicle ownership in LMICs has notably increased over the past three decades due to rising populations, incomes, and urbanization, a trend which is expected to continue. In 2020, road transport emissions in LMICs comprised half of the global total, and this share is anticipated to grow further with the rising motorization in LMICs and stagnation of fleet in High Income Countries (HICs).
- Between 2019 and 2022, passenger car sales in LMICs accounted for approximately 19% of global sales, in contrast to their 30% contribution to the overall global passenger car stock. This notable difference is primarily attributed to the reliance on importing used vehicles in many of these nations.
- Commercial vehicles in LMICs also follow a similar trend where the imports of used vehicles is the norm.
- Currently, about 96% of the imported used cars and commercial vehicles are internal combustion engine vehicles (ICEVs).
- While the absolute number and value of imports of used electric vehicles (EVs) in LMICs is currently low, this number is expected to increase significantly following the past trend of ICEVs imports.

Growth of EVs globally and in LMICs – Affordable e-mobility options for LMICs

- The global EV market is experiencing significant growth, primarily propelled by robust sales in China and Europe. However, the adoption of EVs especially in the 4-wheeler segment remains notably low in LMICs.
- The slow adoption of EVs in LMICs can be attributed to financial constraints to meet the higher upfront cost of EVs, a lack of infrastructure for manufacturing and operating EVs, and a limited emphasis on policies and regulations promoting cleaner transportation.
- Anticipated to reach 85 million annually by 2030, global new EV sales will inevitably lead to a rise in the trade of used EVs as more of them retire. This scenario presents an opportunity for LMICs to embrace EVs affordably, through the importation of used EVs.

Executive Summary

- With more stringent regulations accelerating the retirement of ICEVs in HICs, an estimated 80 million ICEVs will qualify to undergo scrappage in their first use country. A portion of these vehicles will instead be imported into LMICs and if meeting roadworthiness requirements could be retrofitted to EVs locally.

Used EVs in LMICs

- The global flow of ‘used EVs' is increasing, notably with significant contributions from the European Union (EU). Plug-in Hybrid Electric Vehicles (PHEVs) remain dominant in the export; however, the proportion of used Battery Electric Vehicles (BEVs) has risen from 6% in 2017 to 26% in 2022.
- Of the 98 thousand used EVs exported in 2022, LMICs represent 67% of the used EV imports, compared to 87% in the case of used ICEV imports.
- Within LMICs, the Eastern Europe, Caucasus & Central Asia (EECCA) region imports the largest number of used EVs, with notable prevalence of used BEVs majorly imported from by Japan followed by the EU.
- The primary driver for importing used EVs among the top importing LMICs globally is the favourable tax policy.
- While the surge in global EV sales opens prospects for the transition to EVs in LMICs, it is crucial to consider potential challenges. Battery degradation in EVs may impact the usability and environmental impacts of these vehicles in LMICs after importation.
- The lifetime of a used EV hinges on factors such as its age and the State of Health (SoH) of the battery. Therefore, imported used EVs will have different useable life before the battery reaches its end-of-life (EOL). Other factors such as climatic conditions of the imported country also have an impact on the overall battery degradation and therefore its EOL management.
- Opportunities exist for EV technology transfer through the export of used electric vehicles to LMICs. Thus, assisting countries to leapfrog to cleaner vehicle technologies faster.

Executive Summary

Country Case Studies on the management of used EVs in LMICs

- **Mauritius** has experienced significant growth in used BEV imports due to favourable tax incentives and import restrictions on older vehicles. While the CIF cost of a used EV like the Nissan Note is 2.3 times higher than its ICE counterpart, the on-road cost is only 1.3 times higher because of reduced excise duty and road taxes for used EVs. Over a 7-year period, the TCO for a used EV is 28% lower than that of a used ICE vehicle. The country also has restricted import of older vehicles of age more than 4 years and mandated pre-shipment inspections.
- In **Cambodia**, used BEVs of various ages are being sold without restrictions. For example, Tesla Model 3 aged 2-5 years and BMW i3s aged 6-9 years are available. Due to battery degradation and the remaining vehicle lifespan, many of these vehicles will require battery replacements. As an importing nation with limited access to EV batteries, the high cost of replacement could drive the TCO of these used vehicles close to that of a new EV.
- In **Mongolia**, reduced excise duties for hybrids, similar to those for BEVs, have made them cost-effective for passenger cars, leading to a surge in imports of very old hybrids. As a result, Mongolia has become the highest importer of hybrids leading to an early accumulation of EOL batteries, while limiting the penetration of used BEVs. Updating the tax structure with improved vehicle classification and prioritizing BEVs could enhance their adoption.
- **Kenya** is a leading importer of used BEVs in Africa, driven by favourable EV policies. The country has prioritized EV adoption through improved vehicle classification and regulations, including new standards that restrict the import of used EVs with a battery SoH below 80% and those older than 8 years.
- The import of used EVs in **Ukraine** has surged from 450 vehicles in 2015 to 7,000 in 2021, driven by the removal of customs duty in 2016 and VAT in 2018. Skilled technicians in Ukraine are capitalizing on this growth, even replacing batteries, further expanding the EV fleet. However, regulations are needed to control the import of used vehicles and prevent an influx of end-of-life batteries.

Executive Summary

Key challenges identified along the used EV value chain

- **Battery SOH & Pre-Shipment Assessment Gaps:** Limited access to battery SOH data makes verifying remaining life at export challenging. Many LMICs lack pre-shipment inspections (min SoH, max age), increasing the risk of stranded EoL batteries. Shipping agencies are hesitant to transport used EVs due to liability concerns.
- **Repairability & Resource Challenges:** EV repairability is restricted by manufacturers' control over software, a problem worsened in LMICs with limited authorized technicians and informal repair sectors. Additionally, securing batteries and spare parts for post-sales services is difficult due to underdeveloped supply chains.
- **Vehicle Classification & Taxation Issues:** Used EVs are often not included in registration guidelines, and Revenue Authority officers lack training in EV classification and battery life assessment. Differences in vehicle classification rules between exporting and importing countries, coupled with taxation based on vehicle price, increase costs due to lack of data on used EV values and lifespan.
- **Charging Infrastructure & Maintenance Gaps:** Limited charging infrastructure and unreliable power are major barriers to used EV adoption, especially with lower ranges. Regular inspections to monitor battery degradation and resistance increases and safe charging points are critical to prevent overheating and safety risks.
- **EoL Battery Management:** There is a lack of robust testing for battery reuse and lack of warranties decrease consumer confidence. The recycling ecosystem faces profitability challenges, high shipping costs, and regulatory gaps. Some exporting countries and OEMs have imposed restrictions on used EV imports until proper EoL battery management is in place hindering the used EV imports in LMICs.

Executive Summary

Key recommendations to improve the quality of used EVs

- **Enhanced National Inspection & International Compliance:** Strengthen national inspection protocols for used EV imports by setting minimum battery SoH and maximum age limits. Integrate these measures into international frameworks like Basel, Bamako, and ELV directives. Adoption of common standards such as On-Board Diagnostics (OBD) and Battery Passports will improve battery health assessments and ensure third-party inspection access through vehicle telematics systems.
- **Certification & Training for Refurbishment:** OEMs should certify refurbishing entities in importing countries, ensuring service quality through training and standardized SOPs. Vehicle repair information must be accessible to independent repairers, while training programs should equip technicians with essential EV repair and maintenance skills while ensuring safety.
- **EV Registration & Tax Incentives:** LMICs should design comprehensive EV registration systems modelled on countries with high EV adoption and offer favourable taxes and levies for used EVs. Reducing registration fees and road taxes will incentivize used EV adoption.
- **Mandatory Periodic Inspections:** Introduce mandatory yearly inspections for used EVs, starting one year after initial registration. Inspections should cover both conventional roadworthiness and high-voltage systems, including the charging inlet, cables, and batteries, to ensure safety and functionality.
- **EoL Battery Management Collaboration:** LMICs should develop schemes for EoL battery management, promoting innovation in battery testing and secondary use. Collaborating with exporting countries on battery recycling will ensure the return of critical minerals, securing the EV battery supply chain while providing economic and environmental benefits.

Executive Summary

Retrofit of ICEVs to EVs in LMICs

- ICEV to EV retrofitting, which replaces an old vehicle's ICE powertrain with an electric powertrain, can complement used EV imports to promote affordable e-mobility adoption, particularly for segments like 2Ws and 3Ws, which are not typically available as used imports.
- Economically, retrofits offer a viable transition solution, especially in livelihood taxi segments. Retrofitting 2Ws and 3Ws can be cost-effective compared to new EVs for vehicles aged 3-5 years, excluding donor vehicle costs. For LCVs, retrofitting remains viable even when donor vehicle costs are included, due to the high price of new EVs and rapid ICE depreciation.
- While retrofitting extends the vehicle life, reduces emissions from new vehicle manufacturing, and allows for customization to meet user needs, it lacks the established performance, reliability, and warranty guarantees of used EVs. Therefore, retrofitting will require new standards and regulatory compliance measures to ensure safety and protect end-user interests.

Executive Summary

Assessment of different retrofit solutions by companies through cases studies

- Rwanda Electric Motors (REM) retrofitted ~100 fossil fuel-driven taxi **motorcycles in Kigali, Rwanda**, achieving a 7% lower TCO than new electric motorcycles due to reduced upfront costs. Riders save ~$1,650 annually on retrofitted motos, which is ~$850 more annually compared to ICE motos. This resulted in a a payback period of 6 months for retrofitted motos (retrofit cost: $800).
- In **India, three-wheelers** are a key transport mode of public transportation, and retrofitting offers significant cost advantages. The TCO for a retrofitted vehicle facilitated by Zero21 is 58% lower than an ICEV and ~19% lower than a new EV. Drivers save ~$4,200 annually by retrofitting. This resulted in a payback period of 7 months (retrofit cost: $2,400) for retrofitted 3-wheelers.
- For **electric LCVs in India**, although operational costs are 50% lower than diesel LCVs, the TCO is still 10% higher due to high upfront costs. Retrofitting LCVs by Northway Motors reduced the TCO by 21% compared to diesel variants and by 28% compared to new EVs, making it a promising solution.
- In Tanzania and other **African countries, retrofitting safari vehicles** for eco-tourism has emerged. Retrofit costs are comparable to new vehicles, but operational savings are higher due to remote locations distant from fuel stations.
- In **Latin America**, Autolibre's retrofitting ecosystem, driven by mechanic training and demand aggregation, has standardized retrofit kits and reduced costs. The company retrofitted over 2,800 vehicles through 40+ workshops in 15 countries.
- In **Kenya, Roam Electric piloted retrofitting a diesel bus,** but current costs (~1.5 times a new vehicle) and component sourcing challenges limit scalability. Policy incentives, including tax reductions, are recommended to bring retrofitting closer to viability.

Executive Summary

Key Challenges for ICEV to EV Retrofit

- **Sourcing/Import:** Availability of high-quality retrofit kits and components is limited. Import restrictions and tariffs on EV components increase retrofit costs, particularly for buses and trucks. Supply chain disruptions further complicate sourcing.
- **Skills:** There is a shortage of skilled technicians and engineers, necessitating specialized training and certification programs. High labor costs for skilled personnel also add to the challenge.
- **Regulation:** Lack of standardized specifications for retrofit kits, inconsistent regulatory frameworks across regions, and complex approval processes for retrofitted vehicles hinder registration efforts.
- **Usage:** Consumer acceptance and trust in retrofitted vehicles remain low, with uncertainties surrounding warranty and post-retrofit support. Integration with existing charging infrastructure and range anxiety are additional concerns.

Recommendations to improve ICEV to EV Retrofit

- **Sourcing/Import:** Advocate for reduced tariffs and incentives for importing EV components through government policy engagement. Collaborate with trade organizations to streamline import processes. Aggregating demand for retrofit EVs can scale businesses, reduce costs, and enhance supply chain security.
- **Skills:** Develop specialized training programs in partnership with technical institutes and industry experts. Implement certification programs for EV retrofit technicians to ensure standardized skills and quality across the industry.
- **Regulation:** Collaborate with industry bodies to establish and adopt standardized specifications for retrofit kits. Push for harmonized regulatory frameworks at national and regional levels and work with regulators to simplify and streamline approval processes.
- **Usage:** Include provisions for the approval and certification of retrofitment centres, along with the empanelment of qualified retrofitters. Additionally, promote battery swapping solutions for smaller vehicle segments, such as 2Ws and 3Ws, to increase convenience.

Contents

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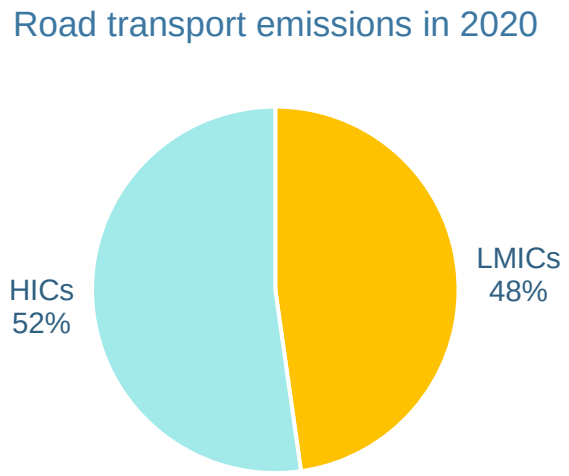
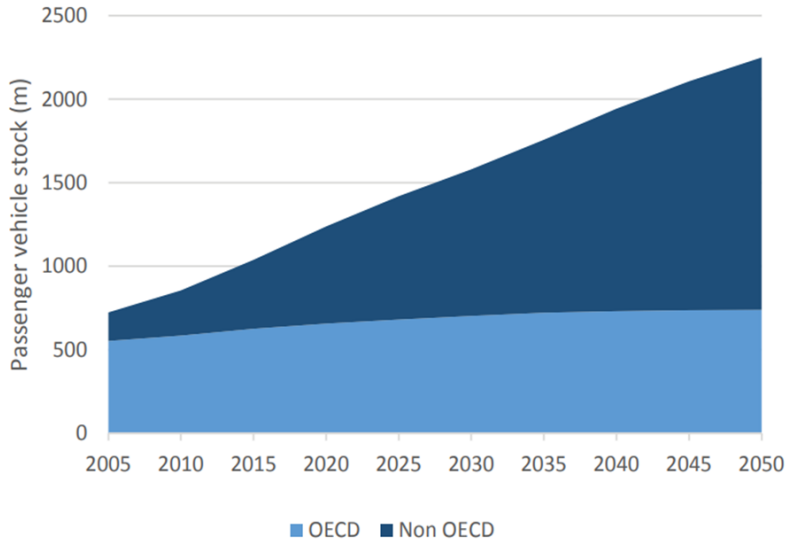
Introduction

- Global transport sector emissions
- Growth of EVs globally
- Affordable e-Mobility options for LMICs
- Methodology of the report

The global vehicle stock is projected to surpass 2 billion by 2050 (from current ~1.4 billion). Motor vehicle ownership in LMICs has notably increased over the past three decades, a trend which is expected to continue and grow beyond 60%. In 2020, road transport emissions in LMICs comprised nearly half of the global total, a share that is anticipated to grow.

- According to the International Energy Outlook 2021, the population growth rate in non-OECD countries is projected to be over three times that of OECD countries. As a result, the motorization rate in these countries is expected to increase substantially, from 92 vehicles per thousand people in 2020 to 173 vehicles per thousand people by 2050.
- With road transport emissions from LMICs already accounting for half of the global total, this share is set to rise further. The growing demand for motor vehicles in LMICs, driven primarily by population growth, rising incomes, and urbanization, **underscores the critical importance of effectively managing motorization in LMICs to align with climate and sustainable development goals**.

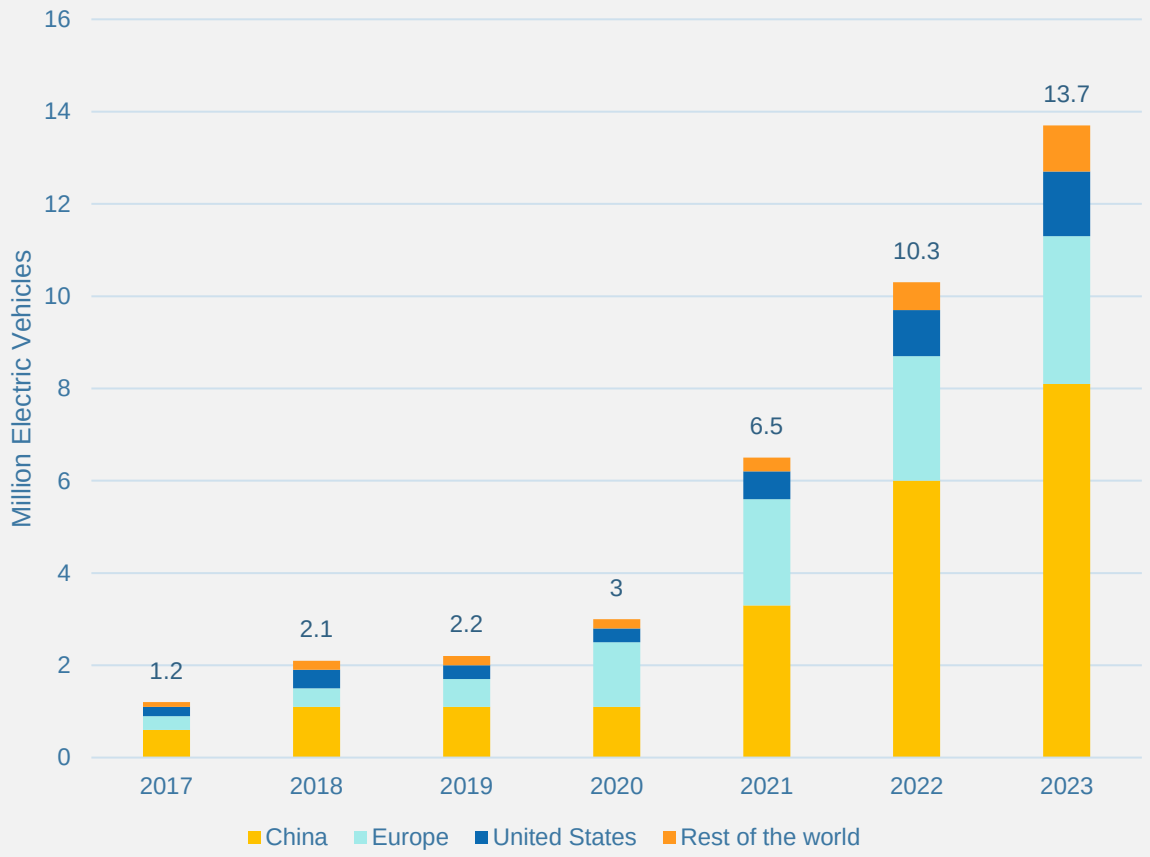




Source: own graphs based on data from IEA Transport Model

The global EV market is experiencing significant growth, primarily propelled by sales in China and Europe. Despite this upward trend, the adoption of EVs in LMICs remains notably low.

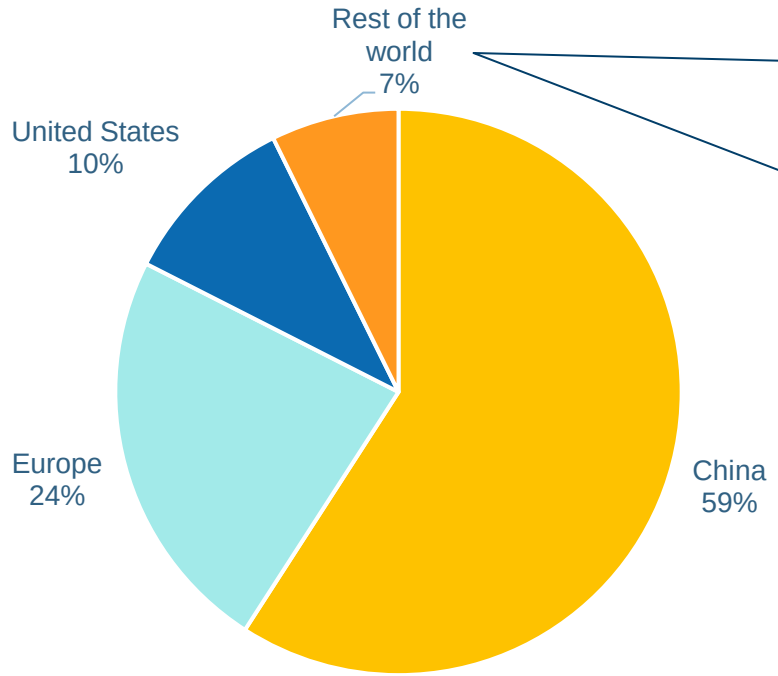
Global new EV car sales between 2017-2023



Source: IEA Global EV Outlook 2024

In 2023, global EV sales have surged to approximately 13.7 million units, marking a remarkable 33% increase compared to the sales in 2022. Among these global EV sales, BEVs constitute around 70%, with the remaining 30% attributed to PHEVs.

EV Sales in 2023 by region



Within the category of countries outside major markets, EV sales in LMICs are estimated to account for less than 1%

The slow adoption of EVs in LMICs stems from challenges like inadequate manufacturing capabilities and charging infrastructure, lower purchasing power, and a lack of robust policies and regulations promoting cleaner transportation

Key challenges for adoption of EVs in LMICs

Infrastructure deficiency

A primary hurdle for EV adoption in LMICs is **the lack of infrastructure**

- The majority of LMICs currently **lack a well-established local EV manufacturing industry** which is resulting in high technology cost
- **Limited charging infrastructure and weak electricity grid infrastructure** in LMICs also pose a challenge in adoption of EVs
- Some LMICs face **economic, security, and political issues that hinder their ability to support the EV industry** and develop the necessary infrastructure

High cost of technology

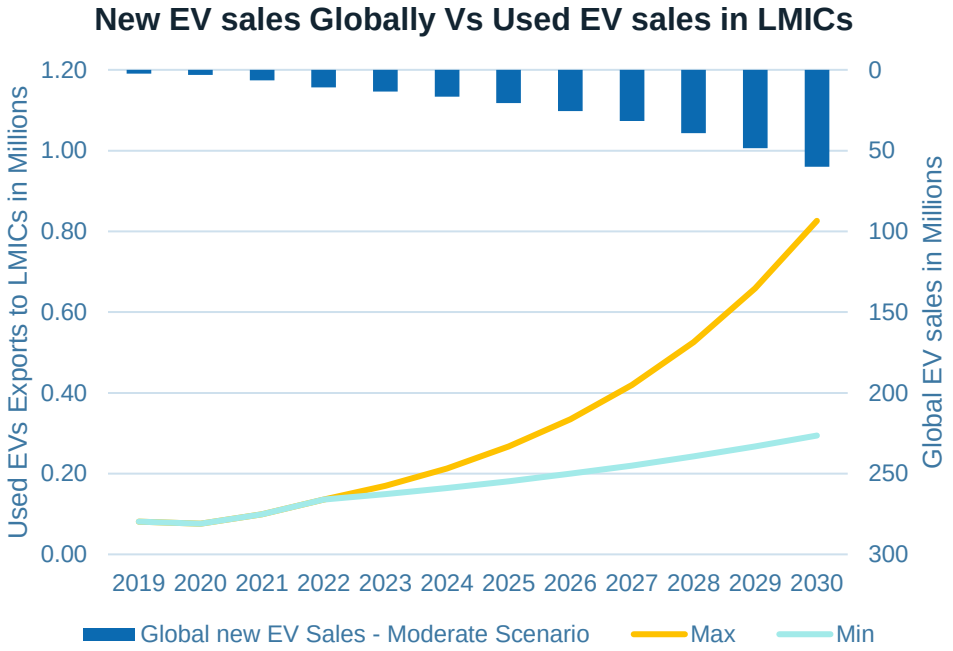
- The elevated initial expense of acquiring an EV stems from **import taxes, the absence of government incentives, and a higher cost of the technology**
- The persistence of **low fuel costs in oil-producing LMICs and the subsidization of gasoline prices in certain LMICs** contribute to the ongoing competitiveness of ICEV
- The influx of **imported pre-owned ICE vehicles in LMICs** exacerbates the price disparity between conventional vehicles and EVs, presenting a notable obstacle to the widespread acceptance of EVs

Lack of policy and regulatory support

- The majority of LMICs **lack supportive policies and regulations** for the promotion of electric mobility or cleaner transportation
- In a **UNEP study covering 146 LMICs, only around 45 countries have established vehicle emission standards**, leaving nearly 100 nations without any emission standards.

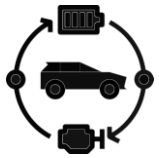
The import of used EVs is expected to dominate EV growth in LMICs, with an estimated annual import of ~1.3 million in 2030 up from 0.16 million in 2022. Additionally, retrofitting old ICEVs to EVs is expected to supplement used EV imports, albeit at a smaller scale.

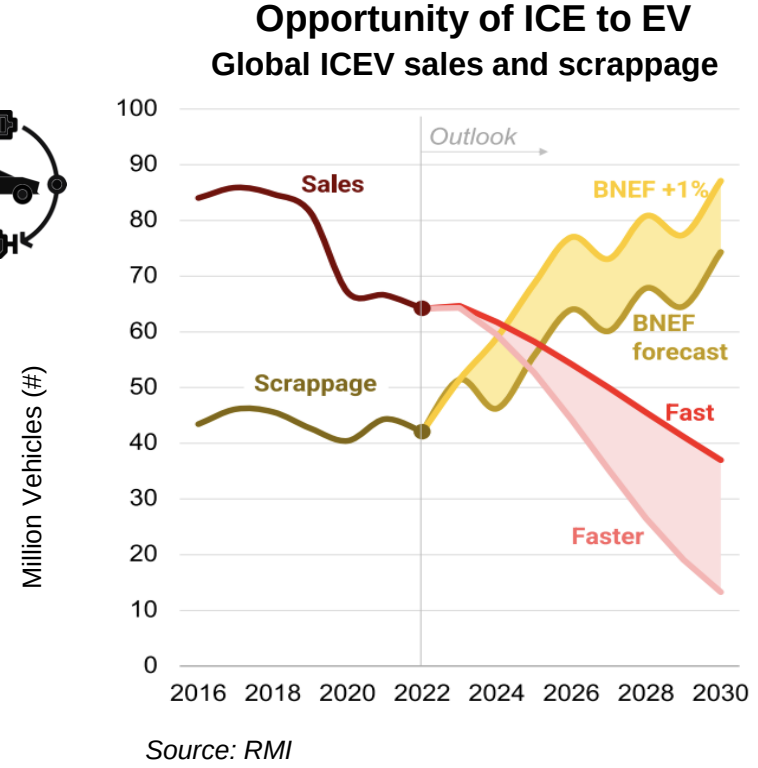
Opportunity of Used EV



- **Most LMICs across the world are dependent on import of used vehicles to meet their demand of vehicles**
- As the global fleet of vehicles is transitioning to electric, **more EVs will also enter the used vehicle export market**
- The **safe import of used EVs into LMICs will help accelerate the transition to electric mobility**

Opportunity of ICE to EV





Source: RMI

- With more stringent regulations accelerating the **retirement of ICEVs in HICs, an estimated 80 million ICEVs will qualify for** scrappage in their first use country. A portion of such imports into LMICs meeting roadworthiness requirements could be retrofitted to EVs.
- Retrofit can **supplement the import of used EVs to accelerate electrification**, and also advance circularity in the automotive sector.

Source: pManifold Analysis, Multiple sources (RMI, IEA, BloombergNEF)

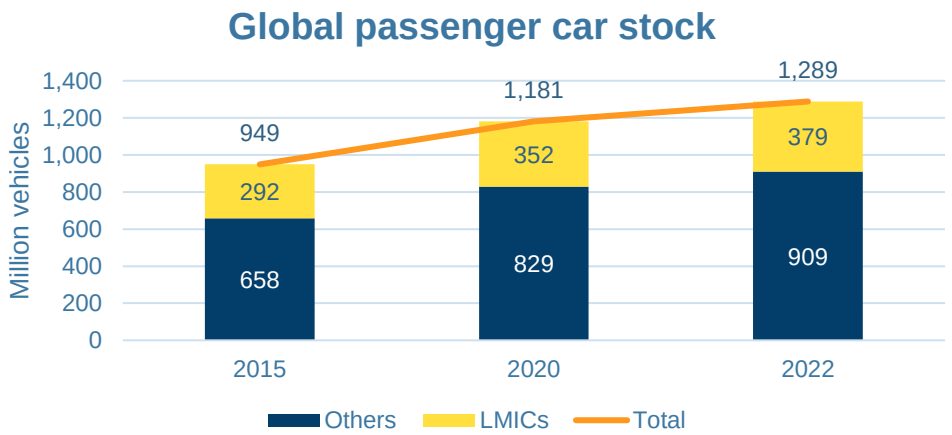
2

Vehicle Trends – LMICs vs Global

- Global passenger car stock and annual sales of old and new cars
- Global Used ICE car trade
- Global new and old commercial vehicles sales

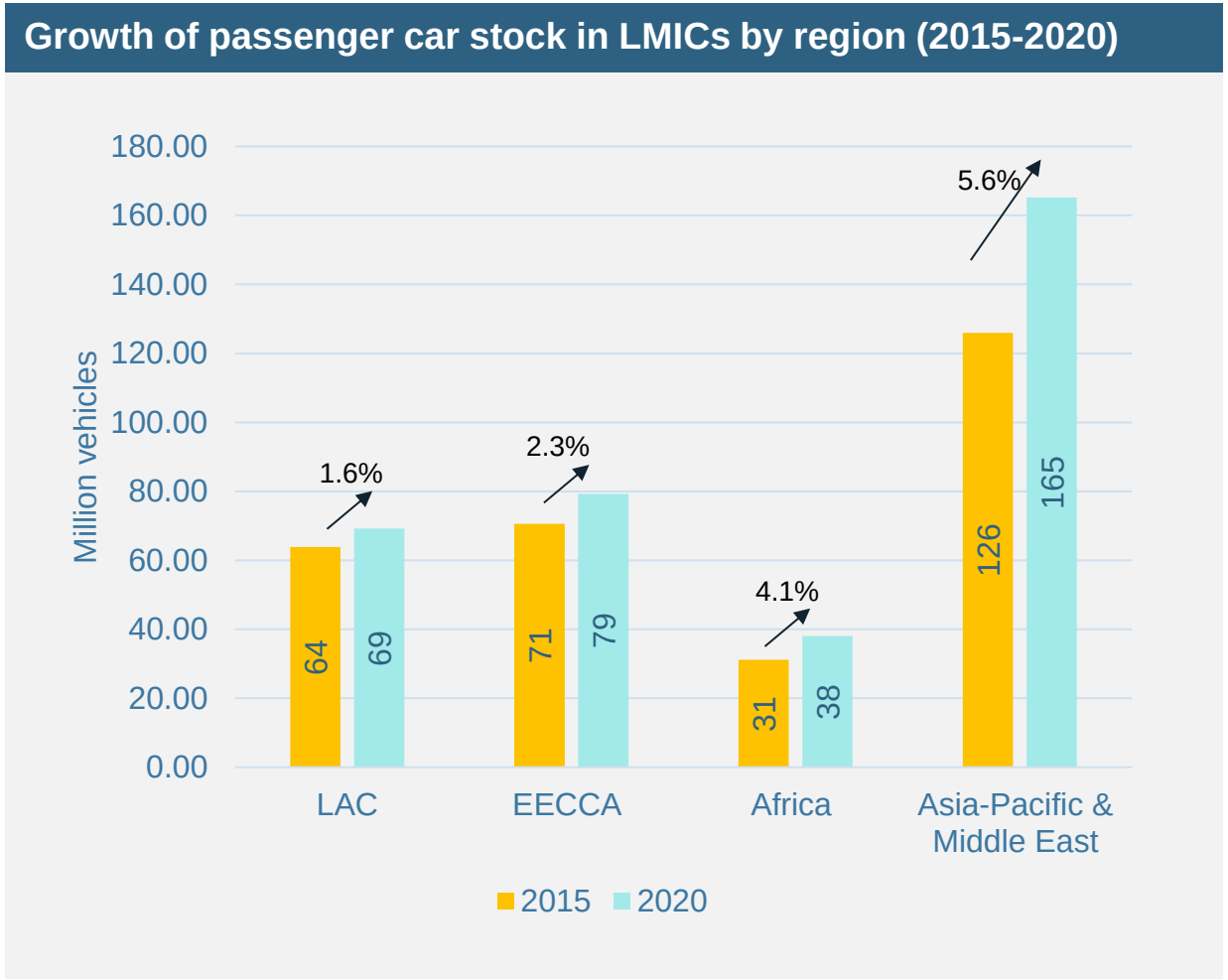
Global passenger car stock and annual sales of used and new cars

In 2022, the passenger car stock in LMICs totalled approximately 379 million, constituting a 30% share of the stock. With the global fleet of passenger cars expected to at least double by 2050, over 90% of this expansion is anticipated to occur in LMICs, given that vehicle markets in HICs are predominantly saturated.



Key Insights:

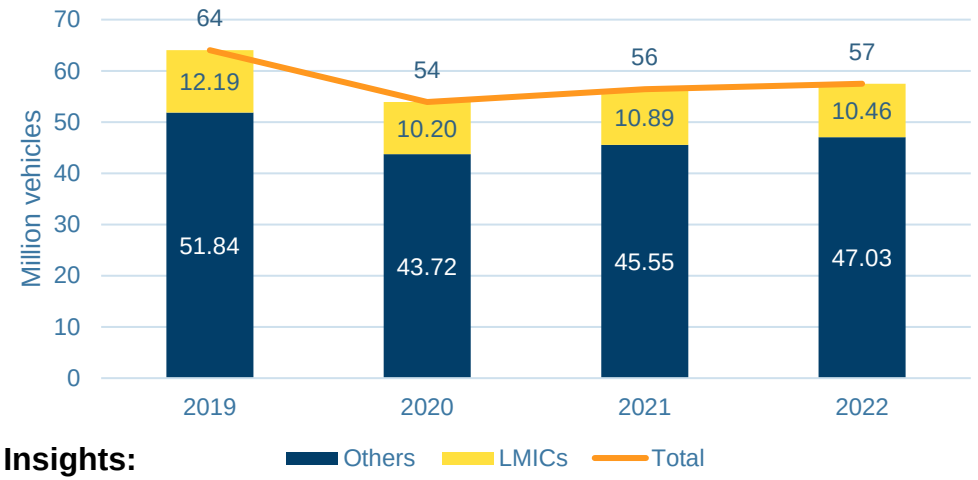
- The global fleet of passenger cars has experienced substantial growth, increasing from approx. 949 million in 2015 to 1,289 million by 2022, reflecting a compound annual growth rate (CAGR) of 4.5%.
- LMICs accounted for about 30% of the total global passenger cars in use, a consistent percentage observed both in 2015 and 2022.
- Among LMICs, the Asia and Middle East regions have exhibited the most significant expansion, boasting a remarkable CAGR of 5.6%. Following closely, LMICs in Africa have demonstrated substantial growth as well, achieving a CAGR of 4.1%.



Source: *OICA, https://www.oica.net/category/vehicles-in-use/*

Between 2019 and 2022, new passenger car sales in LMICs accounted for approx. 19% of global sales, in contrast to their 30% contribution to the overall global passenger car stock. This notable difference is primarily attributed to the prevalent reliance on importing used vehicles in many of these nations.

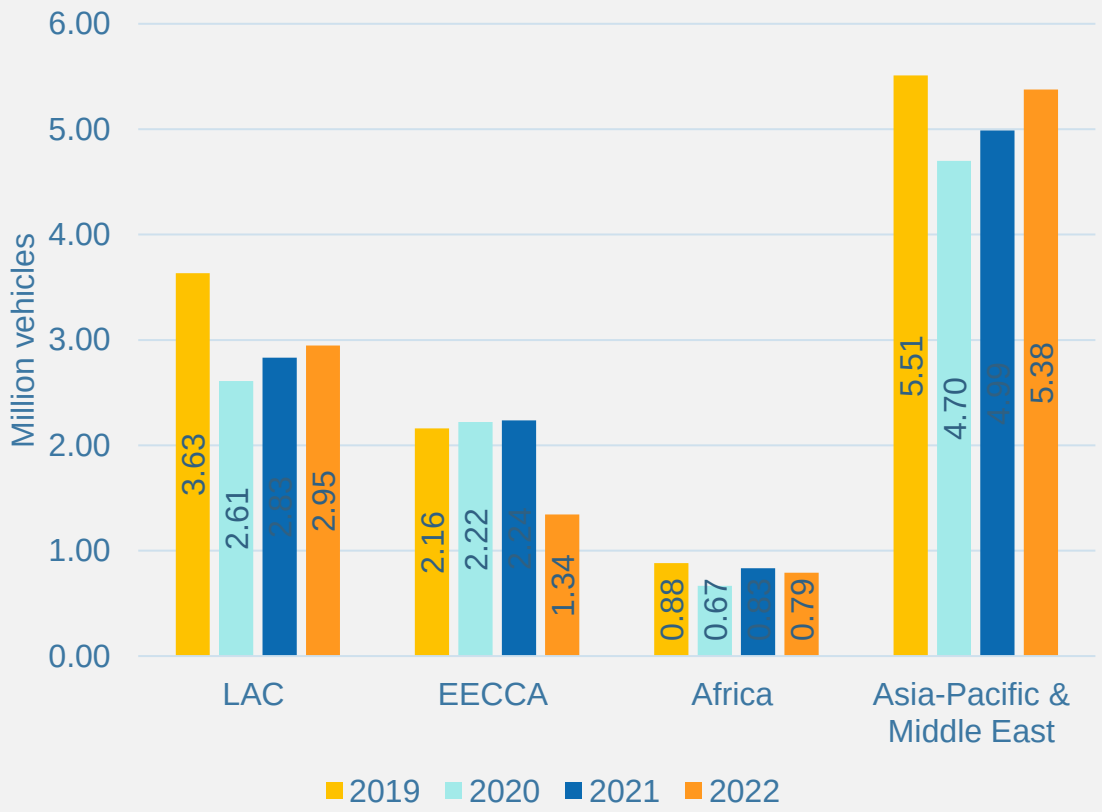
Global new passenger car sales (2019-2022)



Key Insights:

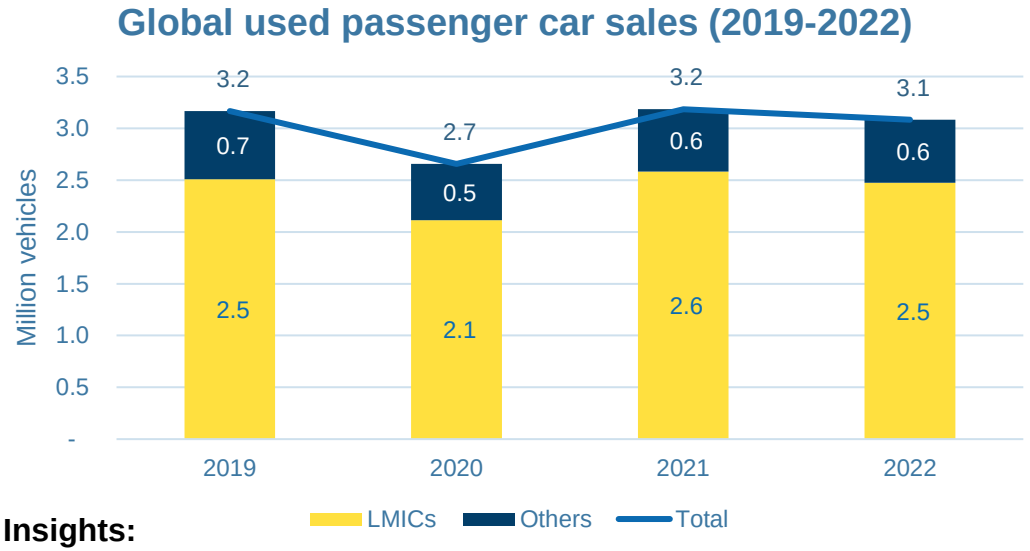
- Worldwide, the sales of new passenger cars have hovered around 60 million units from 2019 to 2022.
- Approximately 19% of these new passenger car sales were attributed to LMICs.
- Post the year impacted by COVID-19, the Asia-Pacific and Middle East regions among LMICs witnessed a significant surge in passenger car sales compared to other regions.
- In African LMICs, while the passenger car stock has experienced a Compound Annual Growth Rate (CAGR) of 4%, the sales of new cars have been sluggish due to a pronounced reliance on imported used vehicles.

New passenger cars sales in LMICs by region (2019-2022)



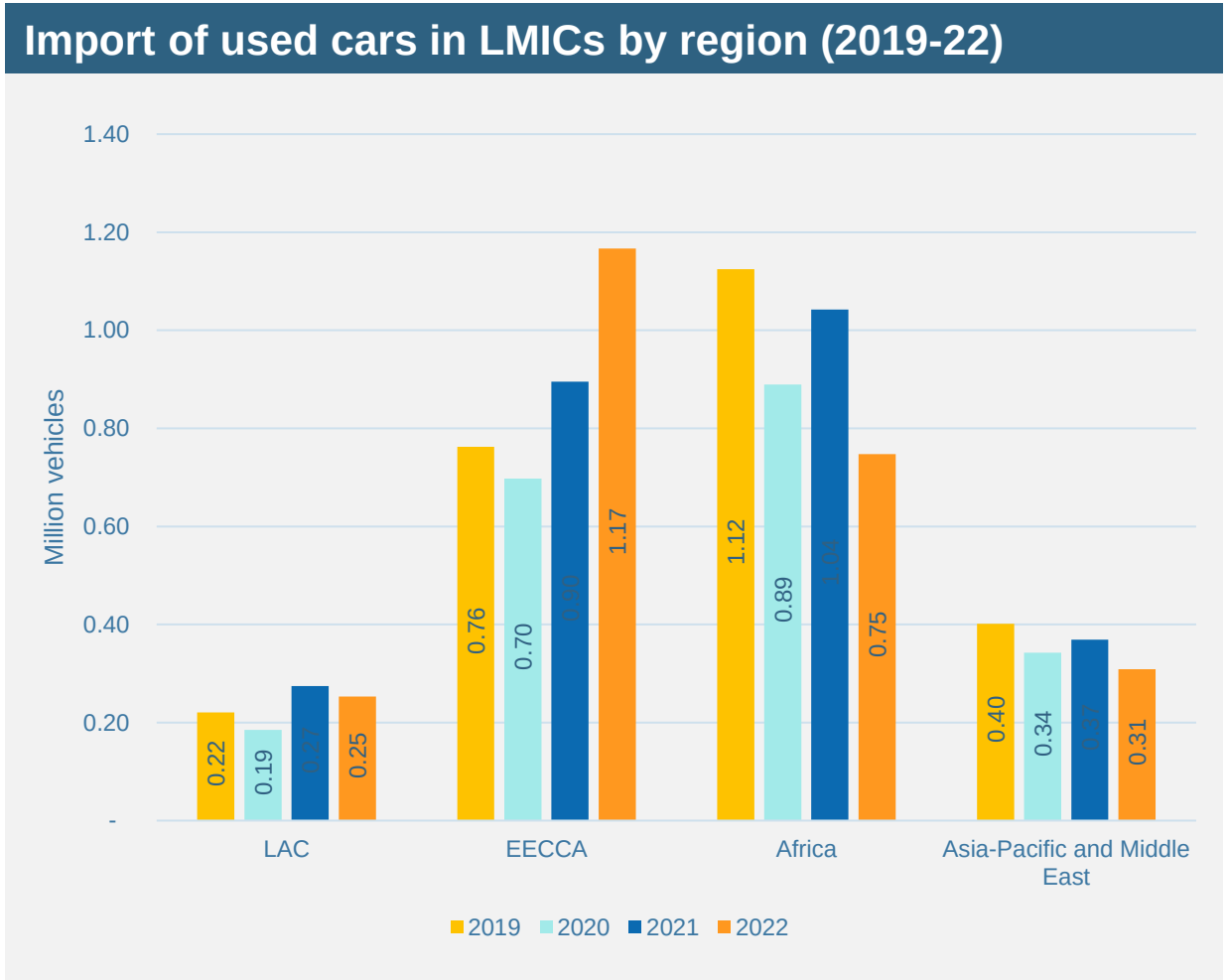
Source: *OICA, https://www.oica.net/category/sales-statistics/*

Globally around 3 million used passenger car are traded annually. LMICs have accounted for about 80% of sales in 2022.



Key Insights:

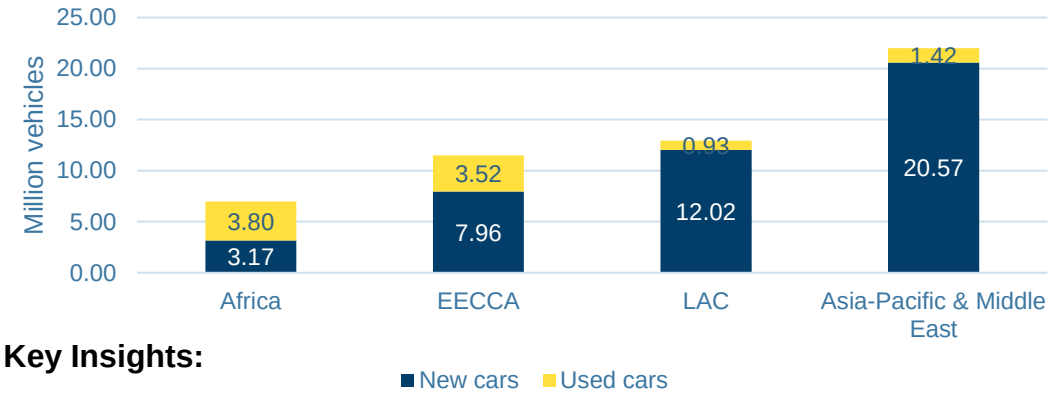
- To meet growing demand for affordable motorized transport, many LMICs rely heavily on importing used vehicles.
- In 2022, 80% of all used vehicles exported from EU, USA, Japan and Korea were sold in LMICs.
- LMICs in the EECCA region are leading importers of used passenger cars. In 2022, LMICs of EECCA have imported about 1.17 million used passenger cars.



Source: *pManifold Analysis, Multiple sources (EU-stat, E-stat, USITA)*

In LMICs, the addition of passenger cars is partly driven by the import of used vehicles, with the reliance on such cars varying across regions. Currently, a significant majority of the imported cars are ICEVs.

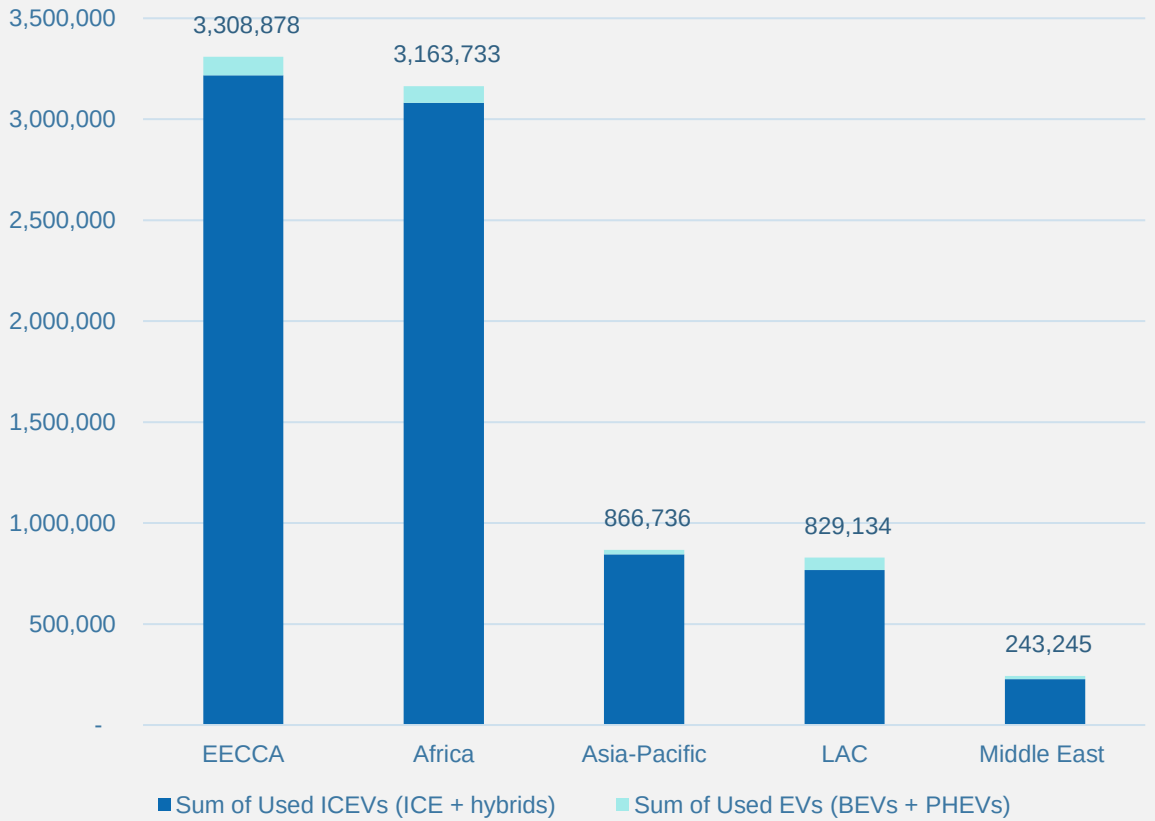
Passenger cars added in LMICs between 2019-2022



Key Insights:

- While many South American nations prohibit the import of used vehicles, exceptions exist, such as Paraguay, where over 90% of their annual fleet additions consist of used vehicles. The predominant source of vehicle growth in Central America and the Caribbean is the import of used vehicles.
- In the EECCA region, approximately 30% of vehicles added to the fleet between 2019 and 2022 are accounted for by used vehicles.
- In Africa, around 55% of vehicles added to the fleet between 2019 and 2022 result from the importation of used vehicles.
- The prevalence of used vehicle imports is lower in Asia-pacific, mainly due to the prohibition of used vehicle imports in many Southeast Asian countries
- In all these regions, more than 95% of all vehicles being imported are currently ICEVs.

Regional distribution of used ICEV imports to LMICs between 2019- 2022 by vehicle type



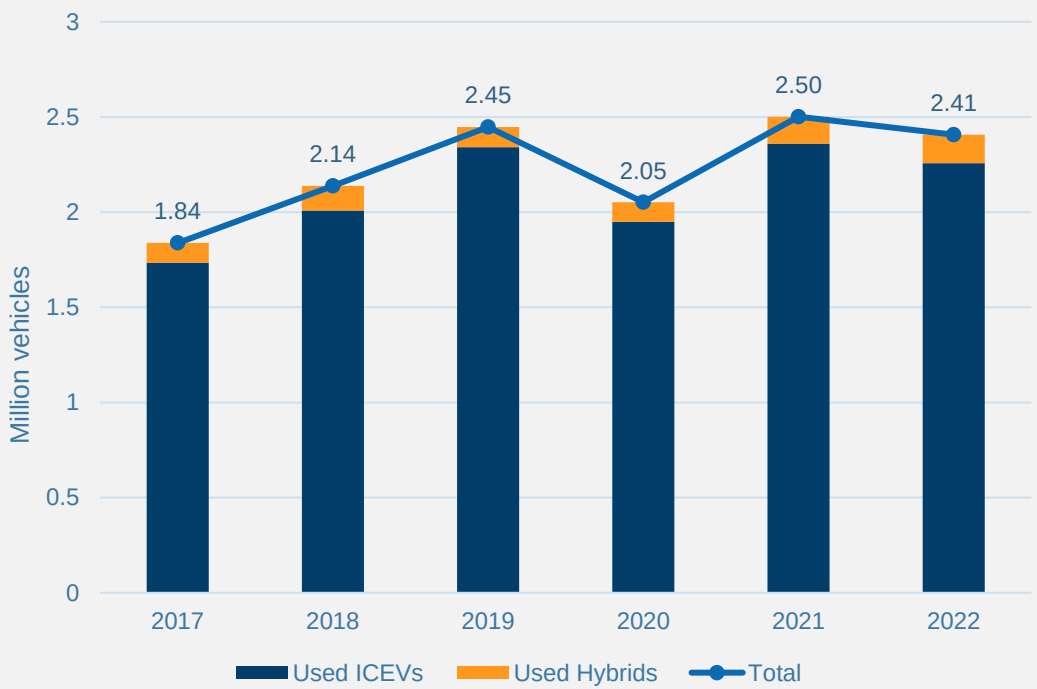
Source: *pManifold Analysis, Multiple sources (EU-stat, E-stat, USITA)*

Global Used ICEV flows

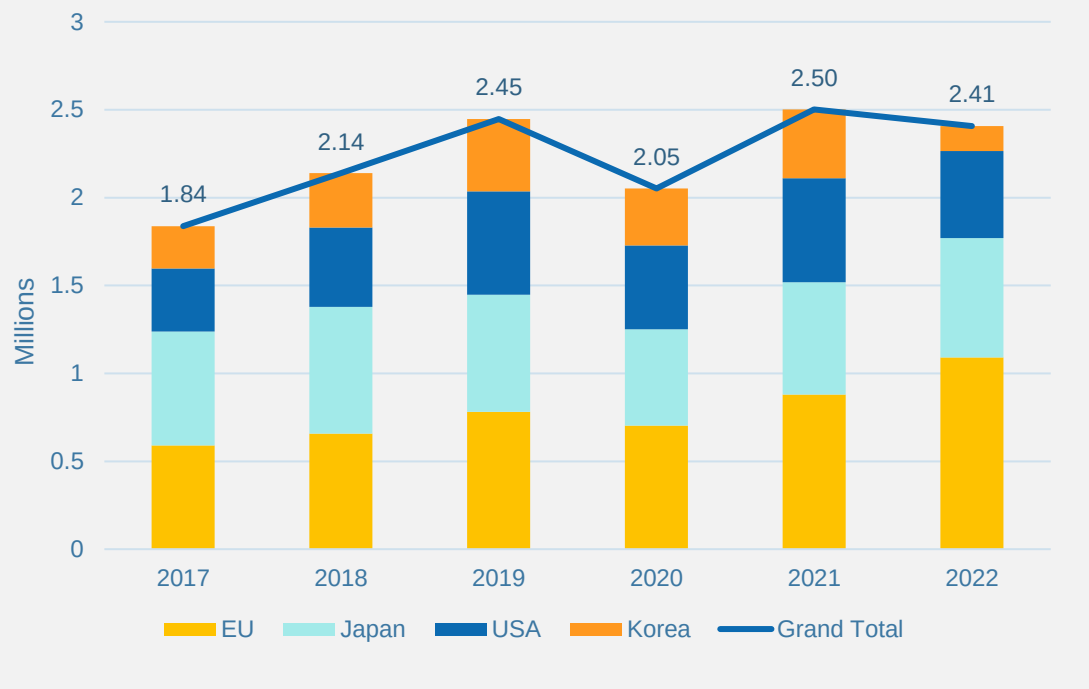
Increasing used ICEV exports from the EU, Japan and USA are boosting the global flow. EU became top exporter in 2022, followed by Japan and USA.

- The global flow of 'used ICEVs' has grown consistently between 2017 & 2022 at **CAGR of 5%**. The estimated cumulative traded vehicles are 13.4 million, of which **Hybrids were only 5%.**
- Decline in trade in 2020 was primarily due to the impact of COVID-19. However, there has been a notable recovery in trade since then.
- **Japan held the position of the primary exporter in 2017**, whereas **in 2022, the EU has taken over as the leading exporter**

Trend in global flow of 'used ICEVs' by 'Vehicle technology'



Trend in global flow of 'used ICEVs' by Exporting country



Source: *pManifold Analysis, Multiple sources (EU-stat, E-stat, USITA)*

Stricter vehicle and fuel emission standards, along with stringent vehicle roadworthiness inspection tests in HICs are propelling the export of ‘used ICEVs’ to LMICs.

Exports of used ICEVs from EU, Japan, USA

Key Drivers

EU

- In the EU, major car manufacturing countries offer various **incentives to encourage the shift from ICE to EVs** which is making consumers to **replace their older cars sooner than they might otherwise**
  - **Italy** provides subsidies for new BEV purchases and road tax exemptions for five years
  - **Norway** offers extensive tax exemptions and reduced tolls, significantly lowering the cost of EV ownership
  - **Germany** exempts BEVs from road tax for up to ten years and offers reductions in company car tax
- EU’s stricter vehicle and fuel emission standards from **EURO I in 1992 to VII in 2024** has led to higher vehicle turnover and export
  - Non-compliant vehicles are heavily disincentivized in EU by restricting the sale and prohibiting usage in certain cities

Japan

- In Japan, stringent vehicle road-worthiness tests often lead owners to sell their vehicles, typically within the 5 to 7-year age range
  - The **'Shaken' tests, conducted after three years, incur initial inspection expenses averaging around $1,000, which can escalate to $2,500 per vehicle**
  - Mandatory inspection certificate **renewals must be carried out every two years**

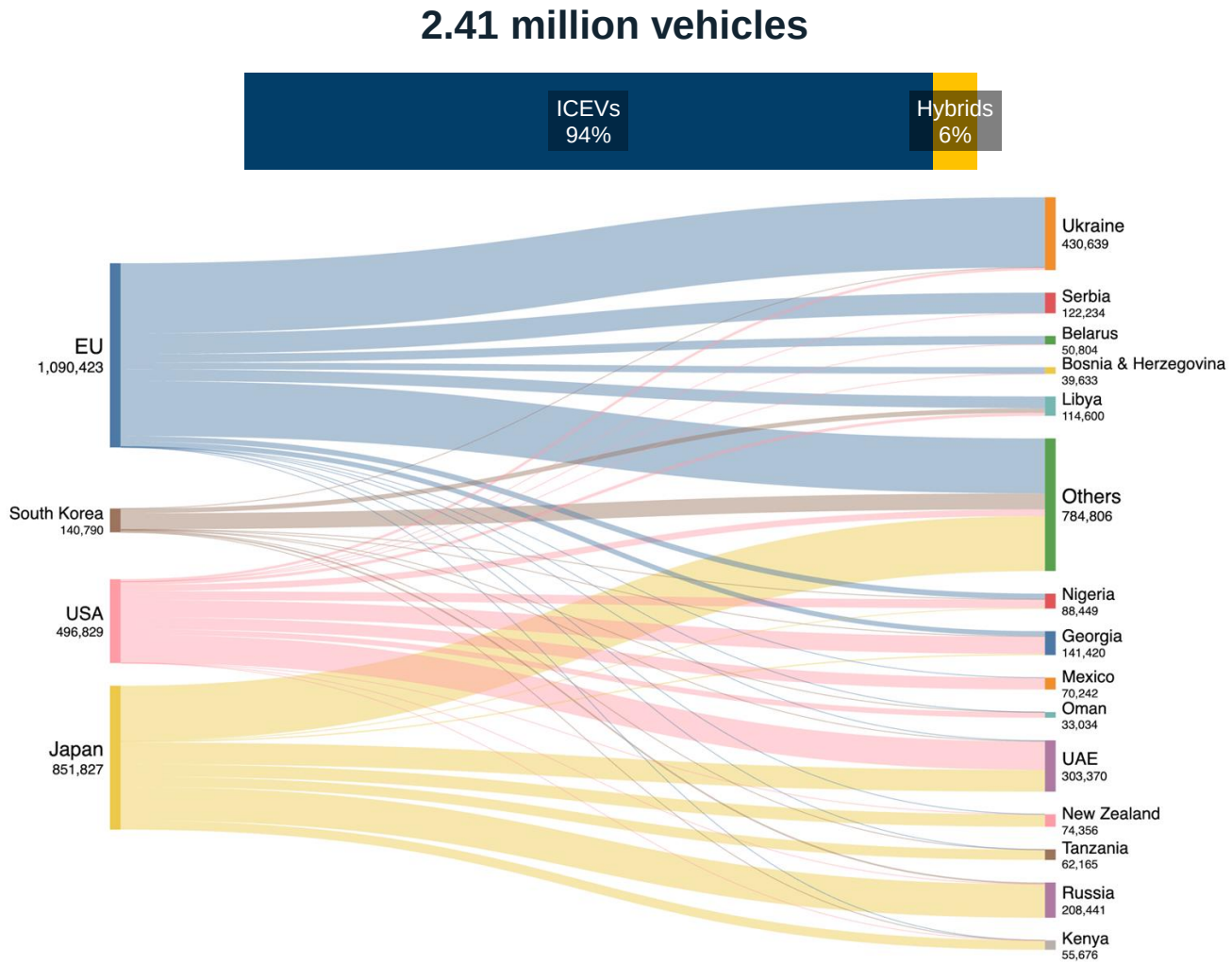
USA

- In the U.S., federal and state governments promote EV adoption through incentives like **federal tax credits up to $7,500, state rebates, and carpool lane access, making frequent vehicle renewal economically attractive**
- In USA, additionally incentives for replacing old vehicles with new efficient vehicles has accelerated sale of used vehicles by owners
  - **Consumer Assistance to Recycle and Save (CARS) program designed to offer financial incentives to vehicle owners for exchanging their old cars for newer, more fuel-efficient models**
  - While the **program aimed to dispose/ recycle the traded-in vehicles, significant no. of them have been exported to regions like Africa or South America.**

During 2022, most of the leading countries importing used ICEVs were LMICs. One of the largest importers of used ICEVs is UAE. Although not an LMIC, it serves as a significant hub that re-exports used vehicles to Africa and the Middle East.

‘Used ICEVs’ export forms ~13% of new ICEV sales in these four regions (i.e., estimated 19 million annual new ICEV sales in 2022)

Additionally**, 1.4 million ‘used ICEVs’ were traded within EU**. Top three importers of used ICEVs in EU include: **Poland, Germany & France**



80% of all used ICEVs traded are imported by LMICs

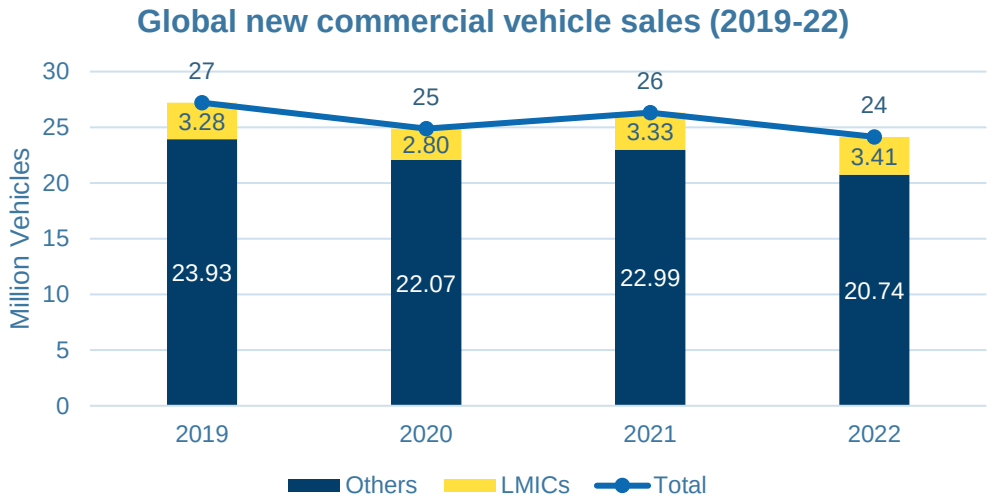
Ukraine, UAE & Russia are top importers of used ICEVs. Among the top ten importers of used ICEVs, 8 are LMICs

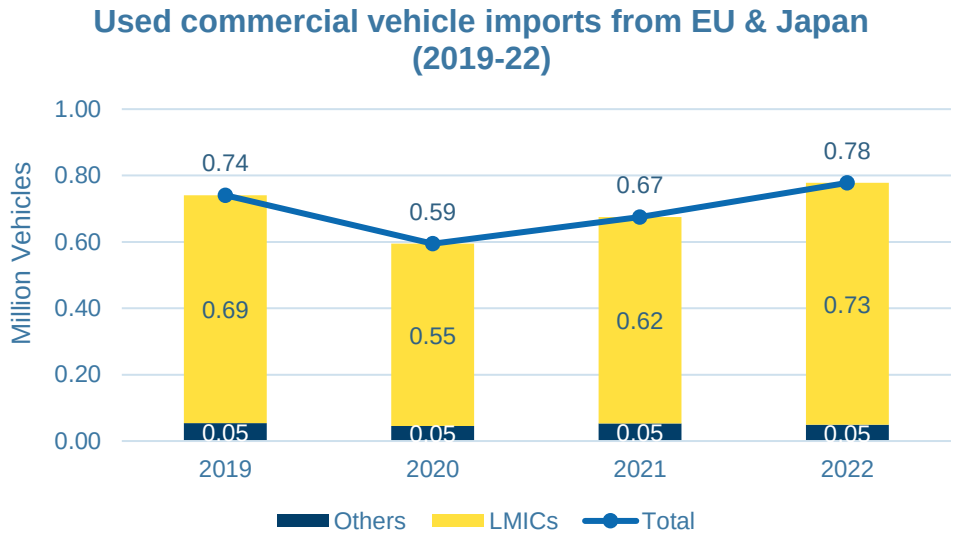
Major export market for **EU, Japan, USA and Korea** are **EECCA, Asia-Pacific, Middle East and EECCA respectively**

Source: *pManifold Analysis, Multiple sources (EU-stat, E-stat, USITA)*

Global new and used commercial vehicles sales

Commercial vehicles follow a similar trend where LMICs contribute to about 14% of new commercial vehicle sales and about 90% of used vehicles sales





Key Insights:

- In 2022, the sale of new commercial vehicles globally was about 24 million. Commercial vehicles include Light Commercial Vehicles (LCV), Heavy Commercial Vehicle (HCV), Buses and Coaches (B&C).
- The share of LMICs in annual sales of new commercial vehicles is about 14%.
- In 2022, the sale of used commercial vehicles imported from EU & Japan was about 0.78 million.
- All these vehicles are ICEVs.
- The share of LMICs in annual sales of used commercial vehicles exported from EU and Japan is between 92-94%.

Source: *pManifold Analysis, Multiple sources (OICA, EU-stat, E-stat, USITA)*

3

Used EVs in LMICs

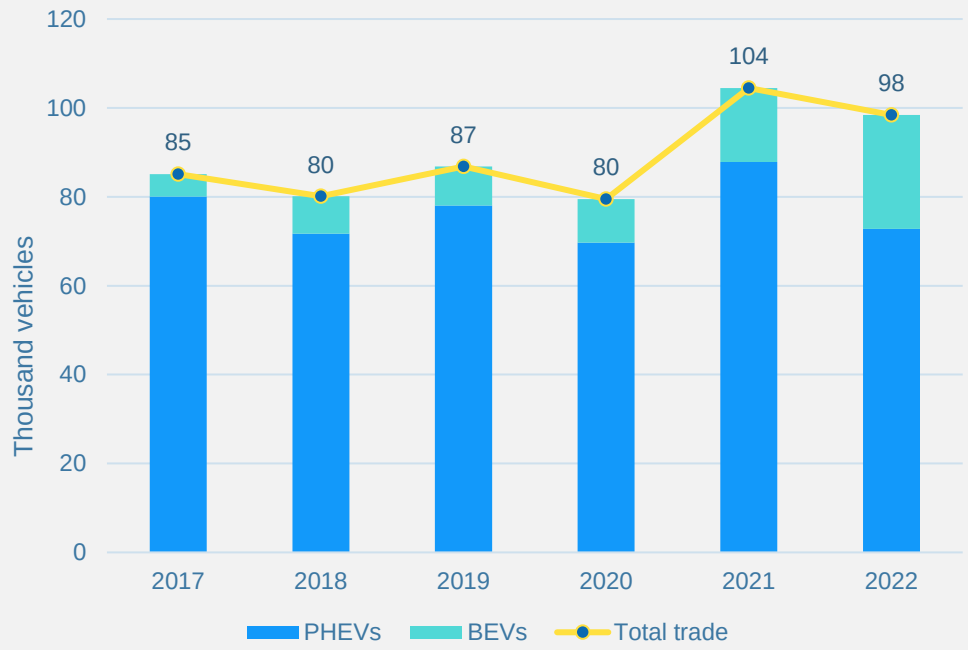
- Flow of used EVs – Global & LMICs
- Case studies of used EVs in LMICs– Technical, Policy, Regulatory and Economic aspects
- Measures to improve quality of used EVs

Flow of used EVs – Global & LMICs

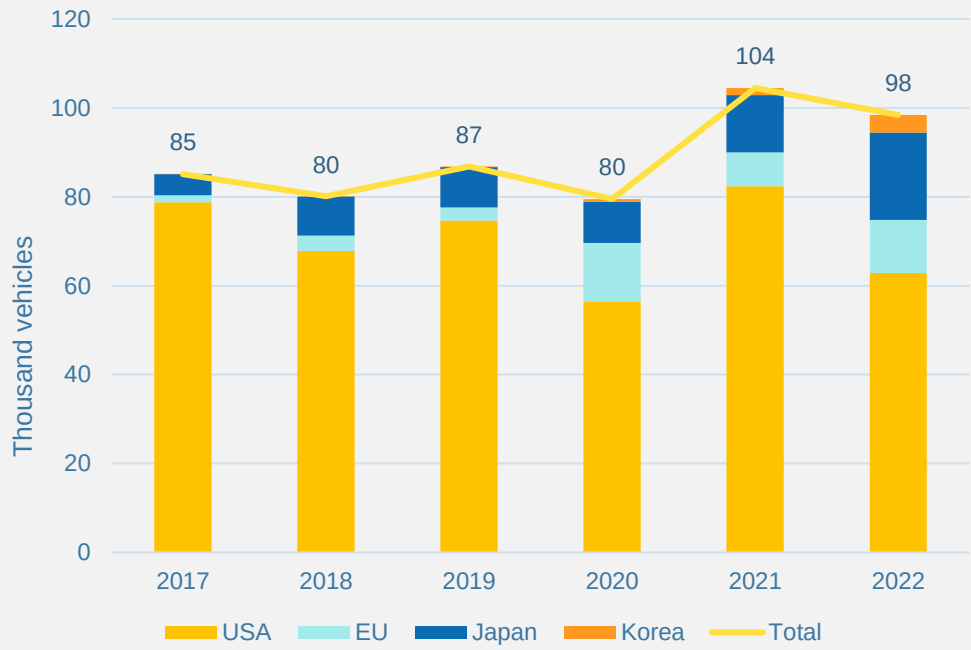
The global exports of ‘used EVs’ are increasing. PHEV remain dominant export, however, the proportion of ‘used BEVs’ has risen from 6% in 2017 to 26% in 2022.

- The global flow of ‘used EVs’ has grown between 2017 & 2022 at **3% CAGR**.
- The **share of BEVs in total used EV exports was 26% in 2022,** mainly due to increasing exports of BEVs from EU, Japan and Korea.
- All **used EVs exported from USA are PHEVs.**

Trend in global exports of used EVs by type of EV



Trend in global exports of used EVs by exporting country



Source: pManifold Analysis, Multiple sources (EU-stat, E-stat, USITA)

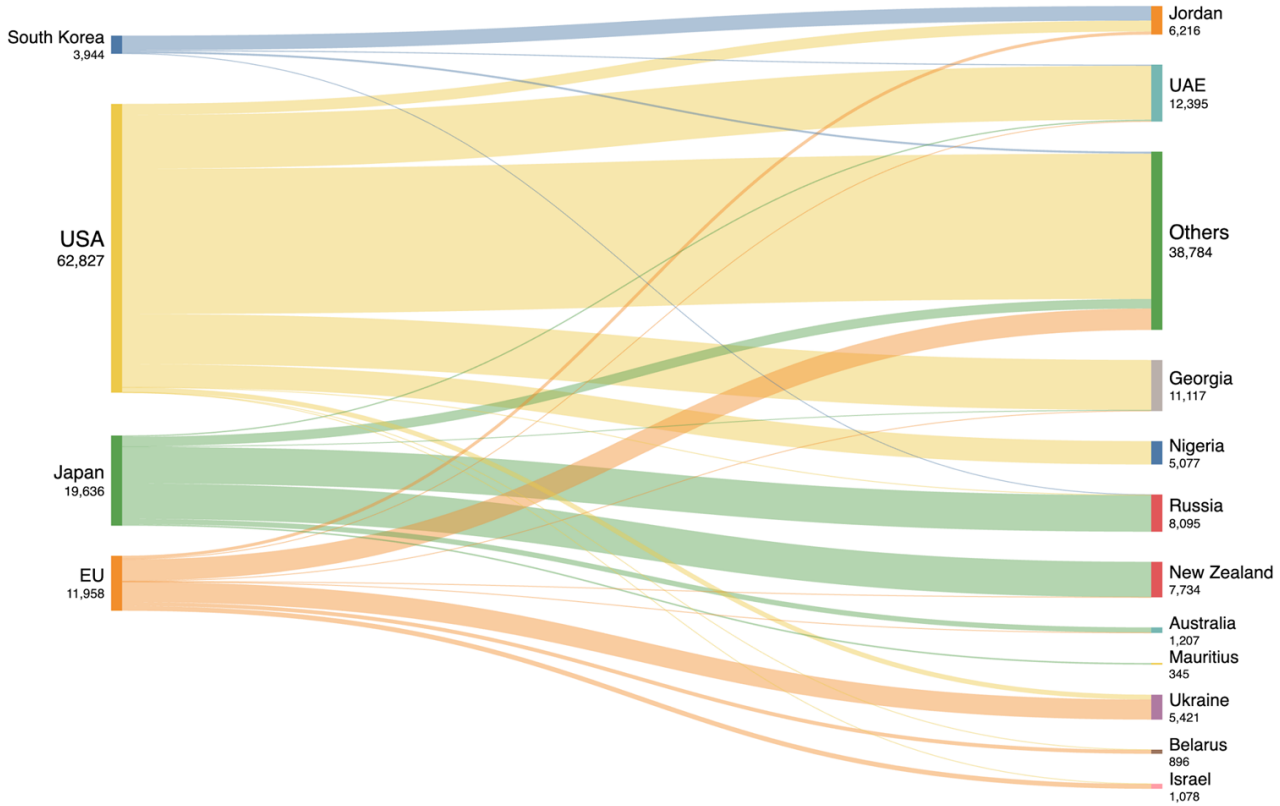
In 2022, LMICs accounted for 72% of used EV imports, whereas for used ICEVs, the figure stood at 87%

98 thousand used EVs

Exporting countries

'Used EVs' export forms ~5% of new EV sales in these four regions (i.e., estimated 2 million annual new EV sales in 2022)

Additionally, **86k 'used EVs' were traded within EU**. Top three importers of used EVs in EU include: Netherlands, Norway and Germany. **Internal trade of 'used EVs' within EU is about 46% of used EV exports** from EU countries



Importing countries

UAE, Georgia and Russia are top importers of used EVs.

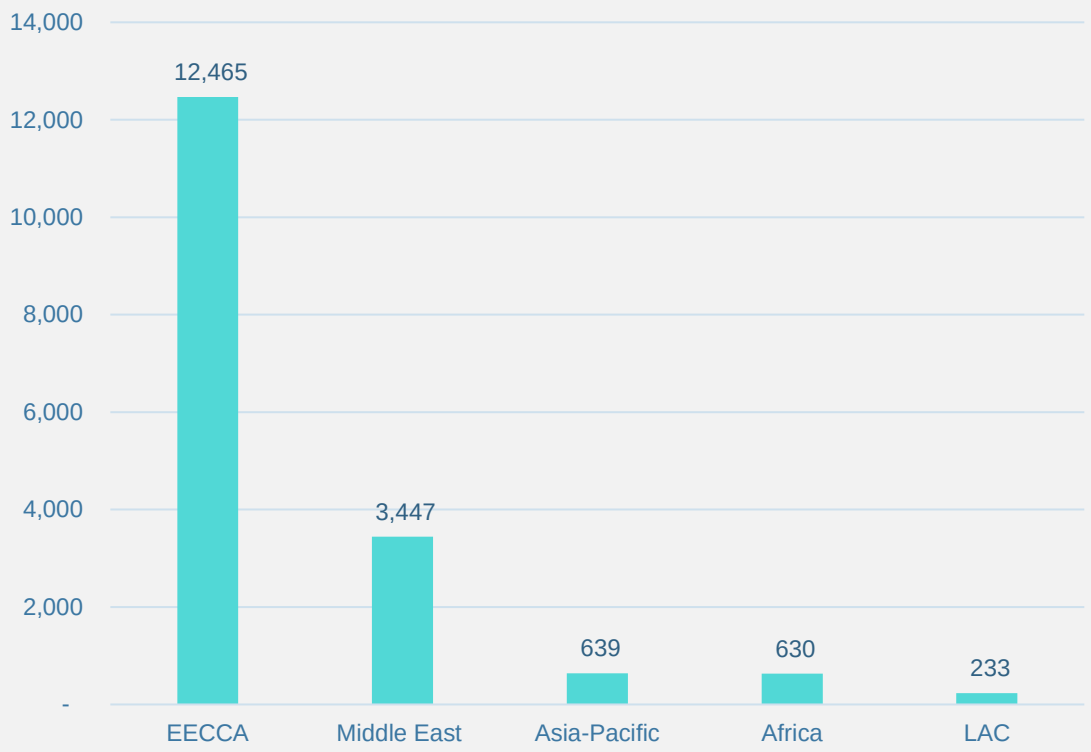
Major export market for **EU and Japan is EECCA**, whereas for **USA and South Korea it is LAC and Middle East** respectively

72% of all used EVs traded are imported by **LMICs (71k)**

Source: pManifold Analysis, Multiple sources (EU-stat, E-stat, USITA)

Within LMICs, the EECCA region imports the largest number of ‘used BEVs’, majorly importing from EU.

Regional distribution of BEV imports to LMICs in 2022



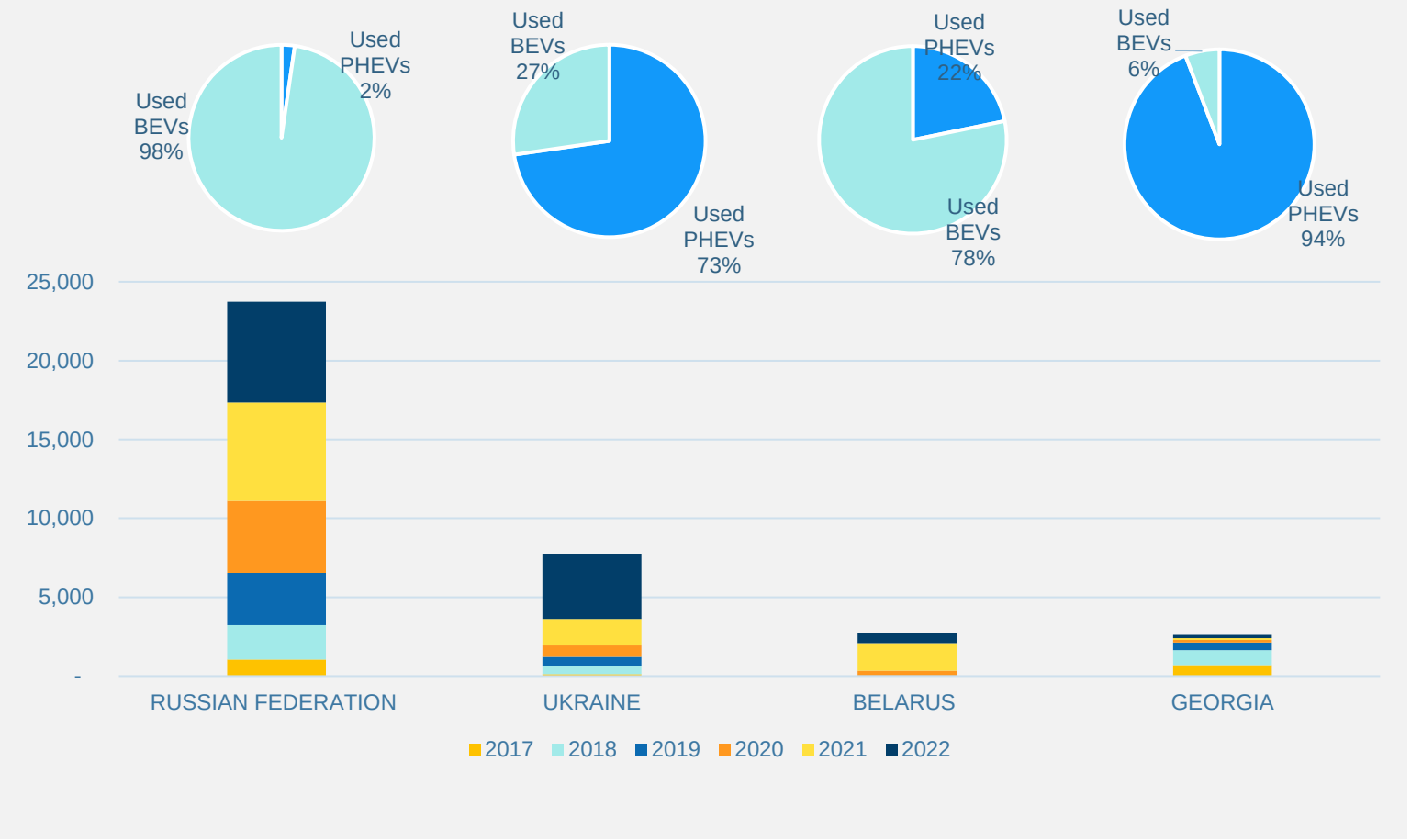
Key Insights:

- **EECCA imports of used BEVs (12.5k) in 2022 was the highest**, whereas in case of ICEVs Africa has highest share of imports
  - **Used BEVs in EECCA are majorly coming from Japan (6.5k) followed by EU (5.6k)**
- **Middle East** imports of about 3.4k used BEVs majorly from Korea
- Used BEV imports by **Asia-Pacific** was about 1.4k majorly from Japan
- **Africa** has imported about 630 used BEVs from Japan and EU
- **LAC** has imported about 233 used BEVs, importing from Japan and Korea

Source: pManifold Analysis, Multiple sources (UNEP, EU-stat, E-stat, USITA)

EECCA region – Russia is largest importer of used BEVs, followed by Ukraine, Belarus, Georgia & Serbia. Russia is primarily importing ‘used BEVs’ from Japan, while Serbia, Ukraine & Belarus are importing from EU.

Used BEV imports by LMICs in EECCA



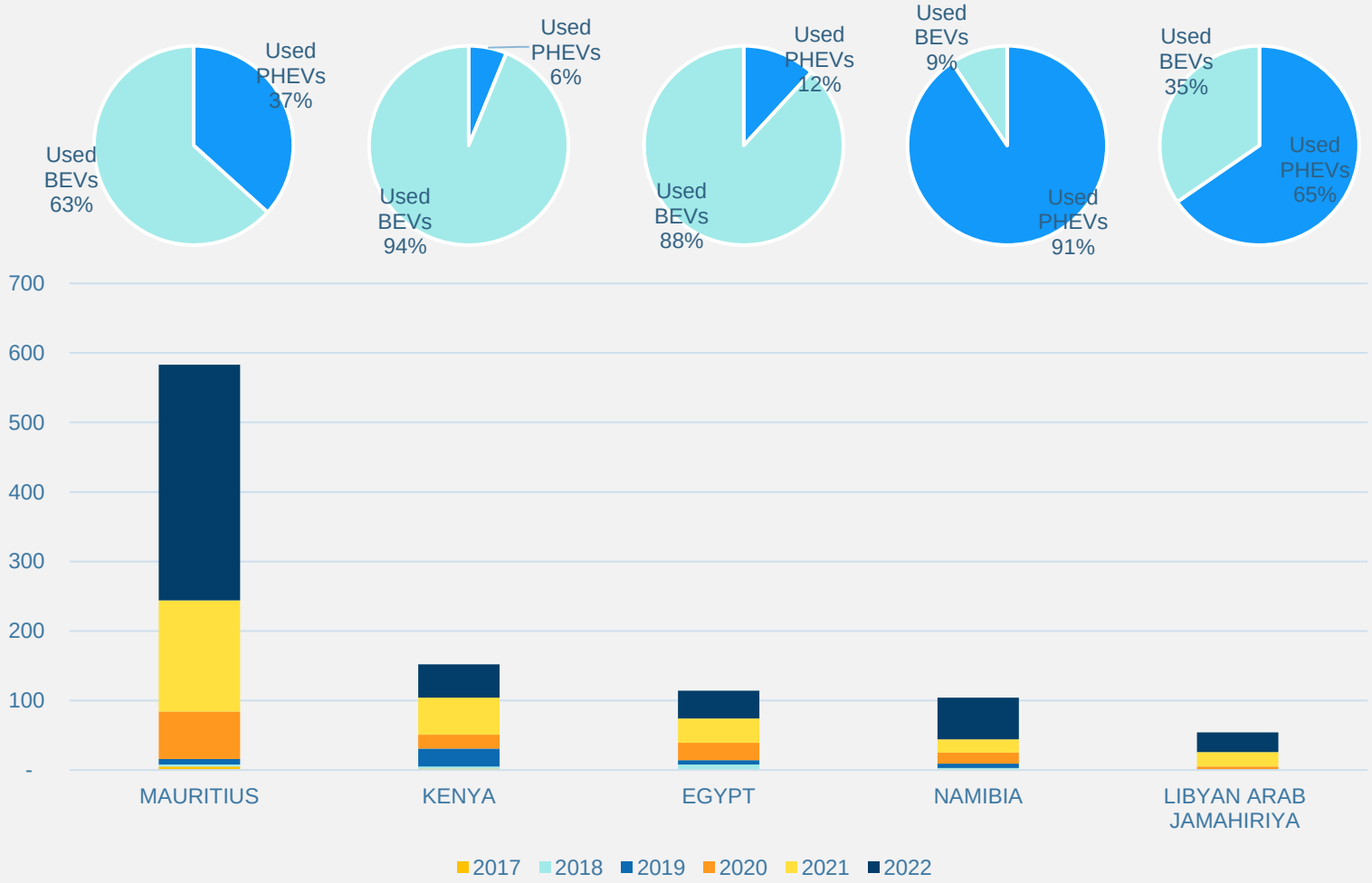
Source: pManifold Analysis, Multiple sources (UNEP, EU-stat, E-stat, USITA)

Key Insights:

- **Russia is biggest market of used BEVs in EECCA region majorly importing from Japan**
- **Ukraine is the second biggest market of used BEVs in EECCA**
  - In 2022, Ukraine has imported highest no of used BEVs with imports of about 4k of them
  - In Ukraine, EVs are exempt from customs and VAT, with an excise duty of about 1 euro per kWh on the battery. The surge in used car imports can also be attributed to the authorization of tax-free imports of EU-registered cars.
- **Belarus & Georgia are other major importers of used BEVs in EECCA region with more than 2.5k of imports between 2017-22**
- **Used BEVs imports in Serbia are gradually increasing, imported primarily from EU.**

Africa region - The top importers of ‘used BEVs’ in Africa are Mauritius, Egypt, Kenya & Namibia. The top three countries are primarily importing ‘used BEVs’ from Japan, while Egypt has imported most ‘used BEVs’ from EU.

Used BEV imports by LMICs in Africa



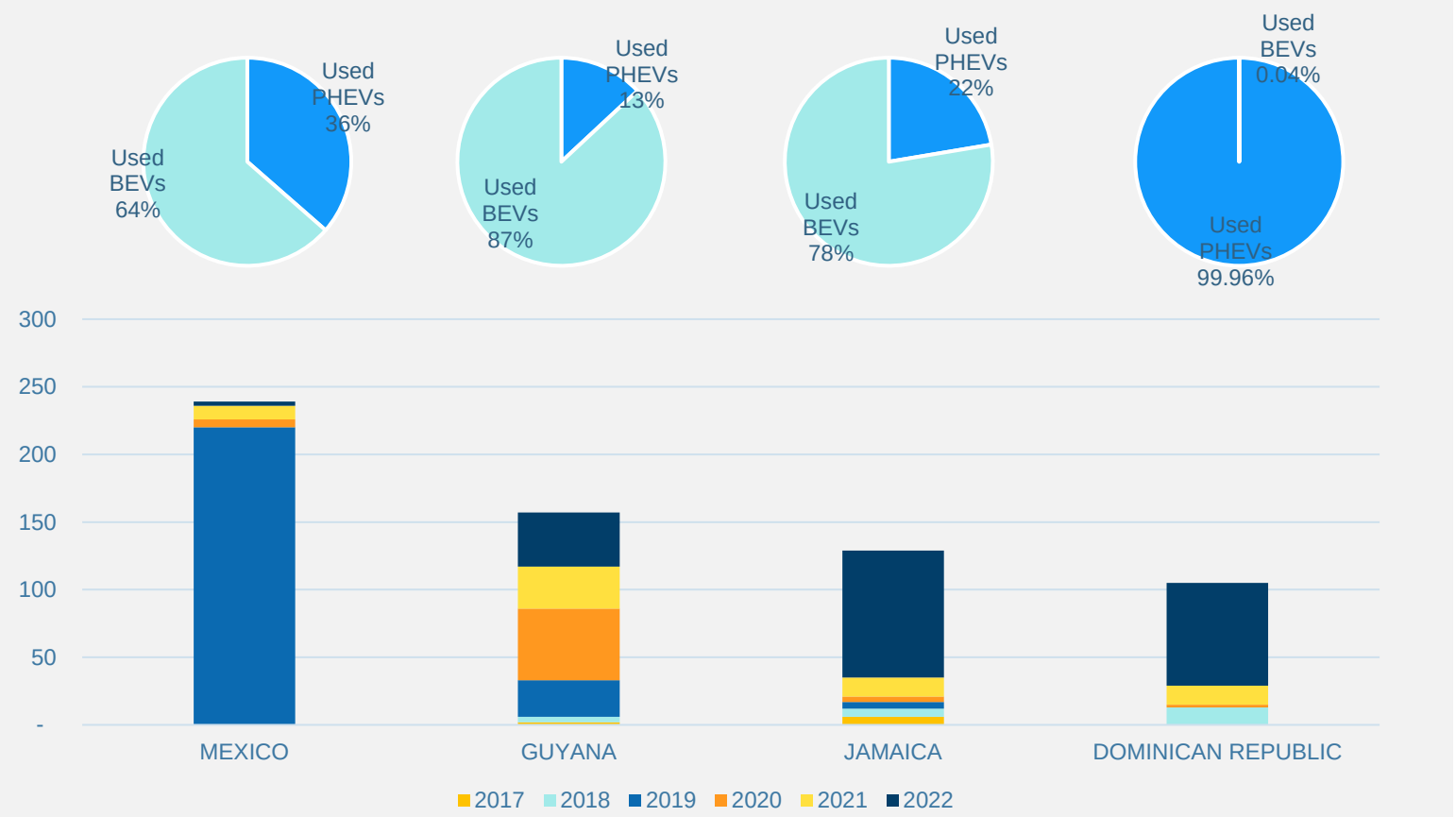
Source: pManifold Analysis, Multiple sources (UNEP, EU-stat, E-stat, USITA)

Key Insights:

- **Mauritius is the top importer of used BEVs in the African region.**
  - Total imports of about 600 BEVs between 2017-22 with an increasing trend
  - Mauritius banned import of used vehicles over 3 years old and issued a vehicle carbon tax. Used EVs are exempted from the ban.
- **Kenya & Namibia are other major importers of used BEVs in Africa, with imports of over 100 used BEVs between 2017-22**
  - In Kenya, the excise duty on import of EVs is reduced to 10% compared to 20-35% in case of ICEVS.
- **Egypt has also imported used BEVs, majorly from EU. Between 2017-22, it has imported a little under 100 used BEVs.**

LAC region - Mexico is top importer of ‘used BEVs’ among LAC countries followed by Guyana, Jamaica and Dominican Republic.

Used BEV imports by LMICs in LAC



Key Insights:

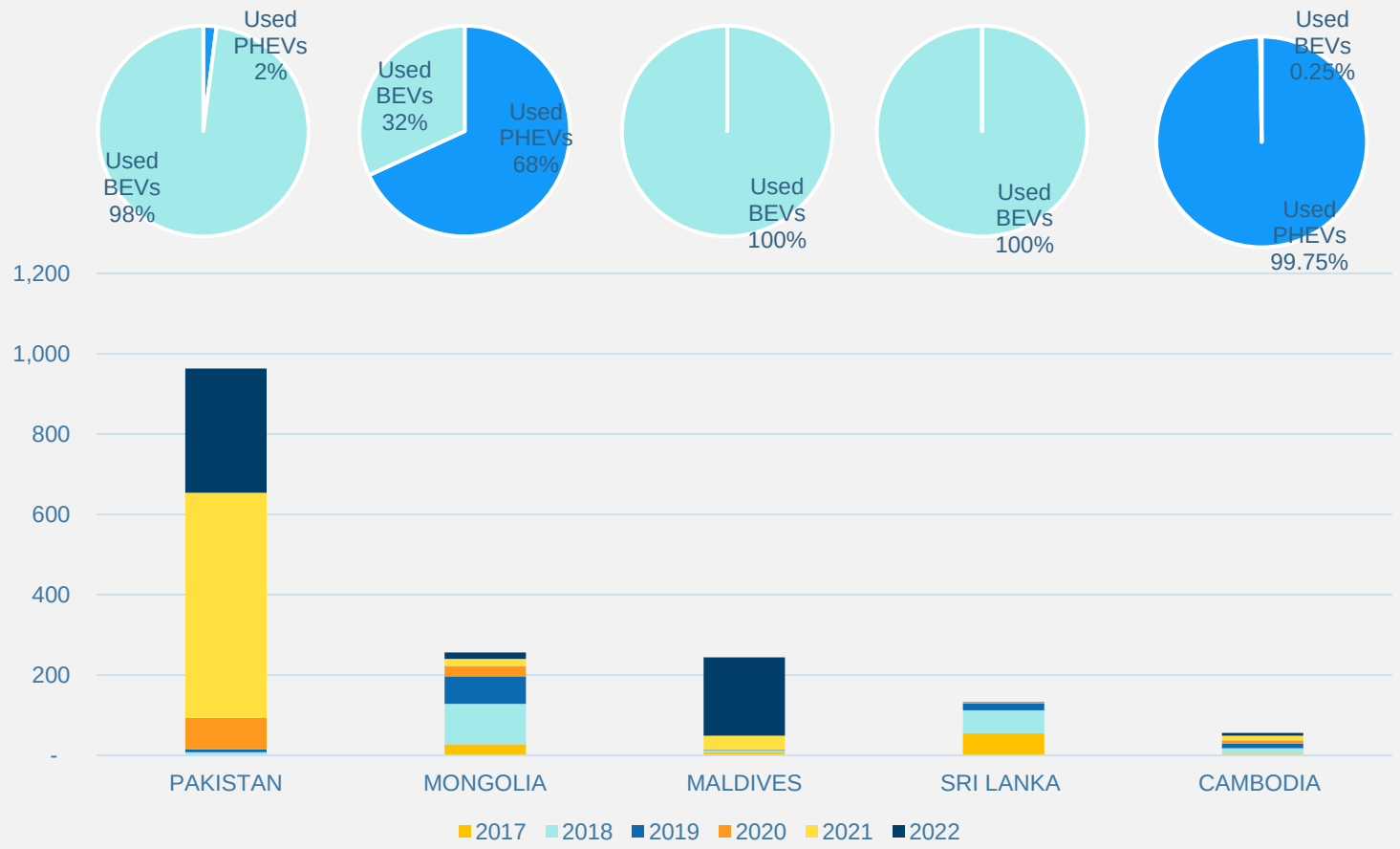
- **Mexico is the highest importer of used BEVs in LAC region**
  - In 2019, it has imported more than 200 used BEVs from EU
  - In Mexico, an import tax exemption for EVs has been temporarily approved until 2024
- **Guyana is second largest importer of used BEVs in LAC region with imports of more than 150 vehicles between 2017-22**
- **Jamaica and Dominican Republic in Caribbean have also imported ‘used BEVs’ within the LAC region**

Source: pManifold Analysis, Multiple sources (UNEP, EU-stat, E-stat, USITA)

Note: In case of Mexico, the analysis based on data from the US International Trade Administration (ITA) often underestimates second-hand vehicle trade flows, as studies like the one by UC Davis show when compared to data from Mexico's National Customs Agency (ANAM) for the same period.

Asia-Pacific region - Pakistan has been largest importer of ‘used BEVs’ in Asia-Pacific region followed by Mongolia, Maldives, Sri Lanka & Cambodia. Majority of these imports in Asia-Pacific are from Japan.

Used BEV imports by LMICs in Asia-Pacific



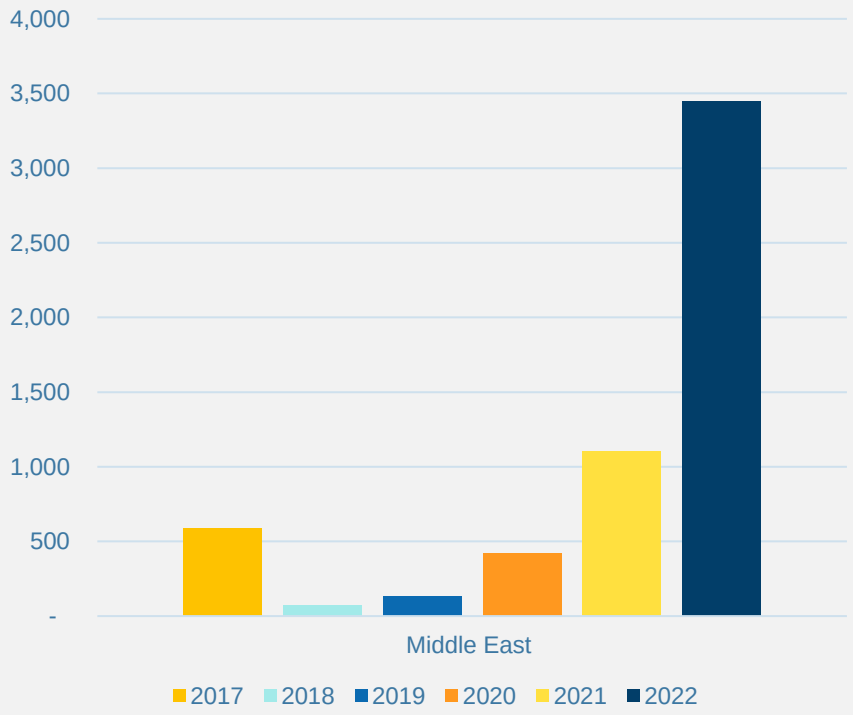
Source: pManifold Analysis, Multiple sources (UNEP, EU-stat, E-stat, USITA)

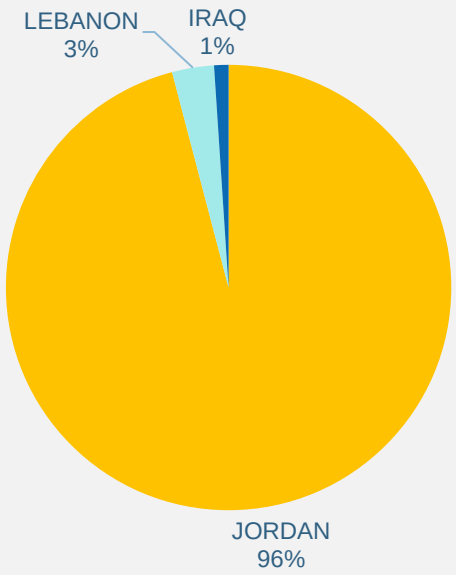
Key Insights:

- **Pakistan as leading importer of used BEVs in Asia-Pacific region** has imported about 560 used BEVs in 2021
  - Pakistan's National Electric Vehicle Policy (2019) allows the import of used EVs up to 3 years old with a reduced 15% customs duty in initial years. This policy led to a rise in imports from 2019 to 2021, followed by a decreasing trend.
- While Mongolia is the second largest importer of used BEVs in Asia-Pacific the imports are on decreasing trend between 2017-22.
- Import of used BEVs in Maldives have grown reaching about 190 in 2022
- Sri Lanka and Cambodia have also imported used BEVs in the last 6 years

Middle East region – The import of used EVs has grown between 2018-22. Among the Middle Eastern countries, Jordan has been the highest importer of used BEVs followed by Lebanon and Iraq.

Used BEV imports by LMICs in Middle East





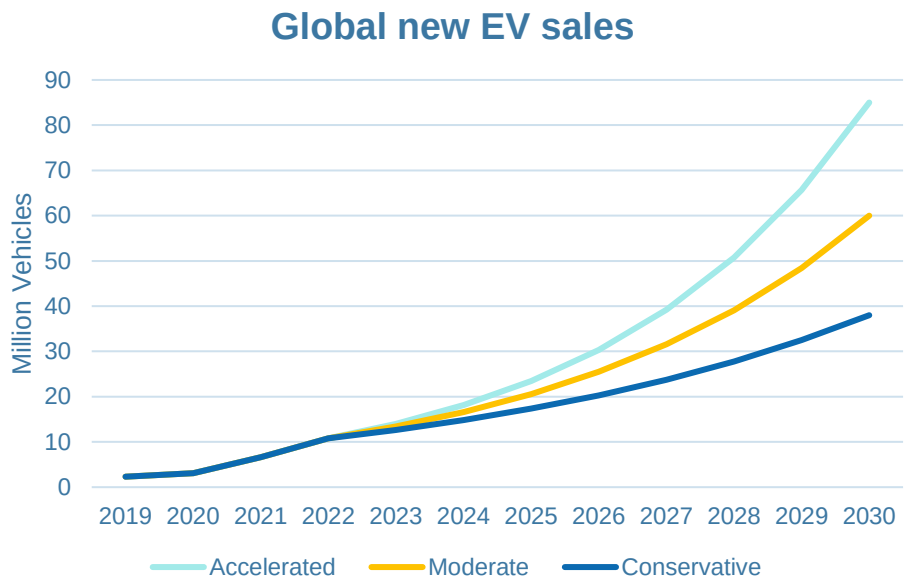
Key Insights:

- **The import of used BEVs is growing in middle eastern countries**
- **Jordan has highest share of used EV imports among the Middle Eastern countries**.
  - **Most electric vehicles in Jordan are second-hand.**
  - In Jordan, import duty on EVs is 10%, a substantial decrease from the previous rate of 25%, which is considerably lower than the import duties for hybrids (55%) and gasoline cars (86%)

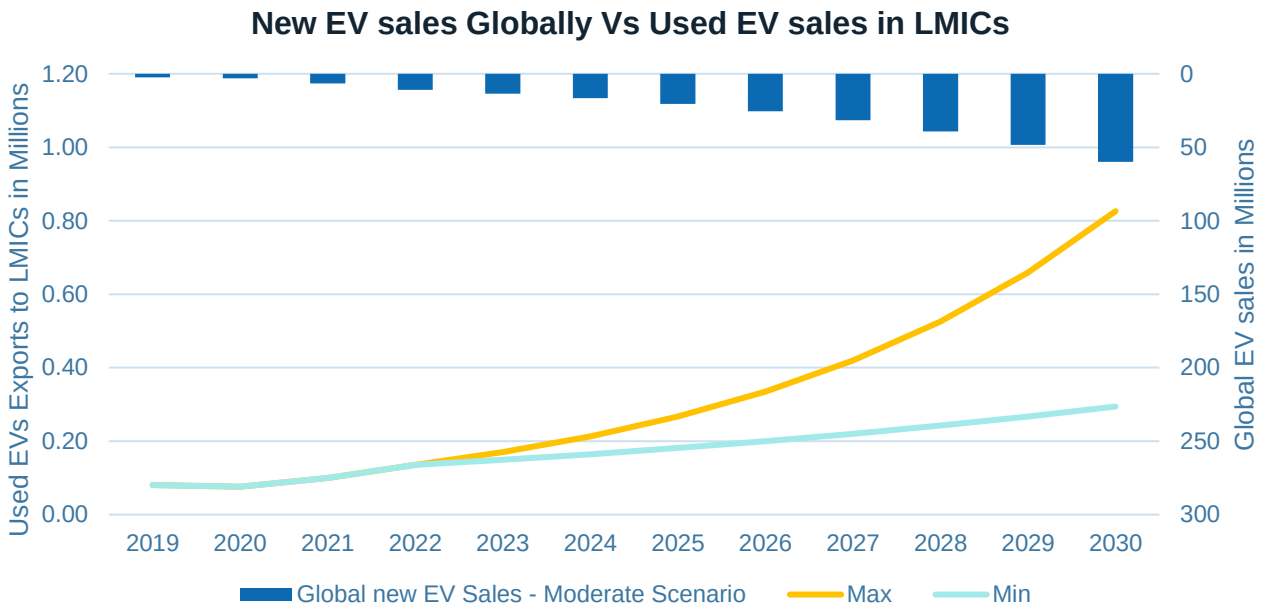
Source: pManifold Analysis, Multiple sources (UNEP, EU-stat, E-stat, USITA)

Outlook for importing used EVs in LMICs

With global new EV sales projected to reach 85 million annually by 2030, the flow of used EVs is set to surge as retirements increase, particularly in LMICs, with imports expected to reach approximately 1.3 million by 2030.



- Between 2019-2023, annual new EV sales have grown by 6 times globally to reach 14.2 million, which is 18% of global passenger car sales.
- Based on the current growth projections of around 40% of sales by 2030 (IEA projected 35%, while BNEF projected 45%), global EV sales is expected to reach 38 million in a Conservative scenario.
- If EV sales growth reaches 62-86% by 2030, EV sales numbers are expected to reach 60 million and 85 million by 2030 respectively in Moderate and Accelerated scenarios (RMI, 2023).



- Considering past growth of used EV sales in LMICs, the sales is expected to reach 0.21 million by 2030 if a similar trend follows.
- However, to provide a more comprehensive outlook, it's essential to recognize that the surge in new EV sales in major exporting countries only commenced in the last 2-3 years.
- Considering more EVs are expected to retire in near future, alternative scenarios have been examined by analyzing the current ratio of used vehicle to new vehicle sales across various vehicle segments.
  - In these scenarios, the projected range for used EV sales in LMICs by 2030 spans between 0.6 million and 1.3 million.

Source: pManifold Analysis, Multiple sources (RMI, IEA, BloombergNEF)

Key challenges in importing used EVs

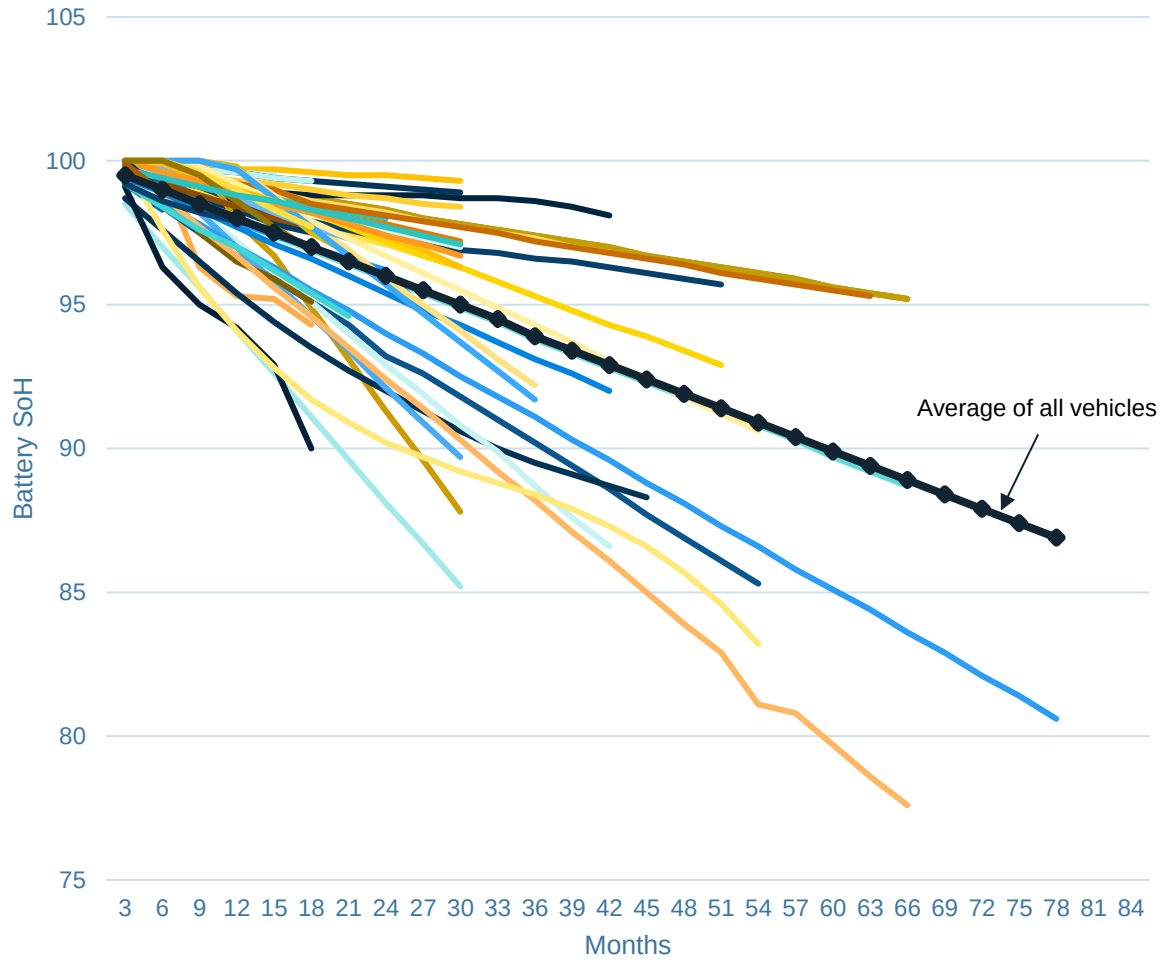
While the surge in global EV sales opens prospects for importing used EVs into LMICs, it's crucial to consider potential challenges. Battery degradation is one of the key challenges that will impact the usability of these vehicles after importation.

Factors affecting battery degradation:

- **Vehicle Model:** Different vehicle models have different battery degradation attributed to battery chemistry and thermal management of the battery pack
- **Climate:** Vehicles driven in hot temperatures may show faster decline in battery State of Health (SoH)
- **Charging type:** The vehicles that are charged through fast DC chargers may show faster decline in battery SoH than those charged on AC. OEMs often suggest lower use of DC fast charging to avoid faster degradation of battery.

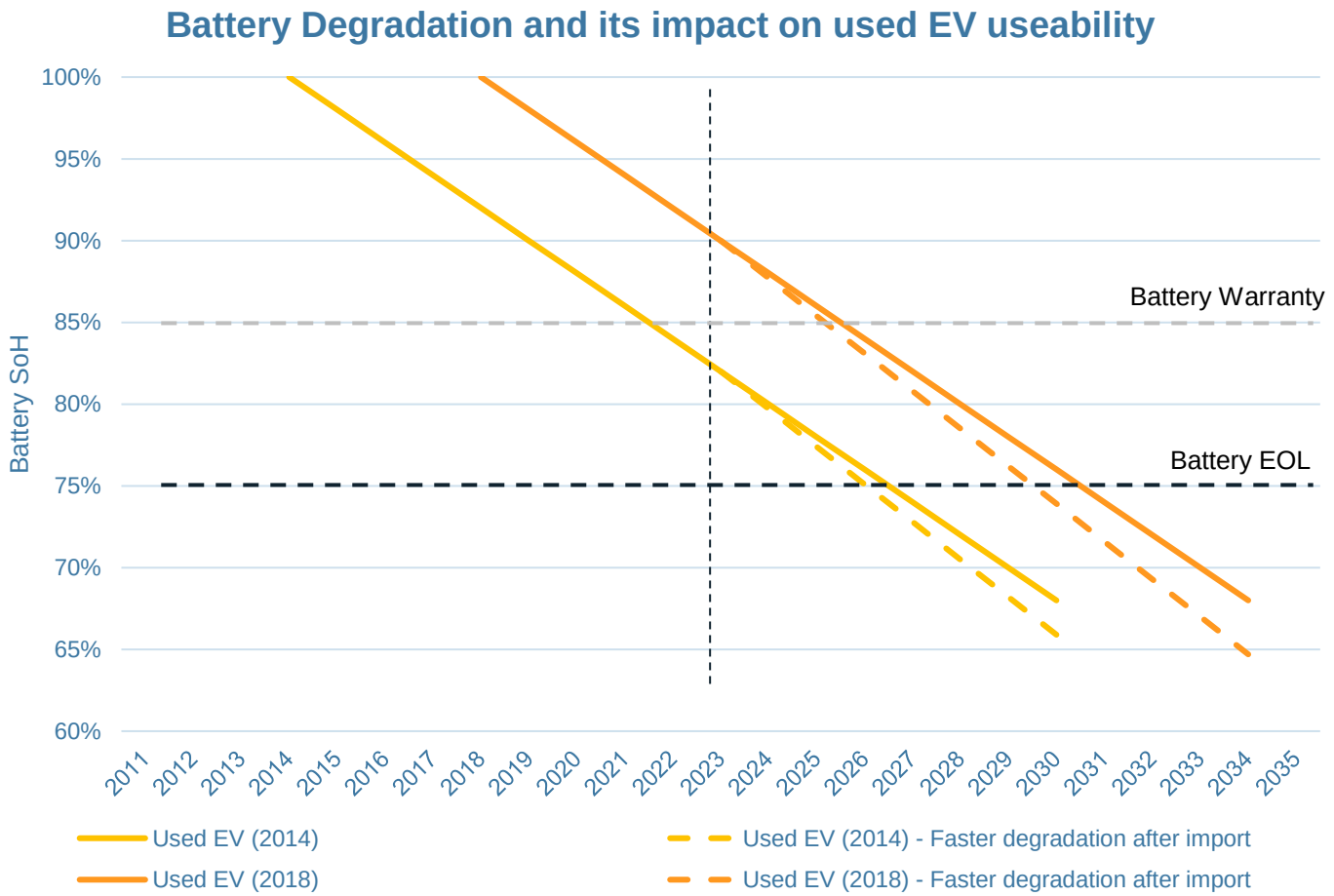
The adjacent chart shows real life degradation observed for various EVs in a study conducted by Geotab analyzing 6,300 fleet and consumer EVs. Average of all vehicles in the study shows an annual degradation of 2% in SoH.

Therefore, after 11 years of use the SoH would be 75%. If an EV is imported used at 90% SoH, the remaining useful life would be around 7 years. After this the battery could be either refurbished or repurposed for a second life application.



Source: EV Battery Degradation Comparison Tool, Geotab

The useability of a used EV hinges on factors such as its age and the SoH of the battery. Therefore, imports of used EVs at different ages will lead to different useable life before the battery reaches its end-of-life. Other factors like climatic conditions of the importing country also have an impact on the overall battery degradation.



- Considering a 2% annual reduction in battery SoH the adjacent graph shows the degradation over the useful life of the vehicle.
- Assuming two different models of the same EV make and model manufactured in different years (2014 & 2018) are imported into LMICs in 2023, the useful life is about 3 years and 7 years respectively after import.
- However, variations in climatic conditions between the origin and importing countries can impact battery degradation. For instance, an EV initially operating in the US and later imported to an African country may experience accelerated degradation due to higher ambient temperatures, surpassing the expected 2% degradation rate (illustrated by dashed lines in the adjacent chart).

Case studies of used EV imports in LMICs

Mauritius is a 4-wheeler LDV dominant vehicle market depending on imports to meet its vehicle demand. The country has witnessed steep growth in the import of used BEVs.

Mauritius

Country Profile:

Mauritius

Population: **1.2 million**
GDP per capita: **$ 10,134**

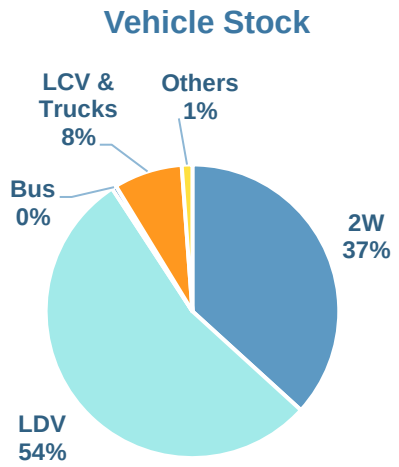
Vehicle stock as of 2022:
0.64 M
(533 vehicles/ thousand people)

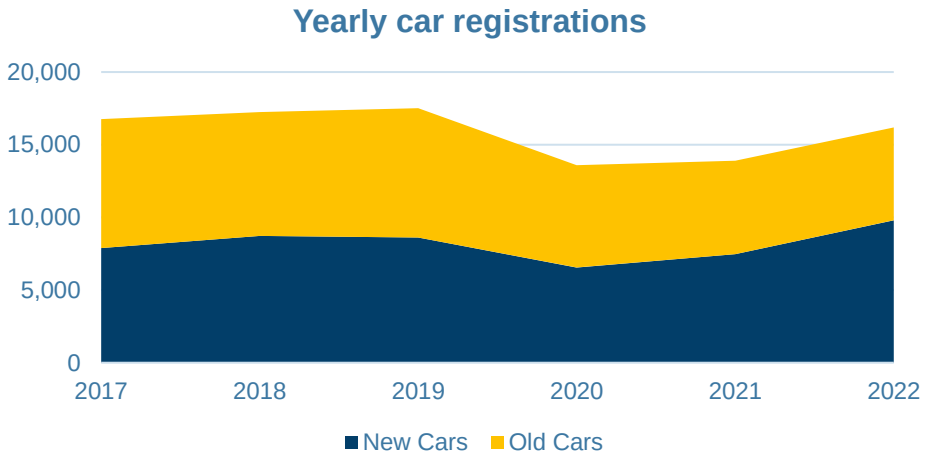
EV stock:
<1,000

No local manufacturing/ assembly

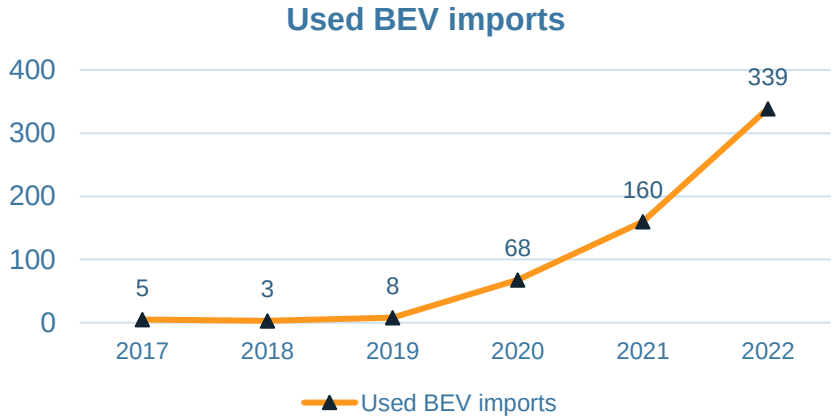
Vehicle and fuel emissions standard:
EURO IV (50 ppm diesel)

Vehicle segments:





- 54% of all vehicle stock is from 4-wheeler LDV segment which includes passenger cars, double cab pickup vehicle and heavy motor cars
- ~50% of yearly car registrations in the country between 2017-22 are imported used cars
- Used EV imports although low in terms of the absolute numbers have grown steeply from ~10 in 2019 to ~350 in 2022
- The growth of import in used EVs can be attributed to the favorable tax structure for EVs in the country

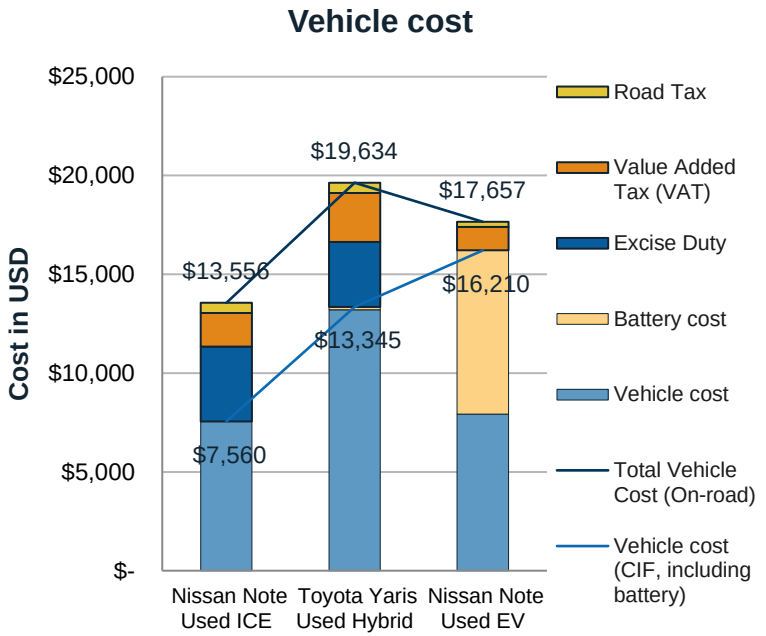


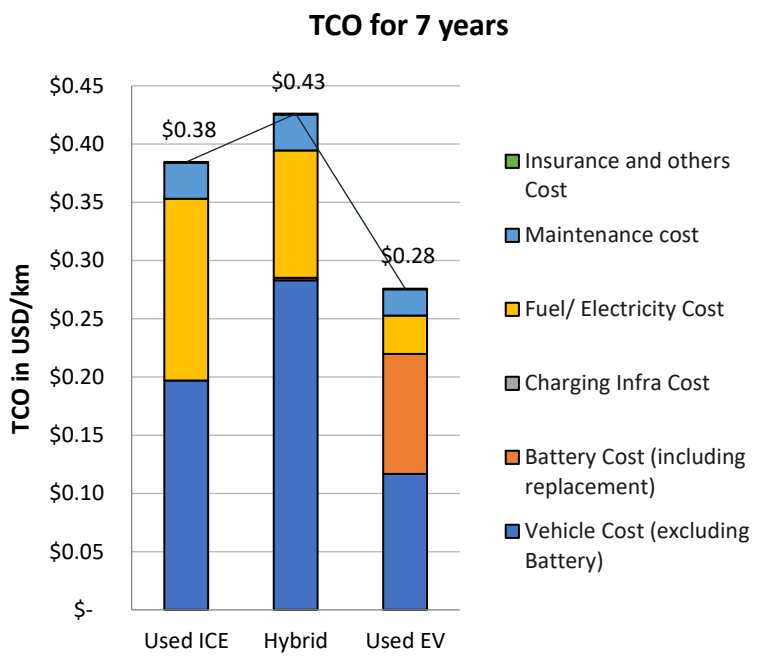
The steep growth in used EV imports in Mauritius is driven by a favourable taxation structure that incentivizes used EVs and import regulations that restrict older vehicles

Mauritius

Economics of imported used EVs

- Mauritius has a favourable taxation structure for used EVs, with **excise duty reduced to 0% and road tax and registration fees cut by half**
- The **Consumer Protection Code of Mauritius restricts the import of older vehicles**, allowing cars that are more than 18 months old but **less than 4 years** old while also mandating **pre-shipment inspection of all imported cars**
  - This is also resulting in **avoiding on the import of very old ICEVs at low cost** into the country helping import of EVs





Type of Tax	ICEVs	EVs (BEVs & PHEVs)
Excise duty	45% for cars up to 1,000 CC 50% for cars between 1,001-1,600 CC 75% for cars between 1,601-2,000 CC 100% for cars above 2,000 CC	0%
Road tax	Varies with cost of the vehicle	50% of that for ICEVs
Registration fee	Varies with cost of the vehicle	50% of that for ICEVs

Key Drivers for growth of used EVs:

- The taxation structure along with restricting very old ICEV imports, makes used EVs competitive with used ICE cars. For instance, although the **CIF cost of a used EV like the Nissan Note is 2.3 times higher than its ICE counterpart, the on-road cost is only 1.3 times higher.**
- **The 7-year TCO for used EV is 28% lower than that of used ICE counterpart**

The 4-wheeler market in Cambodia is relying mainly on imports. While most of the total car registrations are used car imports (~98%), only 30% of BEVs registered between 2017-22 are used imports.

Cambodia

Country Profile:

Cambodia

Population: **17 million**
GDP per capita: **$ 1,765**

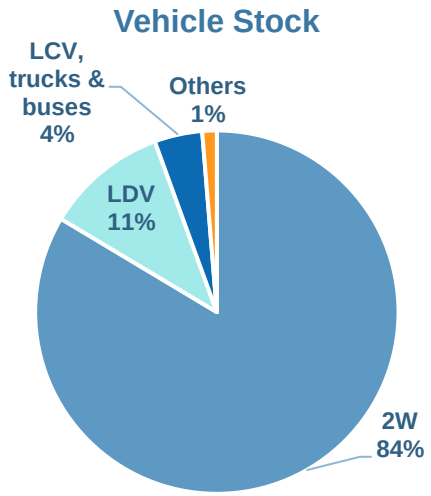
Vehicle stock as of 2022:
6.7 M
(394 vehicles/ thousand people)

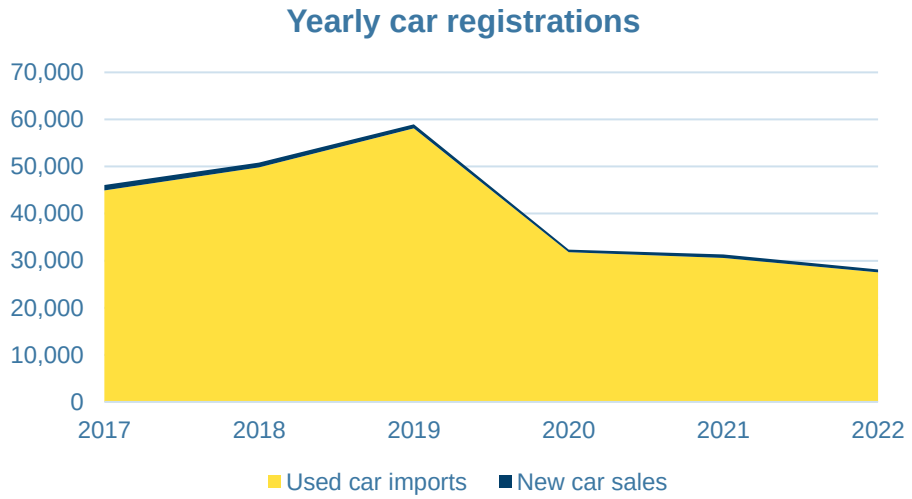
BEV stock: **~ 900**

Local assembly of vehicles (4W) exists. 3 plants are operational and 5 under pipeline

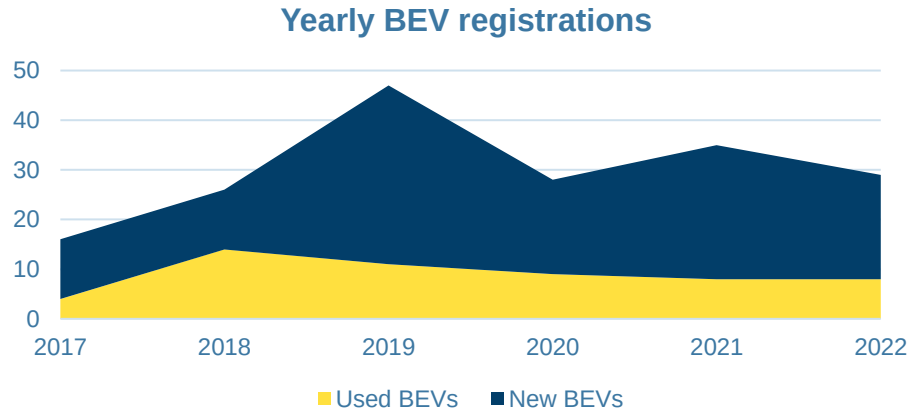
Vehicle and fuel emissions standard:
EURO-IV

Vehicle segments:





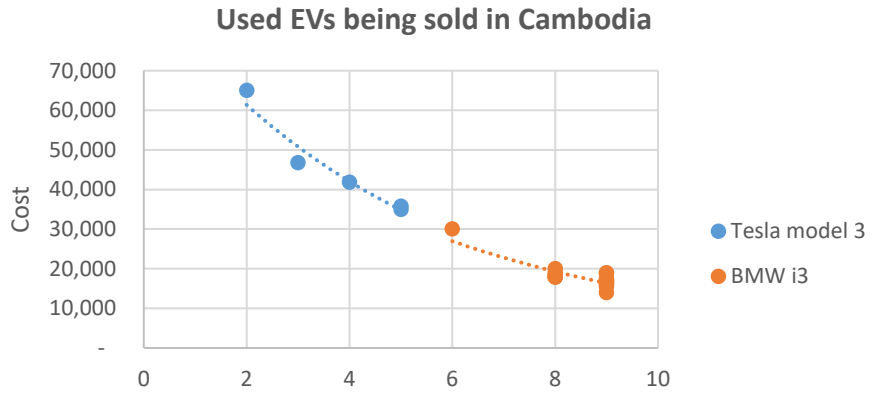
- 11% of all vehicle stock is from 4-wheeler LDV segment
- ~98% of yearly car registrations in the country between 2017-22 are imported used cars
- However, in case of EVs, the used imports are only about 30% of the car registrations



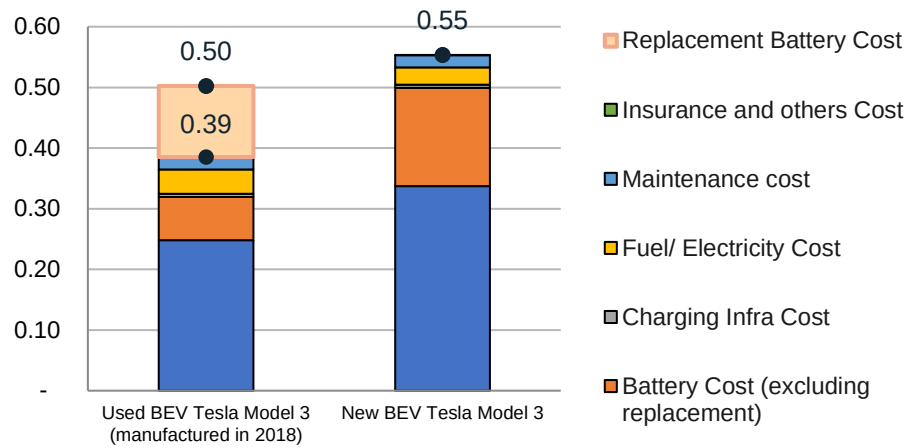
Improving the standards for used EV imports by imposing restrictions on the age of the vehicles and ensuring optimal battery health can significantly boost customer confidence and accelerate EV adoption in the country

Cambodia

Economics for used BEVs



Source: https://www.mykhmercar.com/en



Key assumptions:

Vehicle life: 15 years

Battery life: 12 years

Battery salvage value at EoL: $45/kWh

- **Used BEVs of various ages are currently being sold in the country, given no restrictions in the country**. For example, luxury car brand such as Tesla model 3 used EVs of age of 2-5 years and BMW i3's of age between 6-9 years are available in the country.
- With an annual battery degradation of 2% SoH, the Tesla Model 3 of 5 years age can run for 7 years in country before a battery replacement is required. Similarly, the BMW i3 of age 9 years can run for 3 years in the country before a battery replacement is required.
- The battery replacement in an import dependent country like Cambodia poses a significant challenge of sourcing batteries. The **current import duty of 35% on batteries has significant impact on battery cost**. Additionally, studies also suggest that the sourcing of **replacement batteries in small quantities can cost upwards of $400/ kWh** (CES Global).

Key Learnings:

- TCO calculations indicate that the cost of a 5-year-old Tesla model 3, can be as high as that of a new BEV due to limited availability of replacement batteries.
- Regulations should be implemented to restrict the import of old BEVs with low remaining battery life to protect consumer interests.
- Skills need to be developed to repair used EVs in Cambodia.

Mongolia is a 4-wheeler LDV dominant vehicle market depending on imports to meet its vehicle demand. The country imports highest no. of used hybrid vehicles globally.

Mongolia

Country Profile:

Mongolia

Population: **3.4 million**
GDP per capita: **$ 4,953**

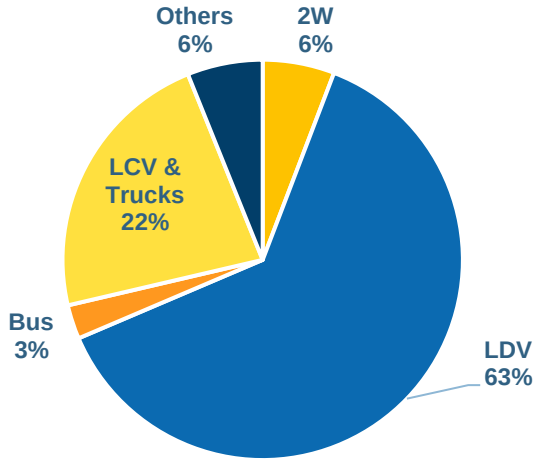
Vehicle stock as of 2022:
1.2 M
(353 vehicles/ thousand people)

EV stock:
<1,000

No local manufacturing/ assembly

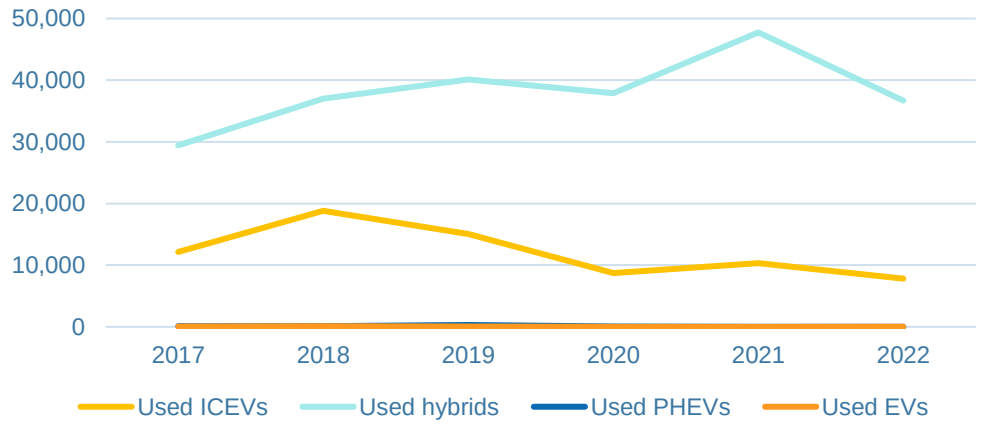
Vehicle and fuel emissions standard:
EURO-II

Vehicle segments:



- 63% of all vehicle stock is from 4-wheeler LDV segment
- Almost **two-thirds (~62%) of car registrations** in Mongolia are in Ulaanbaatar, where motorization rates are almost double that of outside of the capital
- Annual car registration growth – around **40,000 per year**.
  - **Hybrid vehicles** form nearly **50%of new registrations**, followed by ~24% each of petrol and diesel vehicles

Used vehicle imports:

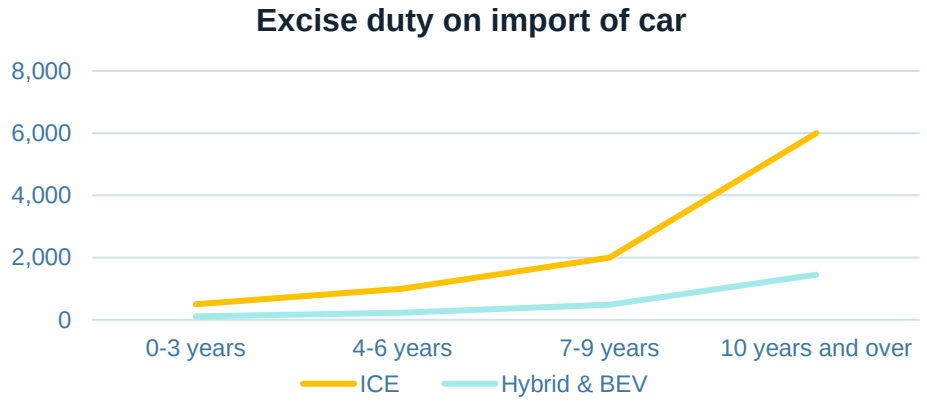


- **Highest importer of 'used hybrids' globally**
- Mongolia is notable for a **very old vehicle fleet, with 81% of vehicles aged 10 years or older and 12% aged 7-9 years in 2023**
- Currently, the **import of used EVs** is very low at **<10 per year**

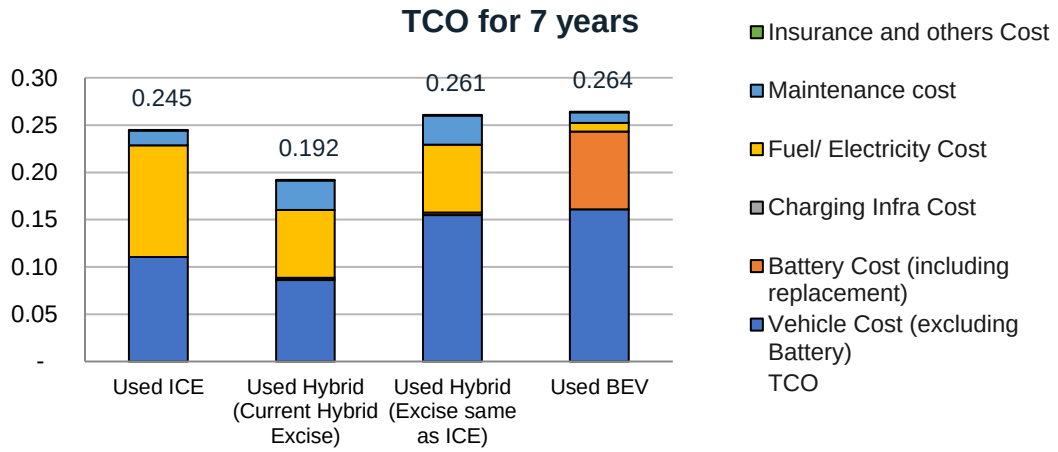
Reduced excise duties have made hybrid vehicles a cost-effective option for passenger cars in Mongolia. However, this is leading to very old hybrid vehicles being imported and soon to be accumulation of EOL batteries, while also restricting the penetration of used EVs.

Mongolia

Economics for personal 4W cars



* For cars with engine capacity <1,500 cm^3



- **The current excise duty applied on import of used hybrids and BEVs are similar.**
- This current scenario may be leading to **unfair advantage for used hybrids especially those with age >10 years and short vehicle lifetimes** as cold temperatures in Mongolian winters make them far less efficient. (UC Davis)

Key Learnings:

- The TCO analysis indicates that **revising excise duties for hybrids to align with those of ICE vehicles could make used BEVs more attractive**.
- Treating hybrid and EVs separately by giving EVs higher incentives is important to not give a cost advantage for fossil fuel powered vehicles and slow down EV adoption.

Kenya is one of leaders in the importation of used BEVs in Africa due to favourable tax incentives for EVs in the country.

Kenya

Country Profile:

Kenya

Population: 53 million
GDP per capita: **$ 2,082**

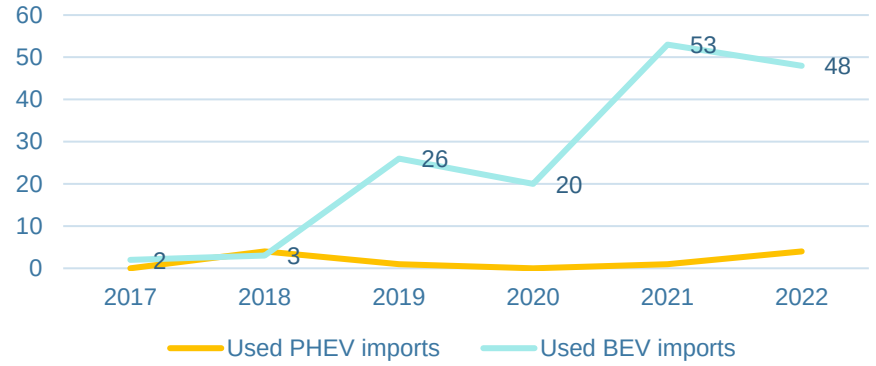
Vehicle stock as of 2021:
4 M

EV stock:
>3,000

Assembly, retail and distribution of motor vehicles

Vehicle and fuel emissions standard:
EURO IV

Used car imports:



- **Kenya ranks as the second highest importer of used EVs in Africa**
- **While the current import numbers remain relatively low, there has been a significant upward trend in recent years**
- The Kenyan government initiatives in classifying EVS, lower import duties and standards for import of used EVs has driven the growth of e-mobility

E-Mobility growth in Kenya

Kenya has about 153 e-3Ws, 844 e-motorcycles and 186 e-Cars registered in the country. The National Energy Efficiency and Conservation Strategy (2020) envisions that 5 per cent of all registered vehicles in Kenya will be electric powered by 2030.

- The Finance Bill of 2023 has proposed a zero VAT on EVs and its components including batteries. The bill also extended the exemption from excise duty on the supply of electric motorcycles. However the Bill has since been revoked and the Finance Bill of 2024 withdrawn due to political unrest meaning that the rate of EV adoption might de slowing down.
- Kenya introduced a special tariff for electric car charging stations of Sh17 per kWh for consumption between 200 and 15,000 kWh, which lower than the usual Sh21.68 per unit.

To ensure sustainable used EV imports, Kenya has introduced new import standards. These regulations ban the import of BEVs with a battery SoH below 80% and BEVs older than 8 years.

Kenya

Standards for used BEV imports

The Kenya Bureau of Standards (KEBS) has issued a **new directive to ensure the quality of imported EVs** in Kenya

- The directive **bans the importation of used electric vehicles with a battery life below 80%**
- This directive also reinforces a previous **restriction on the import of vehicles older than 8 years.**
- Additionally, all used electric vehicles from major exporting countries, including Japan, UAE, Thailand, Singapore, South Africa, and the UK, must undergo **mandatory pre-inspection by QISJ**.
- However, KEBS currently doesn't have the capabilities to test battery life at entry into the country.

Electric Vehicle Classification in Kenya

Vehicle classification and registration are essential for collecting accurate transport data, aiding in transport planning, intelligent transportation systems, and policy formulation. This clarity on registered vehicle types facilitates strategic decisions to promote the adoption of certain vehicle types while reducing the use of others.

Important parameters to include in the vehicle classification system as identified by Kenyan Ministry of Transport, Infrastructure, Housing, Urban Development and Public Works are:

1. Electric motor power rating
2. Seating Capacity
3. Size of battery
4. Battery identifier
5. Power source

Key Learnings:

- Kenya by revising its classification and registration scheme for vehicles has improved clarity of information on the types of vehicles registered in the country which is relevant for transport planning, intelligent transportation systems and in facilitating policy formulation and impact monitoring.
- The standards for importing used EVs, which prohibit the import of vehicles with a battery SoH below 80%, will ensure that only BEVs with better useful range are imported. This measure could also mitigate the risk of end-of-life batteries being disguised as exportable EVs.
- However, a long term EV policy is needed to avoid short term incentive changes that hinder investments in the EV sector.

Since July 2021, Ukraine's EV fleet has more than doubled, surpassing 64,000 vehicles. This surge is mainly fuelled by the import of used EVs into the country.

Ukraine

Country Profile:

Ukraine

Population: 43.8 million
GDP per capita: **$ 4,000**

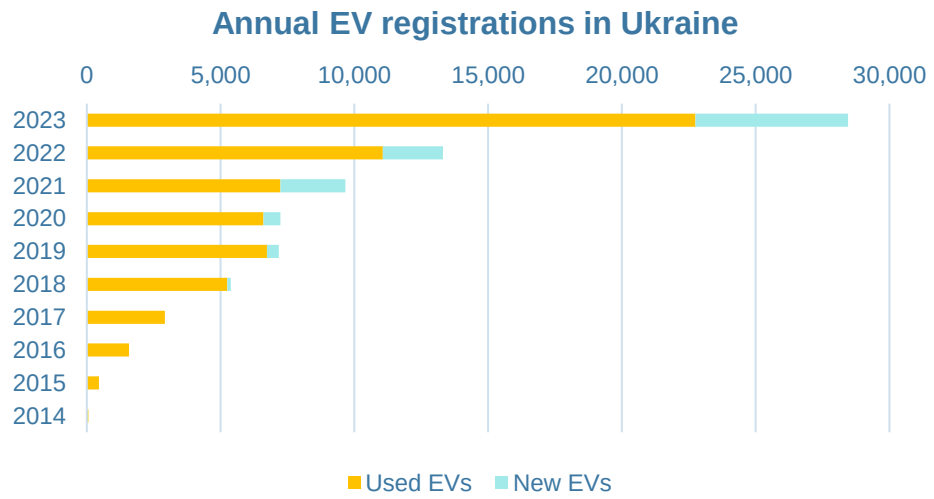
Vehicle sales in 2022:
0.1 M

EV stock:
>64,000

70% of vehicles being imported, with rest being assembled in the country

Vehicle and fuel emissions standard:
EURO-5

Used EV imports:



- Ukraine seized an opportunity with second-hand electric cars by **eliminating customs duty in 2016 and VAT in 2018**, making used EVs a cost-effective option
- Most **used EVs in Ukraine originate from North America**, often arriving with significant damage
- Additionally, **Ukraine boasts a public charging network of over 11,000 chargers**, more than neighbouring Poland's infrastructure.

* The used EV imports include those that are coming from other than USA, EU, Japan and South Korea

Source: Automotive Market Research Institute, Ukraine

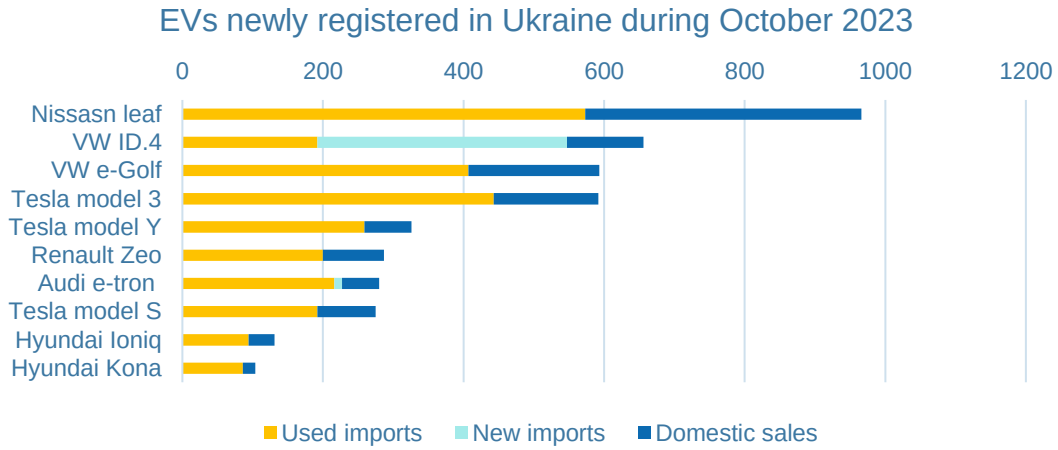
Type of Tax	ICEVs	EVs (BEVs & PHEVs)
Excise duty	213 euros for petrol 140 euros for diesel	1 euro per 1 kWh
Customs duty	10%	0%
VAT	20%	0%

The surge in imported used EVs in Ukraine is driven by the growing availability of crashed EVs from North America. Ukraine's skilled technicians are capitalizing on this opportunity, leading to an expansion in the EV fleet size.

Ukraine

Refurbishing of used EV cars

- Tesla and Chevrolet do not sell cars in Ukraine, but people import them due to the presence of specialized EV workshops. **Ukraine has skilled EV technicians who keep imported electric cars running, including repairing battery packs.**
- These skilled EV technicians are able to source the totaled EVs from North America and refurbish them to make them roadworthy for running in Ukraine by making necessary repairs, cleaning and painting.
- The availability of totaled North American EVs is increasing due to the increased shift from ICE to EV. Additionally due to **unavailability of third-party access to battery cell data, cars with scratched battery packs, which likely have undamaged cells, are written off by insurers and subsequently exported.**



Source: Automotive Market Research Institute, Ukraine

Key Drivers for used EV growth in Ukraine:

- Skilled technicians in Ukraine have capitalized on the affordability of salvaged EVs and their expertise in refurbishing*, leading to significant local value creation in the sector. This has boosted the adoption of EVs in Ukraine.
- Nevertheless, unregulated imports of vehicles with hazardous batteries pose safety risks for technicians and end-users alike. Therefore, implementing robust regulation and inspection protocols for refurbished EVs is crucial to ensure their roadworthiness and enhance overall safety standards.

* Refurbishing is to make the totaled cars roadworthy for running by making necessary repairs, cleaning and painting

Measures to improve the quality of used EVs

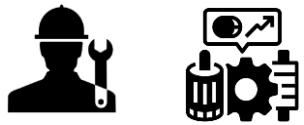
Barriers across the value chain impeding growth of used EV

Import

Gaps in quality check of used EVs getting imported due to lack of pre-shipment inspection in origin country

- **Battery Health Assessment**: A lack of access to information on battery SOH make assuring sufficient remaining life at the time of exportation nearly impossible.
- **Lack of Pre-Shipment Inspection of used EVs:** Many LMICs currently lack established pre-shipment inspection requirements (min SoH and max age) specifically tailored for EVs.
- **High risk of stranded EoL batteries** not being allowed to be shipped
- **Reluctance of shipping agencies to transport used EVs due to liability issues**

Refurbishment



Gaps in resources for refurbishing and maintenance of vehicles and batteries

- **Repairability of EVs:** EVs face repairability issues as manufacturers claim intellectual property rights over their software, preventing unauthorized repairs.
- **Skilled workforce**: The problems of repairability may be magnified in LMICs, where a manufacturer may have not authorized technicians and work is often done in the informal sector.
- **Battery and Spare Parts Availability:** Due to the underdeveloped nature of the automotive industry in many LMICs, securing an adequate inventory of batteries and spare parts for post-sales services poses a challenge.

Registration

Gaps in existing rules for classification of vehicles

- Used EVs may not currently be included in the existing vehicle **registration guidelines.**
- Revenue Authority officers are not trained and aware of EV classification and EV battery life assessment.
- **Inconsistencies in the vehicle classification rules** of exporting country and importing country may result in challenges for registration.
- **Taxation based on vehicle price** leads to increased purchase and insurance cost putting EVs at a disadvantage, due to lack of data on used EV prices and remaining useful life.

Usage, Maintenance and Servicing

Gaps in assessment of useability of the vehicles after registration

- **Charging and Energy infrastructure**: The lack of widespread charging infrastructure and reliable power are a significant barrier, especially for used EV adoption due to lower ranges.
- **Importance of Regular roadworthiness Inspections**: Periodic assessments to analyze vehicle conditions including battery degradation and increase in internal battery resistance are needed, as increased resistance can lead to battery overheating and potential explosions.
- **Reskilling of vehicle maintenance technicians to be able to service EVs in a safe manner**

Disposal

Gaps in legislation for EOL battery management

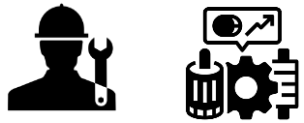
- **Lack of robust testing technologies** for assessing the cells and modules of batteries for reuse.
- **Battery recycling ecosystem** facing problems of scale for profitability, high shipping cost of batteries and gaps in regulations for EoL management of batteries
- **Exporting country restrictions**: Additionally, some exporting countries and OEMs have imposed restrictions to prevent used EVs from entering countries until safe handling and disposal of batteries is established.

Recommendations to facilitate the import of used EVs

Import

- Development of EV regulations:
  - Enhancement of **national inspection protocols for used EVs, including minimum battery SoH and maximum vehicle age restrictions** for import
  - Formulation of/ or inclusion in international legislations like Basel, Bamako, and ELV directives for used EV handling
- **Adoption of common standard for vehicle and battery monitoring**:
  - On-Board Diagnostics (OBD) for EVs can improve battery health assessment
  - Minimum safety parameters should be displayed through infotainment for third-party inspection access
  - Adoption of Battery Passports

Refurbishment



- **Certification of refurbishing players in the importing countries by OEMs**
  - To ensure service quality through staff training and Standard Operating procedure (SOP) standardization
- **Information pertaining to vehicle service and repair shall be accessible to independent repairers**
- **Promoting the training of individuals to become proficient EV technicians**. These courses shall encompass essential skills for conducting routine repairs, servicing and maintenance of EVs.

Registration

- National transport authorities in LMICs are recommended to **design a comprehensive registration template for EVs, based on the systems employed by countries with substantial EV adoption rates**.
- Favorable taxes and levies for used EVs to **incentivize used EV adoption including reduction in registration charges and road tax**

Usage, Maintenance and Servicing

- **Periodic inspections to be mandated for used EVs** under minimum requirement concerning roadworthiness tests. This shall include:
  - Frequency of testing: One year after the first entry into service of the first registration and annually thereafter
  - Contents and methods of testing EVs: **in addition to the conventional roadworthiness tests, tests shall cover high-voltage electrical systems, including the charging inlet, cables, and traction batteries for any signs of damage**

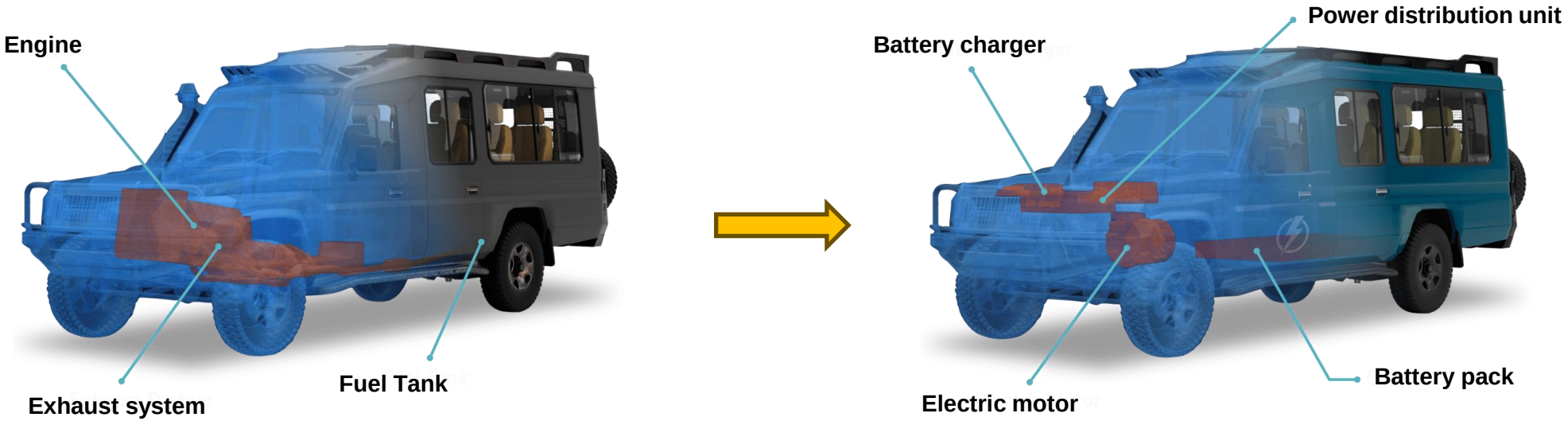
Disposal

- EOL management strategies for both exporting and importing countries
  - LMICs **need to develop schemes for EoL battery management** promoting innovation in battery testing and, reuse of battery in secondary applications
  - LMICs **collaborating with exporting countries can support battery recycling programs, ensuring the return and reuse of critical minerals.** This secures the EV battery supply chain and offers economic and environmental benefits to importing countries.

4

Retrofit of ICEVs to EVs in LMICs

- ICE to EV retrofitting and its opportunity
- Case studies of ICE to EV retrofit solutions – Technology, Business Models and Regulations
- Challenges and Solution for adoption of retrofit EVs in LMICs



***Credits**: E-motion*

ICEV to EV retrofitting – opportunities and challenges

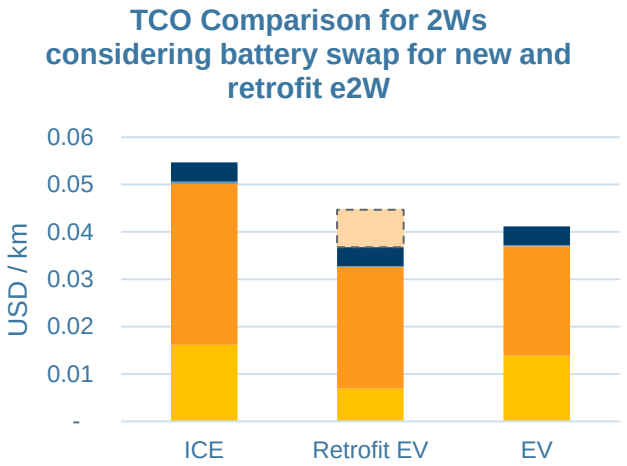
What is ICEV to EV retrofitting?

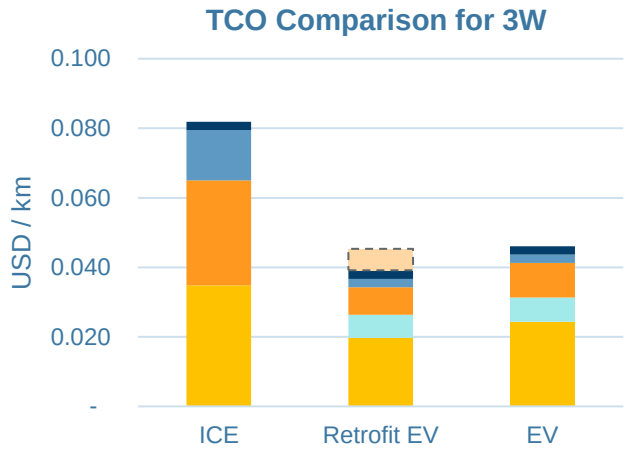
ICEV to EV retrofitting, which involves replacing the ICE powertrain of an old vehicle with an EV powertrain, **can supplement the import of used EVs to enhance affordable e-mobility adoption**, particularly for vehicle segments other than four-wheelers as they are typically not imported used.

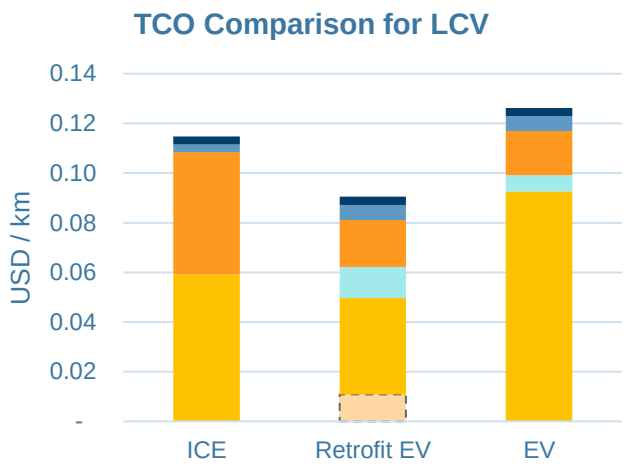
While **retrofitting can extend the life of a vehicle, resulting in lower emissions from manufacturing of new vehicles, and provide customization to meet end-user needs, it lacks the established performance, reliability, and warranty assurances of used EVs**, which have the same standards as new EVs. Therefore, retrofitting will **require new standards for regulatory compliance** to protect end-user interests and ensure safety.

Parameter	Used EV	Retrofit ICE to EV
Age of Vehicle and Powertrain	Old vehicle with old powertrain whose age is determined by market availability, purchasing power and condition	Typically, an older vehicle with a new powertrain
Battery Health	Depends on usage and age; can be verified	New battery installed during retrofit
Customization	Limited to manufacturer options	Retrofit can be tailored to specific needs
Performance	Established and tested by manufacturer	Depends on quality of retrofit components
Reliability	Proven track record from original manufacturer	Dependent on retrofit quality and components used
Warranty	May come with remaining manufacturer warranty	Retrofit components may have separate or no warranties
Regulatory Compliance	Generally compliant with EV standards	Needs to be homologated to meet standards

Economic analysis shows retrofitting ICE to EV in 2W and 3W segments can be cost-effective compared to new EVs for 3-5 year old used vehicles, if donor vehicle costs are excluded. For LCVs, retrofitting can be economically viable even when donor vehicle costs are included, due to the high cost of new EVs and faster ICEV depreciation.







Vehicle Cost (excluding Battery) | Battery Cost | Fuel/ Charging Cost | Maintenance cost | Insurance and others Cost | Donor Vehicle Cost

1. TCO calculated for 5 years considering the loan tenure
2. For new electric 3Ws and LCVs in the Indian context, a battery subsidy of $120/kWh is considered, capped at $600 for 3Ws and $1,800 for LCVs

Retrofit of 2Ws:

- Retrofit of 2Ws is being carried out in Africa with a battery swap model for an old 2W owned by the end users.
- With the battery swap model, retrofitting e-2W costs around $ 800 without including cost of donor ICE 2W, compared to $1,600 for a new electric 2W, both without battery.
- In this case, TCO of a retrofitted e-2W is ~30% lower than that of an ICE moto and ~7% lower than that of a new e2W.
- If the retrofit were also to consider the donor vehicle cost (3-year old), the TCO for a retrofit e-2W comes out to be ~9% higher than that of a new e-2W but still ~18% lower than that of an ICE 2W.

Retrofit of 3Ws:

- Retrofit of 3Ws is being carried out in India.
- The TCO of a retrofitted e-3W is ~52% lower than that of an ICE-3W without considering the donor vehicle cost and ~15% lower than that of a new e-3W.
- If the donor vehicle cost (5-year old) is also to consider, the TCO for a retrofit e-3W comes out to be ~2% lower than that of a new 3W and still ~45% lower than that of an ICE 3W.

Retrofit of LCVs:

- Retrofit of LCVs is being carried out in India.
- Currently, an electric LCV costs almost twice as much as the diesel variant.
- Retrofitting the LCV segment appears to be a promising solution, as the TCO for a retrofitted LCV including donor vehicle cost (@20% salvage value with 5-7 years age) is 21% lower compared to the ICE version and 28% lower compared to the new EV version.

The economics suggest retrofits can provide a good transition solution especially in the livelihood taxi segments (2W, 3W and 4W CVs) - however challenges such as unclear policies, warranty, consumer acceptance issues, and limited regulatory support hinder the widespread adoption of retrofitting

Key challenges:

- A lack of visibility and knowledge of retrofitting solutions among possible customers and policymakers alike hinders the inclusion of such solutions in transport electrification strategies.
- With retrofit of older ICEVs to EVs, the converted vehicle may void the manufacturer's warranty. The retrofit EVs may also result in confusion on who is liable for repairs and aftersales services which can lead to lower customer confidence on the retrofit solution.
- Insuring retrofitted vehicles is challenging because traditional insurance principles like the law of large numbers do not apply easily. This issue is further complicated by the lack of comprehensive information on the various components of these vehicles.
- Limited regulatory support in terms of defining safety and homologation standards is resulting in slower uptake of ICE to EV retrofit.

***Credits**: EVreporter*

Case studies of ICEV to EV retrofit solutions across vehicle segments and regions

Rwanda Electric Motors (REM) retrofitted ~100 used fossil fuel-driven taxi motorcycles in Kigali, resulting in a 7% better TCO compared to new electric motorcycles due to reduced upfront cost for motorcycle riders

- Rwanda's geography is dominantly hilly with an average elevation of 1,598 meters. Only 1,000 km out of the 12,000 km roads are paved. The remainder are dirt roads with smooth to hard surfaces with extremely uneven tracks.
- As a low-income nation with a GDP per capita of ~USD 1,000, affordability and cost-effectiveness are important factors for the transport users and providers alike.
- Rwanda is an ICE motorcycle dominant market. Over 65% of Rwanda's vehicle stock consists of motorcycles, primarily used as taxis, forming the core of the transport system.
- There are ~100k motos in Rwanda. Out of these, ~50k are registered as moto-taxis. Most of the remaining 50k motos are also being used as unregistered moto-taxis.
- At present, ~2,800 e-motos are operational, with the majority equipped with swap batteries. Out of these, ~100 are retrofit e-motos.

Retrofit solution:

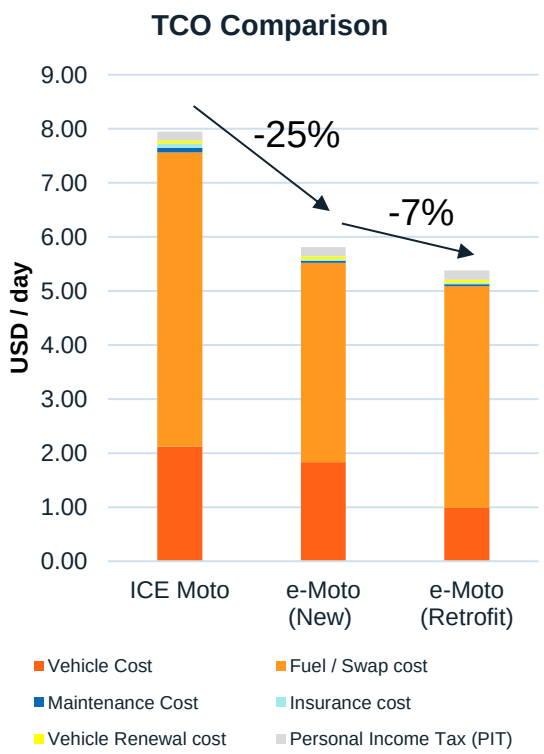
Company: Rwanda Electric Mobility (REM) Ltd.

Country of operation: Rwanda

Services & Products: BaaS, Retrofit Service and New e-Motos

- Retrofitted ~100 motos for moto-taxi riders (motari) in Rwanda
- Only retrofit vehicles that are out of warranty i.e. older than 3 years

***Credits**: Rwanda Electric Motors*



Economics:

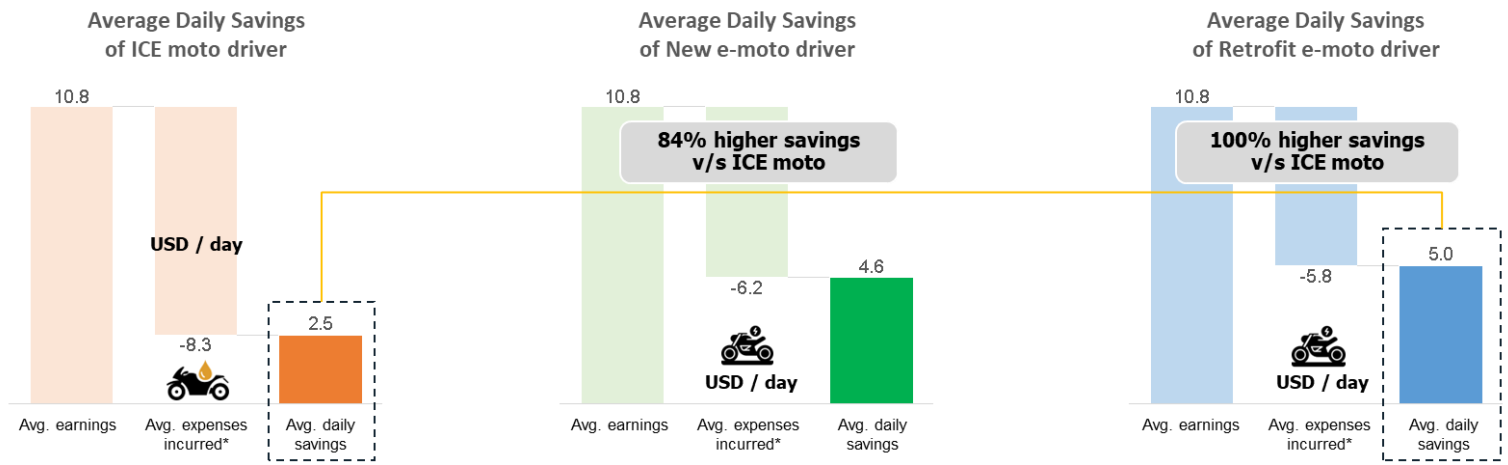
- Retrofit e-moto costs around $ 800 compared to $1,600 for a new e-moto, both without battery. The battery swap model improves the affordability of retrofit and new e-motos as the battery CapEx is not passed on to the user. The Battery as a Service (BaaS) model, makes the battery part of the OpEx to the end user.
- On average the ICE moto and e-moto travel a distance of 160 km daily
- The TCO of a retrofitted e-moto is ~30% lower than that of an ICE moto and ~7% lower than that of a new e-moto
- It is expected that retrofitted e-motos will have lower vehicle efficiency (10-15%) due to the lack of optimization in the powertrain. Hence, higher operational costs compared to the new e-moto could occur.

Note: The retrofit vehicle TCO does not account for donor vehicle cost as the vehicle is pre-owned by the motari and they only need to pay the retrofitting cost to REM.

- If the retrofit vehicle were also to consider the donor vehicle cost (3-year-old), the TCO for a retrofit e-moto comes out to be ~9% higher than that of a new e-moto and still ~18% lower than that of an ICE moto

A Moto driver can save annually ~$1,650 on a retrofitted vehicle making the payback period about 6 months (price - $800). Compared to ICE motos, a moto driver can save ~$850 extra annually on a retrofitted vehicle.

Daily Savings for end-user with Retrofit Vehicle:



**Expenses incurred include capital and operational expenses rationalized on a daily basis*

- The average daily earnings of a REM moto driver is ~$10.8. The moto driver driving ICE moto can save ~$2.5 after deducting all expenses. This includes a CapEx finance cost of $2.1 per day (interest rate @ 36% p.a.)
- By switching to retrofit e-motos, the same moto driver can reduce its expenses by ~30%. This leads to an increase in daily earnings by 100%.
- Retrofit e-motos are a more affordable option delivering annual operational savings of ~$1,650 (i.e. $850 more than the ICE moto driver). The payback period is about 6 months due to lower upfront cost

Key Learnings:

- Government policy is acting as the biggest growth driver for the Rwanda EV market. The government has taken proactive measures to support the e-motos market in the country by providing several tax exemptions (import, VAT, and excise duty), tax holidays, rent-free government land for charging, and more.
  - This is driving innovations to retrofit ICE vehicles and business models to improve customer affordability through battery swaps.
- REM is the only company in Rwanda focusing on retrofit, thus also allowing them to capture the market through retrofit services

Challenges:

- Lack of standards and regulations for retrofitting of old ICEVs.
- The company is highly dependent on a single country for the supply of retrofit kit components, making it vulnerable to supply chain disruptions. The lead time for these components is typically 4-6 months.

Three-wheelers are an important mode of transportation in India and this segment has already seen a consolidation of prices, bringing the cost of ICE vehicles and EVs closer. This makes retrofitting an even more cost-effective option for this vehicle segment. The TCO for a retrofit vehicle is 58% lower than that of an ICE vehicle and ~19% lower than the new EV.

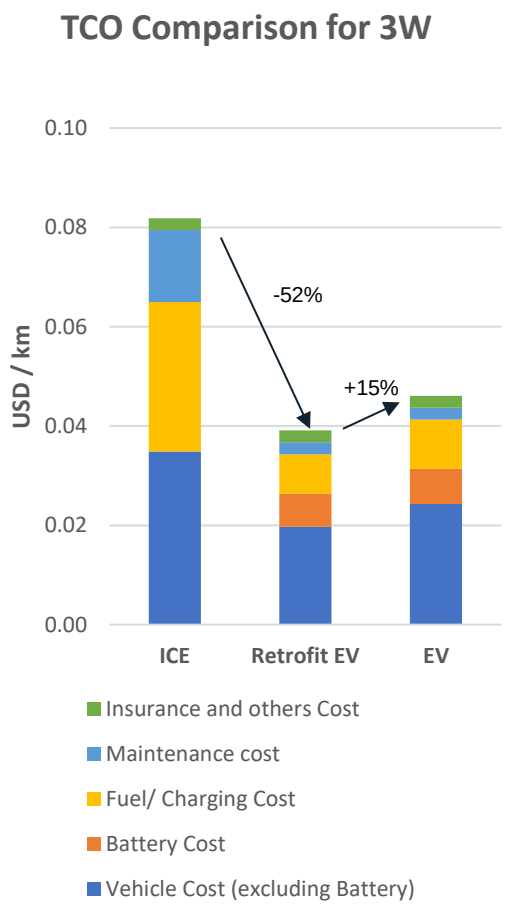
- Three-wheelers are essential for transportation in many LMICs, providing affordable and accessible mobility of people and goods, in both urban and rural areas, and supporting millions of livelihoods.

Retrofit solution:

Company: **Zero21**

Country of operation: **India**

- The retrofit kit has 6 components designed for Bajaj RE, but can be used for other models of 3Ws with GVW in range of 680 kg ± 10%.
- Retrofit of vehicle can be done in less than a day (3.5 to 4 hours)
- 4 variants available:
  - Fixed battery – 5kWh & 8 kWh
  - Swappable battery – 6kWh & 8 kWh



Economics:

- The cost of a new e-3W is ~40% higher than that of an ICE-3W. However, the fuel costs for an ICE-3W are three times higher than the electricity costs for an e-3W. Additionally, existing subsidies on batteries (~$120 per kWh) and lower tax rates on EVs in India make the overall cost of an e-3W more affordable for the end customer.
- Retrofitting a 3-wheeler costs around $2,400 (with a 4.8 kWh battery), compared to the purchase cost of $3,100 for a new e-3W (with an 8.9 kWh battery)
- On average, both ICE and electric 3-wheelers travel a distance of 100 km daily
- The TCO of a retrofitted e-3W is ~52% lower than that of an ICE-3W and ~15% lower than that of a new e-3W
- Unlike other vehicle segments in India, the 3W segment has already seen a consolidation of prices, bringing the cost of ICE vehicles and EVs to parity. This makes retrofitting an even more cost-effective option for this vehicle segment.

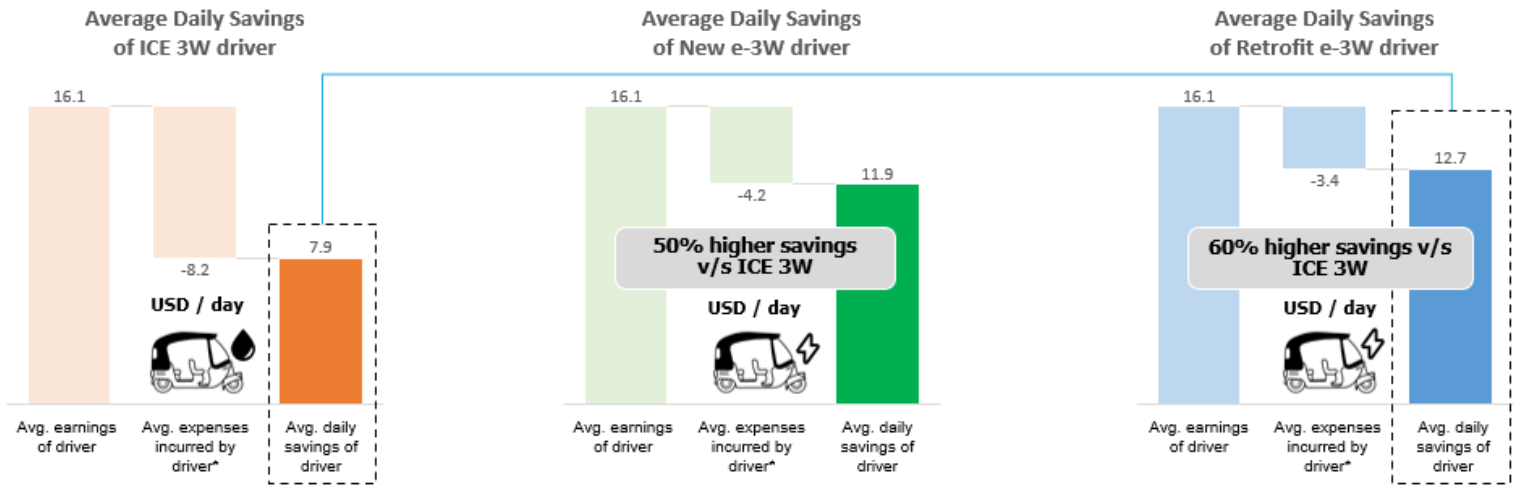
Note: The retrofit vehicle TCO does not account for the ~5-year-old donor vehicle cost as the vehicle is pre-owned by the autorickshaw (3W) drivers in India and they only need to pay for the retrofitting cost.

- If the retrofit vehicle were also to consider the donor vehicle cost, the TCO for a retrofit e-3W comes out to be ~2% lower than that of a new 3W and still ~45% lower than that of an ICE 3W (annualized over 5 years)

***Credits**: Zero21*

A driver can save annually ~$4,200 on a retrofitted vehicle making the payback period about 7 months (price - $2,400). Compared to ICE motos, a driver can save ~$1,600 annually with a retrofitted vehicle.

Daily Savings with Retrofit Vehicle:



**Expenses incurred include capital and operational expenses rationalized on a daily basis*

- The average daily earnings of a 3W driver is ~$16.1. ICE-3W drivers can save ~$7.9 after deducting all expenses. This includes a CapEx finance cost of $3.5 per day (interest rate @ 10% p.a.)
- By switching to retrofit e-3W, the same driver can reduce its expenses by ~58%. This leads to an increase in daily earnings by 60%.
- Retrofitted e-3W is a more affordable option delivering annual savings of ~$4,200 (i.e. $1,600 more than the ICE-3W). The payback period is about 7 months due to lower upfront cost.

Key Learnings:

Key enablers for retrofit in 3W

- **Lower tax (GST) on EVs and retrofit vehicles**
  - 28% tax on ICE-3W v/s 5% on EV and retrofit
- **Government subsidies for retrofitting**
  - 6 states in India have included incentives to retrofit 3-wheelers as part of their EV policies
  - The state of Telangana has 70% of retrofitted 3Ws in country, by offering a retrofitting incentive of 15% of the retrofitting cost, capped at $180 per vehicle
- **Established regulations for retrofits**
  - AIS 123 Part 3 - Central Motor Vehicle Rules Type Approval of Electric Propulsion Kit Intended for Conversion of Vehicles for Pure Electric Operation
  - Includes various tests and safety requirements for converted vehicles

India has extended regulations for approving and homologating retrofitted vehicles. Retrofitting LCV is a sensible choice given the high depreciation costs and the significant price difference between ICE and EV models.

- India is a two-wheeler dominant country. However, in terms of daily distance traveled, greenhouse gas emissions, and pollution, commercial vehicles take the lead. Light commercial vehicles account for around 60% of the total commercial vehicle segment.
- The restrictions on trucks entering cities have increased the use of LCVs in India. Additionally, the growth of e-commerce and SMEs has further amplified the use of LCVs.

Retrofit solution:

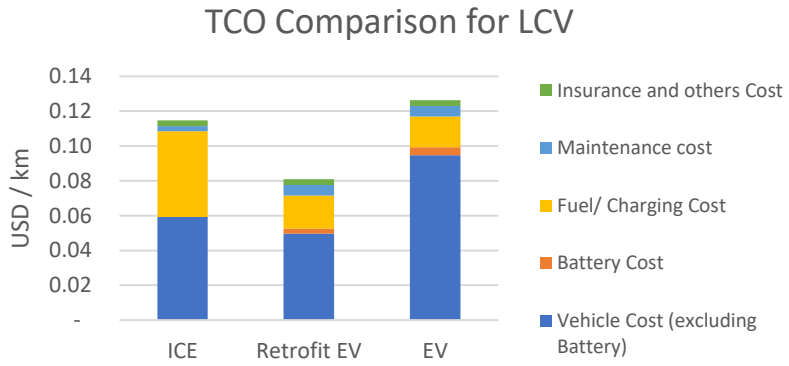
Company: **Northway Motors**
Country of operation: **India**

- Retrofit kits designed for Tata Ace (Light Commercial Vehicle)
- Offers three different retrofit kits with a battery range of 60 to 350 km based on the target application:
  - Last mile delivery – 60 to 90 km
  - Intra-city – 90 to 120 km
  - Inter-city – 300 to 350 km

***Credits**: Northway Motors*

Economics:

- An electric LCV costs almost twice as much as the diesel variant. Even though the operational cost for an EV is more than 50% less than that of an ICE vehicle, the TCO for an e-LCV is still 10% higher than that of a diesel LCV when annualized over a 5-year vehicle life, even after considering subsidies.
- Retrofitting the LCV segment appears to be a promising solution, as the TCO for a retrofitted LCV is 21% lower compared to the ICE version and 28% lower compared to the new EV version. This calculation includes the cost of the donor vehicle at 20% of the salvage value of the ICE variant, which typically corresponds to a 5-7 year old vehicle.



Regulations for retrofit in India:

AIS 123 Part-3
Central Motor Vehicle Rules Type Approval of Electric Propulsion Kit Intended for Conversion of Vehicles for Pure Electric Operation

Vehicle Category	Permissible increase in ULW (%)
L5M (3W –passenger)	25
M1 (4W – D + 8 (max passenger)) M2 (Bus – D + 9 (min passenger) & GVW<5 tons)	25
M3 (Bus with GVW>5 tons)	25
L5N (3W – Goods carriage)	Equal to weight of Electric Propulsion Kit

The regulations include other requirements like

- Gradeability test
- Electric Range measurement
- Break Performance test
- Traction Motor test
- Electromagnetic compatibility (EMC) test
- Constructional and Functional Safety requirements
- Rechargeable Energy Storage System (REESS)
- Wiring Harness / Cables / Connectors

In Tanzania and other African countries, retrofitting safari vehicles for eco-tourism has emerged. Retrofit costs match those of new vehicles, and operating expenses are lower compared to ICE counterparts due to remote locations, distant from fuel centres.

- The safari industry is a major contributor to the economies of many African countries, particularly in East and Southern Africa. Countries like Kenya, Tanzania, and South Africa attract millions of tourists annually, generating significant revenue with over 25,000 safari vehicles operating in these countries.
- The most common vehicles used for safaris are modified 4x4 vehicles such as Land Rovers, Toyota Land Cruisers, and Nissan Patrols. These vehicles are chosen for their durability, reliability, and ability to navigate rough terrains. Traditional safari vehicles run on diesel or petrol, leading to high fuel consumption, significant CO2 emissions and noise impacting wildlife and the natural ecosystem.

Retrofit solution:

Company: E-motion
Country of operation: Tanzania, East Africa

Retrofit of 4W safari vehicles (Land Cruiser)

***Credits**: E-motion*

Moving to e-mobility through retrofit of safari vehicles in Africa

- The conversion of ICE to EVs in the niche application of safari vehicles presents a positive business case with reduced operational costs for vehicle operators in Africa
- This development has facilitated the adoption of e-mobility in the tourism industry across the continent with examples of deployments in Kenya, Tanzania, Zambia, Botswana and South Africa
- Currently, more than 35 safari vehicles in Africa have been retrofitted to operate on electric power by E-motion and other retrofitting companies.

Retrofit kit details:

Retrofit kit details:

- Motor power: 75 kW
- Battery size: 54 kWh
- Range: 150-170 kms
- 2- speed gearbox

Economics:

- Operating on a model of exchange of old vehicle with new retrofitted EV
- Cost of retrofitting vehicle is about $70,000 compared to new ICE Toyota land cruiser cost of $75,000
- The safari vehicles run approx. 80 kms/day
- These vehicles are being charged through 10 charging station deployed between Arusha and Serengeti National Park augmented by solar energy generated within the national park
- While using the fossil-based vehicles, the fuel was fetched from 200 kms because of the remoteness of the safari locations
- The ROI for retrofitted safari is about 3 years

The development of ecosystem for retrofit of 4Ws by Autolibre in Latin America through their approach of training mechanics & technicians on retrofitting has helped them in aggregation of demand, standardizing retrofit kits and achieving reduction in cost of retrofit. The company was able convert more than 2,800 vehicles through network of 40+ workshops in 15 countries.

- Globally, an estimated 80 million ICEVs will qualify to undergo scrappage by 2030. Similarly in Latin America, millions of ICEVs in use will have to be scrapped and recycled or worse still, they will be abandoned in areas with the risk of local contamination.
- Retrofitting is an opportunity to modernize a large percentage of these units, adding about 10 years of extra life, without local emissions.

***Credits**: Organización Autolibre*

Retrofit solution:

Company: **Autolibre, Uruguay**
Region of operation: Latin America

- Retrofit kits designed for vehicles with GVW of 1000 to 3000 kgs
- Training to individuals and workshops on retrofitting

Retrofit kit details:

- AC motor, speed controller with VCU, accelerator pedal, DCDC converter and battery charger.
  - 72V 25 Kw- $1300
  - 108V 40 kw- $1700
  - 144V 60 Kw- $1900
- LifePo4 modules, 25.6V 100Ah prestressed lithium modules allow custom batteries to be assembled from $120/kwh
- This allows conversions in Latin America that range from $6,500 for 1,000 kg vehicles to $16,000 for 3,000 kg vehicles

Business model:

- First Retrofit program of 200 Nissan trucks converted for Bimbo in Toluca, Mexico
- The company has created a low-cost (150 dollars) online training program and in-person training every year in Mexico, Peru, Argentina, Uruguay and Paraguay for mechanics and technicians to promote processes and created a community of installers in 15 countries
- Clients have a free App to inform them of processes and technical data
- By leveraging the network of workshops that generated the demand for retrofit kits, the company was able to negotiate a lower supply costs of electric traction systems and lithium batteries, by buying from manufacturer in China under a single purchasing account .
- Autolibre and its network of 40 distributors have converted some 2,800 vehicles in 15 countries

Roam Electric in Kenya conducted a pilot retrofit of a diesel bus for public transportation. However, the current cost of the retrofit is approximately 1.5 times that of a new vehicle, making it uneconomical. Additionally, difficulty in sourcing retrofit components like batteries further hinder its scalability.

Retrofit solution:

Company: Roam Electric
Country of operation: Kenya

- Pilot Retrofit of Diesel Bus

***Credits**: Roam Electric*

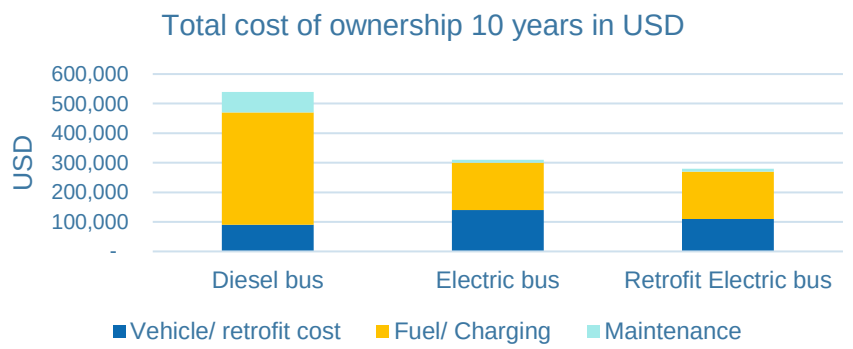
Pilot details:

Retrofit kit details:

- Motor power: 250 kWp
- Battery size: 121 kWh
- Range: ~200 kms
- 2-speed gearbox

Economics:

- Cost of retrofit (excluding the donor ICE vehicle) is about 1.2 times the cost of new ICE vehicle
- Cost of retrofit kit is about 110,000 USD, including the current taxes of 35% import duty and 16% VAT
- TCO for 10 years of retrofit e-Bus is about $200,000 lower than that of Diesel bus and $3,000 lower than electric bus (~ purchase price around $150,000)



Challenges and required interventions:

Challenges:

- Challenges in scaling the retrofitting of vehicles because of high cost of retrofit which is at par with new electric bus
- Challenges in sourcing the components of the retrofit kits, especially the batteries

Recommendations:

- Policy measures such as reduction in taxes and providing incentives on retrofit adoption would be needed. For example, the grant scheme, “retro-fit bonus” in France provides grants and concessional loans for conversion of light commercial vehicles and trucks.

Regulations for ICEV to EV retrofit

Regulations for ICE to EV retrofit being implemented globally

Regulation Name	Region	Vehicle types	Description
UN-ECE R100	EU, Global	Buses & 4Ws for passenger transport - M and, Goods vehicles (GVW<3.5 Ton) - N1	Standards for conducting approval tests and of Type Approval Authorities which includes standard EV testing covering, ▪ Gradeability test ▪ Electric Range measurement ▪ Break Performance test ▪ Traction Motor test ▪ Electromagnetic Compatibility (EMC) test ▪ Constructional and Functional Safety requirements ▪ Rechargeable Energy Storage System (REESS) ▪ Wiring Harness / Cables / Connectors
AIS 123 Part-3	India	3W motor vehicles - L5N, L5M Buses & 4Ws for passenger transport - M1, M2, M3	Type approval for retrofit kits as per UN-ECE R100. Additionally covering the permissible increase in unladen weight (ULW) (%) and authorization of retrofit company & retrofit centres.

The standards adopted in EU and India are similar to the United Nations Economic Commission for Europe (UN-ECE) R100 standard for vehicle type approval. However, the approval process for retrofitting can vary by country in terms of whether approval is granted for retrofit kits that can be used for specified vehicle models or for individual retrofitted vehicles.

- In France, each retrofit kit used for modifying a vehicle model must be officially approved, which can be a costly process, ranging from €100,000 to €800,000 per retrofit kit, depending on the model. This approval process for cars can be expensive for retrofit companies, considering the wide range of models in the market and the cost associated with approving each vehicle model.
- On the other hand, in Germany and the Netherlands, the approval process is for individual retrofitted electric vehicle. This system is more cost-effective, with a maximum cost of €2,000 per retrofitted vehicle.

It is crucial to develop a feasible and viable procedure for retrofit type approval based on the vehicle segment and its prevalence for retrofitting in the country. The approval process should strike a balance between ensuring safety and quality standards while also being cost-effective and accessible for retrofit companies and vehicle owners.

Source: The Brussels Times, https://www.brusselstimes.com/254356/retrofitting-offers-solution-for-converting-to-electric-cars-by-2035

Challenges and Solutions for the adoption of retrofitted EVs in LMICs

Barriers across value chain impeding growth of used EV

Sourcing/ import

Challenges:

- Availability of high-quality retrofit kits and components
- Import restrictions and tariffs on EV components resulting in higher cost of retrofit kits especially in case of Buses & Trucks
- Supply chain dependencies

Solutions:

- Advocate for government policies that reduce tariffs and provide incentives for importing EV components
- Engage in dialogue with trade organizations to facilitate smoother import processes
- Demand aggregation for retrofit kits to reach scale for retrofit businesses to lower cost and improve supply chain security

Retrofit

Challenges:

- Shortage of skilled technicians and engineers
- Need for specialized training and certification programs
- High labor costs for skilled retrofitting personnel

Solutions:

- Develop specialized training programs in collaboration with technical institutes and industry experts
- Establish certification programs for EV retrofit technicians to ensure a standardized skill level

Registration

Challenges:

- Lack of standardized retrofit kit specifications
- Inconsistent regulatory frameworks across regions
- Complex approval processes for retrofitted vehicles

Solutions:

- Work with industry bodies to develop and adopt standardized specifications for retrofit kits
- Advocate for harmonized regulatory frameworks at the national and regional levels
- Streamline approval processes by working with regulatory bodies to simplify requirements

Usage

Challenges:

- Consumer acceptance and trust in retrofitted vehicles
- Uncertainty in warranty and post-retrofit support
- Interoperability with existing charging infrastructure and range anxiety

Solutions:

- Provide comprehensive warranties and after-sales support for retrofitted vehicle
- Establish service networks to offer maintenance and repair services
- Promotion of battery swapping for smaller vehicle segments like 2Ws & 3Ws

5

Conclusions

Affordable e-Mobility options for LMICs

Import of Used EVs

- Used vehicles are an important mode of transport in most LMICs due to their affordability and availability of low cost labour for service and repair.
- With the rise in EVs in HICs, eventually these vehicles will also be exported used to LMICs – especially given the higher upfront cost of new EVs and lower purchasing power and access to affordable financing.
- As of 2022, around 85 thousand used EVs have already been exported to LMICs. This number is expected to grow and reach just above million by 2030 depending on policy choices made in mature EV markets.
- The current policy framework in the EU for the circularity of EV batteries may prevent EVs and EV batteries from leaving the EU because of Extended Producer Responsibility (EPR) on EV OEMs and the keep critical minerals in the region, thereby limiting used EV flow into LMICs.
- In July 2023, the EU also proposed a new regulation on end-of-life vehicles (the ELV Regulation). The proposal requires the export of good quality used vehicles through mandatory inspections, interoperable vehicle registration systems, improved distinction of used vehicles from end-of-life vehicles and banning the export of unroadworthy used vehicles.
  - The regulation would also be applicable to used EVs with the additional need for the inspection of battery SoH before export, to avoid vehicles just before their end-of-life entering LMICs.
  - LMICs also need to adopt import rules for used EVs to enforce the pre-shipment inspection of EVs including the battery SoH assessment and develop capacities for local battery testing, repairing and recycling.

Affordable e-Mobility options for LMICs

Import of Used EVs

- Key challenges for used EVs are the limited knowledge on the useful life of the battery after the import, the lack of after-sales support and regulations for safe end-of-life management of EVs in many LMICs.
  - Currently, there are no provisions to ensure that a used vehicle (not yet at its end of life) exported to a non-EU country is properly disposed of when it eventually reaches its end of life. This raises the possibility that used vehicles could be exported to LMICs just before their end of life to avoid having to provide evidence of proper disposal.
- The establishment of battery reuse, recycling schemes in LMICs is necessary for proper handling of end-of-life EVs
  - International cooperation is needed to facilitate second-hand vehicle flows while ensuring adequate end-of-life battery handling strategies to address the EPR applicability for OEMs in mature EV markets.
  - For example, there could be incentives or allowances associated with extended vehicle lifetimes via use in second-hand markets internationally before recycling, as long as recycling in the destination market is guaranteed.
  - In any case, LMICs need to develop schemes for EoL battery management promoting innovation in battery testing, reuse in other stationary applications and eventually recycling.
  - This will create opportunities for employment and local value addition within LMICs.

Affordable e-Mobility options for LMICs

ICE to EV retrofitting

- Retrofitting of ICEV to EVs is another option to increase adoption of EVs in LMICs, particularly for vehicle segments other than four-wheelers as they are typically not imported used.
- The economics suggest retrofits can provide a good transition solution especially in the livelihood taxi segments - 2W, 3W and 4W CVs.
- However, challenges such as unclear policies, warranty, consumer acceptance issues, and limited regulatory support hinder the widespread adoption of retrofitting.
- Demand aggregation for retrofit kits can help in scaling up retrofit businesses which will help to address challenges of high cost and supply chain security.
- Choosing appropriate type approval mechanism for vehicle segments based on their scalability will smoothen the regulatory approvals for retrofit EVs and improve quality assurance.